CROP WEATHER MODELLING IN RICE (*Oryza sativa*.L)

BY

SAJITHA RANI, T

THESIS

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DECLARATION

I hereby declare that the thesis entitled ***"Crop weather modelling in rice (Oryza sativa.*L *)"*** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship, associateship or other similar title of any other University or Society.

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SAJITHA RANI,T

CERTIFICATE

Certified that the thesis entitled "***Crop weather modelling in rice (Oryza sativa.*L)"** is a record of research work done independently by Ms. Sajitha Rani. T. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Vellayani
11-07-2002

Dr. G. RAGHAVAN PILLAI
(Chairman,Advisory committee)
Professor and Head (Retd),
Department of Agronomy,
College of Agriculture,
Vellayani,Thiruvananthapuram.

Approved by :

Chairman :

Dr. G. RAGHAVAN PILLAI
Professor and Head (Retd.)
Department of Agronomy
College of Agriculture
Vellayani

Members :

Dr. S. JANARDHANAN PILLAI
Associate Professor and Head
Department of Agronomy
College of Agriculture
Vellayani

Dr. V. MURALEEDHARAN NAIR
Professor and Head (Retd.)
Department of Agronomy
College of Agriculture
Vellayani

Dr. G.S.L.H.V. PRASADA RAO
Professor and Head
Department of Agricultural Meteorology
College of Horticulture
Vellanikkara

Dr. (Mrs.) P. SARASWATHI
Professor and Head
Department of Agricultural Statistics
College of Agriculture
Vellayani

External Examiner :

Dr. MUTHUSANKARANARAYANAN
Professor and Head
Department of Agronomy
Agricultural College and Research Institute
Killikulam, Tamil Nadu

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@	at the rate of
AT	Active tillering
°C	Degree Celsius
Cal cm^{-2} day^{-1}	Calories per square centimeter
CD	Critical difference
CGR	Crop growth rate
cm	Centimeter
cv	Cultivar
DAT	Days after transplanting
DMP	Dry matter production
Fig.	Figure
Filled grains panicle $^{-1}$	Filled grains per panicle
FYM	Farm yard manure
g	gram
g $hill^{-1}$	gram per hill
grains per m^2	grains per square metre
HI	Harvest index
K	Potassium
Km hr^{-1}	Kilometre per hour
Kg ha^{-1}	Kilograms per hectare
LAI	Leaf area index
m	Metre
m sec^{-1}	Metre per second
mm	millimeter
N	Nitrogen
P	Phosphorus
PI	Panicle initiation
Panicles per m^2	Panicles per squre metre

Panicles hill^{-1}	Panicles per hill
RARS	Regional Agriculturel Research Station
t ha^{-1}	tonnes per hectare
TDMP	Total dry matter production
viz.,	namely
var.	variety
%	per cent
m s^{-1}	metre per second
WAT	Weeks after transplanting

INTRODUCTION

Rice is intimately involved in the culture as well as in the food ways and economy of Indians especially Keralites. With growing economic prosperity and urbanization, per capita rice consumption has started declining. The demand of rice is expected to increase by 70 per cent over the next 30 years, primarily due to rapid population growth. Rice is grown over a considerable geographic range from 45°N to 40°S at elevations of more than 2500 m.

On a global basis, rice covers an area of 155 million hectares with a production of about 596 million tonnes in 1999. Asia, the most densely populated region in the world, accounts for about 90 per cent of world's area under rice. In India, rice covers an area of 43.7 million hectares with annual production of 84.7 million tonnes (Siddique, 2000). In Kerala, rice is grown in an area of about 3.45 lakh hectares with a production of about 7.7 lakh tonnes, which is more than the national average. (FIB, 2002). The gap between the requirement and consumption of rice in the state, which was around 50 per cent in the early sixties, is now more than 75 per cent. Hence, the emphasis now should be to reduce this gap at least to 50 per cent in a period of 10 years. By 2010, the total requirement of rice would be 42 lakh tonnes per annum, estimated at an average daily requirement of 320 g per person. This means that by 2010, the rice production is to be increased from the current level of 7.7 lakh tonnes to 21 lakh tonnes. To achieve this objective, the strategy should be to increase the total production. This can be accomplished by increasing the acreage under rice and by enhancing the productivity per unit area.

Among the different factors, weather parameters play a significant role in rice production. Among crops, rice is more vulnerable to change in weather parameters. Climatic parameters like low light, extreme temperature, oscillation in rainfall, cloudiness etc. affect rice crop from transplanting. The earlier transplanting also escaped from the severity of pests and diseases.

Kanchana, Kairali and Jyothi registered similar values for number of days taken to 50 per cent flowering, physiological maturity and number of filled grains per panicle during all seasons at Vellayani. In all seasons the nitrogen, phosphorus and potassium uptake by straw and grain were lower for local variety. Kanchana consistently out yielded other varieties followed by Kairali and the local variety Ptb-10 registered the lowest grain yield.

At Pattambi also during all seasons number of days taken to 50 per cent flowering and physiological maturity were similar for Kanchana, Kairali and Jyothi. In all seasons the nitrogen, phosphorus and potassium uptake by straw and grain were lower for local variety. Highest grain yield was registered by Kanchana followed by Kairali in all seasons except third season where it was on par with Kairali. The lowest grain yield was registered by local variety.

At both locations, all the high yielding varieties registered lower rice bug attack than local variety. Kairali and Kanchana were found resistant to sheath blight and gall midge

At both locations similar trend in growth and yield attributes, nutrient uptake and pest and disease incidence were observed in all the seasons. Result of this investigation revealed that early transplanting of rice and cultivation of high yielding varieties Kanchana would increase the productivity per unit area.

Grain yield data for a period of twenty five years (1960-1985) from a permanent manurial experiment at Regional Agricultural Research Station, Pattambi was subjected to correlation analysis to develop the best fitting crop weather model using step wise regression. In *virippu* season 72 per cent of the variation in yield was attributed to climatological parameters viz.,. evaporation, maximum temperature, minimum temperature, number of rainy days, evening relative humidity and sunshine hours. In *mundakan* season 46 per cent of variation in yield was accounted for the climatological parameters viz., evaporation, maximum temperature and sunshine hours.

dates of planting. Hence, time of planting and prevailing weather conditions play a major role in determining the productivity of rice.

Crop growth model is an effective tool for evaluating the consequences of different management strategies on its response to the environment leading to better crop production. A scientifically prepared yield prediction equation with weather variables will be very much helpful in improving the rice productivity in the state.

Hence, the present investigation was taken up with following objectives.

- To study the influence of weather on the growth and yield of local and high yielding rice varieties, and to identify the suitable variety and date of planting for each season.
- To develop the best fitting crop weather model using step wise regression.

Review of literature

REVIEW OF LITERATURE

Climate plays an important role in rice production. Rice is vulnerable to change in weather and its cultivation continues to be a risky enterprise under unfavourable environment, despite advances made in rice production technologies. Within any season, long days and humid conditions with adequate rains or water supply help towards satisfactory vegetative growth of the rice plant, while bright weather and short days with a diminishing supply of water favour the flowering phase. Cloudiness, low light, extreme temperatures, variation in rainfall, and high relative humidity affect the growth, yield attributes and productivity. Rice has genetic potentiality to some extent to tolerate to adverse weather conditions and hence evolving an appropriate cultivar may enable a farmer to avoid or lessen the problems from climatic stresses (Dash and Rao, 1990).

The present review is mainly confined to the studies made on the influence of weather parameters on growth and yield attributes of different short duration rice varieties during different seasons.

2.1 Effect of season on rice

Chatterjee and Mandal (1987) found that under rain fed conditions in the *kharif* (monsoon season) high rainfall, low radiation and high pest incidence were detrimental to crop production.

2.1.1 Growth

The main seasons for rice in Kerala are fairly well defined, the *virippu* or the *kharif* crop, *mundakan* or *rabi* crop and *puncha* or *summer* crop from April - May to September – October, September- October to December- January and from December- January to March – April respectively (Sahadevan, 1966).

The weather conditions during the crop growth period generally decide the response of paddy to added inputs (Mahapatra and Bedekar, 1969).

Among the various weather factors, which affect the growth of rice, air temperature plays a vital role. Each development stage and growth process responds differently to the same temperature conditions (Ishizuka *et al.*, 1973). Temperature affects the rate of leaf emergence in rice plants and at the time of seedling emergence, the growth rate was 82.65 x 10 g dry matter per plant per day (Yoshida, 1973). Low temperature slows down the rate of germination and root development. For upland rice, the optimum temperature for germination was 30^{0}C (Hall, 1966) and the lower limit was 20^0 C (Downey and Wells,1974). The optimum temperature for elongation and leaf emergence were 25^{0}C and 30^{0}C respectively (Robertson, 1975). Sreedharan (1975) reported that high temperature during the vegetative growth stage increased the tiller number and retarded the rate of development. The minimum air temperature of 25^0 C and 26^0 C was ideal for shoot and root growth . During *kharif*, rainy days are most common and the weather is mostly cloudy. The temperature during this period is favourable for vigorous vegetative growth. In a trial with four dwarf and one tall rice cultivars, average paddy yields were 6.41 tonnes in the dry season (January-May) and 2.95 tonnes in the wet season (July-October) (Sahu and Murthy, 1975).

Another major climatic factor to consider is light intensity. The lower yields during *kharif* season are mainly because of low light intensities. Short duration varieties are generally photo insensitive and can be grown in all the seasons.

From a study on rice canopy Venketeswarlu (1976) found that Leaf area index (LAI) for *kharif* was between four and five whereas it was between five and six for *rabi*. But dry matter production did not differ much between *kharif* and *rabi*.

The mean total dry matter production at flowering and harvest and LAI at flowering were more during dry season than wet season. The low solar energy utilization percentage in dry season was attributed to enhanced duration of the varieties in the season because of exposure to low temperature at early stages of growth (January and February) with mean low temperature of 22^0 C against 29^0 C during July–August of the wet season combined with high solar radiation during the dry season (430 cal cm^{-2} day^{-1}) compared to wet season (310 cal cm^{-2} day^{-1}) (Rao *et al.*, 1985).

2.1.2 Nutrient uptake

The uptake of phosphorus and potassium were greatly influenced by season and cultivars. Sahu and Murty (1975) observed low dry matter production and nitrogen uptake up to the primordial stage in early maturing cultivars and these increased thereafter, while the reverse trend was observed in mid season cultivars. They also reported a higher (1.30 to 1.75 times) nitrogen content in shoots in wet season than in dry season. Increase in nitrogen response by 88 per cent during *rabi* over *kharif* was reported by Murthy and Murthy (1978). Sreedharan and Vamadevan (1981) also noticed similar trend. In low light tolerant cultivars the uptake of phosphorus and potassium were more in February planting and the highest nitrogen content was 2.34 per cent, 1.67 per cent and 1.21 per cent in October, July and February planted crops respectively (Mohandass, 1990). Narayanasamy (1994) reported higher uptake of nitrogen and phosphorus noticed with early sowings of July and August months and with late October sowings. Increased nitrogen and potassium uptake for October 1st transplanted crop was also reported by Pillai (1995).

2.1.3 Yield and yield components

In humid tropical conditions of Andaman and Nicober Islands, early planted crop within June or latest by 1st week of July resulted in significantly higher yield compared to delayed planting (Gangwar and Ahamedi, 1990). They also reported that number of grains per panicle, grain yield per plant and 1000 grain weight were also decreased with delay in planting. Drastic reduction in grain yield due to late planting had also been reported by Kempanna (1960), Rao and Murthy (1982) and Babu (1988).

Lambaga (1973) observed considerable yield alteration due to different dates of planting. Higher yield was due to faster rate of growth and higher dry matter per plant. In Indonesia, highest yield were obtained with medium duration varieties when transplanted from June to August, while the yields were lowest in October planting.

In Tamil Nadu, fortnightly planting revealed that crops planted on 10th February recorded higher grain yield than the other planting dates, while the lowest yield was recorded in 4th November planting (Kembuchetty,1978).

At CRRI Cuttack, the average paddy yield of 12 rice cultivars in the dry season was 12 per cent higher than in the wet season (Narasingarao, 1987). In another study conducted at Cuttack it was shown that the scented rice varieties planted on 25th July gave significantly higher yield of rough rice than those planted late i.e on 5th September. But late planted crop on 11th August gave higher head rice recovery than early planted rice on 25th July (Chandra *et al.*, 1997).

2.1.4 Effect of season on the incidence of pests and diseases.

Uthamaswamy and Karuppuchamy (1986) reported that the incidence of Gall midge (*Orseolia oryzae*) was highest when variety CO 40 was planted on 1st September during *samba* season and when IR20 was planted on 16th September during *thaladi* season, and the pest incidence was the lowest when the crop was planted during August or October.

Early planting tends to escape the seedling maggots and early planting combined with early maturing varieties provide high crop tolerance to white grub. August planting was severely affected by *Atherigona oryzae*. Increasing seed density protects the crop against seed and seedling pest particularly, if the crop germinates quickly (Litsinger *et al.*, 1987).

In a study to find the seasonal prevalence of the cicadellid *Nephotettix virescens* in rice fields in Bihar from April to December, it was found that the first appearance of the pest was in April. The pest population peaked in September (week 39) and in October (week 40). The pest was absent from rice fields through out the whole of December. Temperature and relative humidity were positively correlated with pest density whereas rainfall was negatively correlated with it (Gupta *et al.*, 1989).

In humid tropical conditions of Andaman and Nicober Islands, June planted crops was observed to be free from pests and diseases viz., leaf roller, hoppers and case worm. Stem borer was recorded in moderate to severe intensity in August planted crop (Gangwar and Ahamedi,1990).

Shetty *et al.*(1994) reported that rice gall midge (*Orseolia oryzáe*) was endemic to the coastal regions of Karnataka, which was characterized by heavy rainfall from June to September and high humidity throughout the year, with heavy crop losses during the *kharif* season. Twelve promising rice selections together with the susceptible standard Jaya when grown during *kharif* for three years, it was seen that the mean gall midge incidence ranged from 0.4 per cent in IET10765 to 21.2 per cent in Jaya

2.2 Effect of weather on growth and yield attributing characters

2.2.1 Temperature

Among the various weather factors that affect growth and yield of rice, temperature plays a very important role. Each development stages of rice plants respond differently to the same temperature conditions (Izhizuka *et al.*,1973).

2.2.1.1 Vegetative phase

Temperature regimes greatly influenced the growth, duration and growth pattern of rice. During the growing season, the mean temperature and temperature sum, its range, distribution pattern, diurnal change or a combination of these might be highly correlated with grain yield (Moomaw and Vergara,1965).

Low air temperature at early vegetative phase retarded the growth of shoots (De Datta,1970). Kim *et al.*(1973) observed that height of plants were highest at 20°C. At Coimbatore Rajagopalan *et al.*(1973) reported that during October, plant height was not increased due to low air temperature during early growth periods. Similar findings in the case of October and November planted crop due to lower day and night temperature were reported by Krishnakumar (1986). He also reported that low night temperature during vegetative phase increased the height of plant at harvest. Khushu *et al.* (1988) observed prolonged growth duration with increased air temperature, he also observed a decreased plant height with decreased day and night temperature. Similar findings were also reported by Chae *et al.* (1980). Sunil (2000) reported that increased daily maximum and minimum temperature during the entire cropping season decreased plant height and tillers.

Nagai (1968) observed that high night temperature resulted in early leaf emergence and advanced tiller emergence. The low night temperature increased the number of tillers per plant (Owen,1972). Robertson (1975) reported that optimum temperature for elongation and leaf emergence were 25°C and 30°C respectively. High temperature led to increased production of ineffective tillers and resulted in stunted growth with small leaves (Lin,1976). Venketaswarlu (1976) observed that LAI at flowering was positively correlated with integrated mean temperature during vegetative phase. According to Kempuchetty (1978) tiller production and leaf area were positively correlated to night temperature. Wan (1979) observed an increased tiller and panicle production at 25°C day temperature and 20°C night temperature. Chaudhary and Sodhi (1979) reported that growth duration varied with air temperature. The growth duration increased in proportion to the length of time the plants experienced low temperature during vegetative growth. Flowering temperature accounted for 86 per cent of the variation in growth duration. He also reported that there was positive correlation between number of tillers and straw yield. Winter sown plants produced maximum number of tillers and highest straw yield. Moniperumal (1989) observed increased tiller production under higher temperature.

Sreelatha (1989) reported decreased tiller number with high temperature throughout the crop growth period. In greenhouse trials with rice cultivars Taichung Native 1 and Taichung 65 on the influence of day/night temperature on tillering, Tsai and Lai (1990) reported increased tiller number with increasing difference between day and night temperature, regardless of whether the day temperature was 30 or 25^0 C. They also observed that with a similar day temperature, the environment on hillsides was more likely to increase tiller numbers than that in the plain due to lower night temperature.

Karim (1969) observed an increased dry matter production when night temperature varied from 21 to 32°C. Total dry matter from transplanting to panicle initiation was greater under low daily mean temperature (Place *et al.*, 1971). Sato (1972) found that DMP was favourably influenced by day-night temperature regime of 25 to 20°C for the rice varieties IR8. Maximum dry matter was observed at 25°C. Kim *et al.* (1973) observed that dry weight of plants was highest at 20°C. Kang and Heu (1976) and Kembuchetty (1978) had observed increased DMP with lesser night temperature during vegetative phase.

Analysis of temperature components shows that the minimum air temperature has the best negative correlation with growth duration. Kang and Heu (1976) and Chaudhary and Sodhi (1979) reported extended vegetative growth due to low temperature. In a study on the influence of air temperature on duration of vegetative phase at Regional Agricultural Research Station, Pilicode with two photo insensitive rice varieties Jaya and Thonnuran under different planting dates in *kharif* and *rabi*, it was noticed that the duration of vegetative phase in both varieties was much less in *rabi* when compared to *kharif*. The number of days required for vegetative phase was significantly less when the maximum temperature was more than 31°C (Rao, 1988).

2.2.1.2 Reproductive phase

Nagato and Choudhury (1970) reported that high temperature during kernel development affected kernel weight in rice. Exposure to low temperature during active vegetative phase can extend the time of flowering (Chang and Vergara,1972). The critical minimum temperature for floral initiation was around 15°C, optimum was 25-30°C, and floral initiation was delayed at low temperature (Owen,1971).

According to Satake (1976) the rice plant was very sensitive to low temperature at about nine days before flowering. Inaba and Sato (1976) opined that the response of rice to high temperature after heading was resulted from direct effect on the kernel itself, possibly related to starch synthesis in the endosperm. Increased tiller and panicle production were reported at 25°C and 20°C for day and night temperature respectively (Wan,1979). Yoshida (1981) observed a 13 days delay in flowering for each degree drop in temperature between 24°C and 21°C in varieties IR 26. High temperature both maximum and minimum and lower diurnal variation in temperature are more conducive for early flowering in rice. The average flowering duration of the varieties ranged from 58 to 91 days in August and December planting respectively at CRRI, Cuttack (Sahu *et al.*,1983). They also found earlier flowering of the crop when the difference between day and night temperatures was minimum.

Park (1975) reported a close relationship between number of panicles and environmental factors. Kembuchetty (1978) recorded a positive correlation of panicle production and spikelet per panicle with day temperature. Satake and Yoshida (1978) reported that high temperature induced sterility in rice, and heading time was the most sensitive stage to high temperature. Chaudhary and Sodhi (1979) revealed that minimum spikelet sterility of 12-18 per cent was found in November sown plants which experienced a temperature of 27-28°C during flowering and sterility increased when plants were exposed to higher or lower temperature during flowering.

Spikelet sterility was caused by low temperature at flowering phase (Peterson *et al.*,1974). Yoshida (1981) observed high percentage of spikelet sterility with a temperature of above 35°C for a period of more than one hour at anthesis. The change of day/night temperature seven days after heading from 27/22°C to a range from 24/19°C to 30/25°C resulted in little variation in kernel dry weight (Toshiro and Wardhlaw,1991).

From an experiment conducted at Regional Agricultural Research Station, Pattambi. Alexander *et al.* (1993) found that the ill effects of mean temperature beyond 34°C is counteracted by a minimum temperature below 22°C up to 18°C and a higher temperature regime reduce the yield by reducing the duration of their time span for grain filling, possibly through a higher heat unit accumulation in unit time.

In rice grain, chaffy parts composed of 75 to 95 per cent at 30^0 C and 0 to 17.5 per cent at 20^0 C (Jia *et al.*, 1991). They also reported that during the first 15 days after flowering high temperature resulted in more chalkiness by shortening the effective filling stage. Rice grain chalkiness increased with increase in temperature up to 29^{0}C. Chalkiness suddenly increased at 25^0 C.

Yield attributes like filled grains percentage, panicle weight and degrees of ripening were negatively correlated with night temperature during reproductive and ripening phases (Krishnakumar, 1986). Sunil (2000) reported that increase in daily maximum temperature during active tillering stage decrease the number of panicles hill $^{-1}$. He also reported that maximum temperature above 33°C during reproductive period reduced the number of filled grains panicle^{-1}. A minimum temperature above 23°C during ripening period reduced grain chaff ratio.

2.2.1.3 Grain yield

In general, grain yields are higher when temperature during ripening stage is relatively low, which is attributed due to a more favourable balance between photosynthesis and respiration during the grain filling period.

Temperature appeared to influence the ripening of rice in two ways. The length of ripening period is inversely correlated with daily mean temperature (Yamakawa, 1962) and low temperature favoured an increase in weight per grain (Murata, 1964). Persistent cloudy weather conditions will be more detrimental to grain filling under high temperatures because of a shorter ripening period. The longer duration of grain filling might have resulted in higher grain yield. Similar correlation between longer duration taken for grain filling period and greater grain yield in rice has been reported by Tanaka and Vergara (1967).

Warm climate during early growth period resulted in low average yield in tropics (De Datta, 1970). A significant negative correlation between yield and the minimum temperature at 30 days after transplanting was reported by De Datta and Zarate (1970). Similar findings of reduction in yield due to higher maximum and minimum temperature during tillering, ear initiation and maturity was reported by Huda *et al.* (1975).

Higher grain yield in temperate countries than in tropical countries had been attributed to lower temperature during ripening period. The ripening period was found extended due to low temperature, giving more time for grain filling. The variation in yield of high yielding rice varieties were due to the fluctuations in mean temperature during growth and ripening periods (Murata and Togari,1973).

Paddy yield was significantly associated with maximum, minimum and mean air temperatures during periods from transplanting to flowering, flowering to maturity and transplanting to maturity (Khushu *et al.*, 1988)

Yang and Heilman (1993) found that high temperature during grain filling stage decreased spikelet per panicle, percentage of filled spikelet and 100 grain weight and increased number of panicles per hill, leaf growth and tillering.

In an investigation conducted at Regional Agricultural Research Station, Pattambi, Kerala to find the relationship between weather and rice yield, Samui *et al.* (1998) found that yield of rice increased as the average minimum temperature increased from 21.5°C and decreased as the maximum temperature increased from 29.1°C. They also observed that the optimum value of minimum and maximum temperature were 23.5°C and 29.1°C respectively.

2.2.2 Solar radiation and light

2.2.2.1 Vegetative phase

Several workers had reported that solar energy is the major governing factor for photosynthesis and hence dry matter production. The solar radiation requirement of crop differs from one stage to another (Yoshida and Parao,1976).

According to Venketeswarlu (1977) compared to *rabi* season, low light intensity up to flowering in *kharif* imposed a ceiling on tillering and reduced dry matter production(DMP). Radiation had been reported to influence tillering during vegetative phase and fertilizer response during flowering. Low light intensity reduced tillering by 45 per cent and increased the rate of production of weak tillers. The reduction in tillering at 50 per cent of natural light ranged from 40 to 56 per cent of the control.

Under low light conditions, there was 15 per cent increase in plant height and the increase was more apparent in tall indica late varieties than in early varieties under subdued light (Janardhan and Murthy, 1980).

Sreedharan and Vamadevan (1981) reported that LAI reduced to a great extent in plants shaded either from planting to panicle initiation or from flowering to harvest. Shading also caused senescence of many lower leaves. The photosynthetic rate and DMP were reduced under low light condition whereas plant height and leaf area were increased (Chatterjee and Maiti,1985). Plant height and LAI were seen to be negatively correlated with sunshine hours and solar radiation during later phase of crop growth (Krishnakumar,1986). Difference in total DMP among different cultivars was observed under low light intensities. The leaf area was not much altered but DMP was greatly affected. The dry matter content of leaves decreased under low light intensity from 10 to 30 per cent while the stem weight increased from 20 to 68 per cent (Vijayalakshmi *et al.*, 1987). Thangaraj and Sivasubramanian (1993) observed that low light caused the plant to grow taller with more leaves but retarded tillering and decreased the

DMP, while additional light decreased the plant height, leaf area and increased the tillering and DMP.

Sreelatha (1989) from her studies on rice also observed a positive relationship between yield and total solar radiation during 5 to15 days before 50 per cent heading.

2.2.2.2 Reproductive phase

Yoshida and Parao (1976) reported that low light intensity during the vegetative phase slightly affected the yield and yield components while low light intensity during reproductive phase had a pronounced effect on spikelet numbers and grain yield. Low solar radiation during ripening phase decreased the percentage of filled grains and grain yield. A mean yield reduction of 6.5 per cent was observed for every one per cent reduction in solar radiation during the period of 42 days from heading.

Solar radiation received during one week before harvest (De Datta and Zarate,1970) or 15 days before and 25 days after flowering (Matsushima,1970) or three weeks before and after flowering had positive influence on grain yield (Murata and Togari,1973). Rao and Deb (1975) reported that low light intensity reduced the number of panicles per m^2. The amount of solar radiation received from panicle initiation to crop maturation was critical for accumulation of dry matter during that period. Murthy and Murthy (1981) reported higher sterility due to continuous shading. Nishiyama (1985) observed high correlation between grain yield and solar radiation during ripening phase. Krishnakumar (1986) and Vaithialingam (1986) reported that grain yield was directly proportional to the intensity of solar radiation received during reproductive or ripening phase. Patro and Sahu (1986) observed that exposure of plants to low light during vegetative phase had a low adverse effect while during reproductive phase low light drastically reduced the spikelet number per panicle and most of the differentiated spikelet were degenerated and during ripening phase low light impaired grain filling there by reducing grain numbers per panicle.

Thangaraj and Sivasubramanian (1993) reported that low light intensity from panicle initiation to harvest significantly reduced the number of panicles, number of spikelet per panicle, 1000 grain weight and 15.9 to 45.4 per cent grain yield reduction over control.

2.2.2.3 Grain yield

Moomav *et al.* (1967) established a strong correlation between grain yield and solar radiation in the last 30 days of the crop growth period. Mishra and Khan (1973) reported that an eight hour photo period in general reduced the 1000 grain weight.

Narayanasamy (1994) in a study reported that cumulative solar radiation and cumulative day length during vegetative phase had a positive influence on grain yield.

2.2.3 Effect of rainfall on growth and yield attributing characters

Variability of rainfall affects the rice crop at different stages. Chatterjee (1970) observed that in rainy season tillering continued up to 42-45 days where as in dry season it continued up to 50-55 days. High rainfall during active growth phase resulted in plants growing tall, lodge and decay in standing water. Under heavy rainfall conditions, panicles had shown large number of blank florets (Robertson, 1975). Moraes (1978) found that drought for a period of 5 to 10 days adversely affected the upland rice and caused severe damage at the reproductive and ripening stages.

Analysis of data on rainfall, number of rainy days and grain yield, Prabhakaran (1985) reported that rainfall during the first week after sowing (WAS) weakly and positively correlated with grain yield of cv Ptb 1 and Ptb 5. Correlation between grain yield of cv Ptb 1 and rainfall during the 8th WAS, number of rainy days during the 12th WAS and ripening was negative. Correlation between number of rainy days during the 7th WAS and yield was positive. For the cv Ptb 5, correlation between rainfall in the 11th WAS or early tillering and yield were negative.

Ajitha (1986) reported that in *kharif* season, rainfall was found to be the most important factor affecting rice yield and in *rabi* season, average rainfall during the third week after sowing had significant positive effect on rice yield.

In an analysis for the daily rainfall data of the Mapalana Meteorological Station for 35 consecutive years, Weerasinghe (1989) found that crop establishment should commence around 16th April and 10th September in the wet months of *yala* season (May and June) and rainy months of *yala* season (September and November) respectively. The rainfall availability in the period 1st to 15th April appeared to affect crop success, while dry conditions in October could delay *maha* season crop establishment until late October.

Shanker *et al.* (1992) found that upland rice could be cultivated during the years in which the rainy season started before the meteorological week 23 and that its cultivation should be restricted to low lands during years in which the rainy season stared after this dates.

Samui *et al.* (1998) reported that yield decreased with increase in total amount of rainfall during planting to maturity from 900 to 1100 mm. The yield appeared to remain more or less stationery as long as the total rainfall remained within 900 mm and decreased as the total rainfall exceeded 900 mm.

In a rainfall analysis for planning upland rice crop in Bihar plateau, Mishra *et al.* (1996) found that the sowing of varieties with a maturity period of 80-95 days should be completed in June, while varieties with shorter maturity periods (75-85 days) should be chosen for sowing later in the year.

2.2.4 Effect of relative humidity on growth and yield attributing characters

Rice crop requires a fairly high degree of humidity for proper growth (Ghosh, 1961). According to Sreedharan (1975) a relative humidity of 80 to 85 per cent was ideal for shoot and root growth. De Datta (1981) observed that rice required fairly high humidity for proper growth and flowering. Relative humidity showed a negative relationship with panicles per m^2, grains per m^2, filled grain percentage and grain yield, and a positive correlation with plant height at harvest (Krishnakumar, 1986).

From a correlation analysis between yield and weather parameters of *virippu* crop, Raghavan (1996) found that during nursery period, higher relative humidity favoured a better yield.

2.2.5 Effect of wind on growth and yield attributing characters

A gentle wind during the growing period is known to improve grain yield of rice as it increased turbulence in the canopy. Photosynthesis of the plant community increases with wind speed and the increase was mainly caused by the decrease in the boundary layer resistance near the leaf surface within the plant community (Yubuki *et al.*,1972).

According to Wordsworth (1959) photosynthesis of plant community increased with wind speed and wind speed greater than 0.3 to 0.9 m sec^{-1} had no further effect on increasing photosynthesis. At flowering time, strong wind caused sterility by desiccating the plant (Tsuboi, 1961). Strong wind after heading caused severe lodging and shattering in some rice varieties. Strong winds often desiccated the panicles of rice crop leading to increased spikelet sterility (De Datta and Zarate,1970). Sreelatha (1989) reported that higher wind speeds during the period from heading to ripening phase of late planted crops increased the spikelet sterility through higher evaporation rate and desiccation of the spikelets and this decreased the percentage of filled grains. Similar result was reported by Krishnakumar(1986). Vishambharan *et al.* (1989) also reported reduced grain yield due to the high wind speed during flowering and maturity phases.

2.2.6 Effect of weather on the incidence of pests and diseases

Weather conditions influence the various growth and development stages of a crop and indirectly, the incidence of pest and diseases (Yoshida and Parao,1976). A combination of cultural practices like early planting, synchronous planting, crop rotation and early maturing varieties protects the rice crop against most insect pests and diseases (Litsinger *et al.*,1987)

From experiments carried out at Indonesia, Suharto and Noch (1987) reported that the incidence of *Cnaphalocrocis medinalis* on late transplanted rice (2nd March) was lower than on early transplanted rice (30th December) or that transplanted on 30th January. The infestation by *Leptocorisa oratorius* was also highest on late transplanted rice.

Gutierrez *et al.* (1991) found that the population density of rice bug was highest from May to November, when the air temperature was between 25.2 and 27.7°C and relative humidity was 80 per cent and the population was lowest during the dry season. Bhatnagar and Saxena (1999) reported that rice gundhi bug (*Leptocorisa acuta*) had a significant negative correlation with minimum temperature, evening relative humidity and rainfall and a positive correlation with sunshine hours and maximum temperature. Path analysis revealed that minimum temperature played an important role in population build up of gundhi bug.

In a study conducted at Regional Research Station, Pattambi, Thomas *et al.*(1975) found that the percentage of silver shoots caused by *Orseolia oryzae* was positively correlated with rainfall and negatively correlated with maximum temperature, but fluctuations in relative humidity and minimum temperature appeared to have no effect. The earliness or lateness of planting affected gall midge incidence only indirectly, through the weather to which the plants and the insects were exposed as a result of planting at a particular time. Jena *et al.* (1983) observed that the infestation of silver shoots was positively correlated with rainfall in the preceding 15 days and 30 days, indicating a lag effect. Relative humidity had no lag effect. During the wet season at Raipur, Kalidas and Agarwal (1984) revealed that peak incidence of *Orseolia oryzae* on rice was observed in late October, when the crop was 100 days old and the optimum conditions for this pest were found to be maximum temperature of 30.1-32.1°C, minimum temperature of 20.8-24°C and 90 per cent relative humidity. Sundararaju (1986) in Goa assessed Cecidomyiid (*Orseolia oryzae*) and its impact on grain yield, and it was found that rice planted early (June) in the monsoon had a better chance of escaping infestation than late planted crops. Nambiar and Rao (1988) reported from a study conducted at RARS, Pilicode that gall midge incidence was high in the varieties Jaya and Allikkannan, transplanted during the third week of June and was low when transplanted during the second week of June.

Srinivasan (1977) reported that the incidence of rice sheath rot (*Sarocladium oryzae*) was extremely high on crops planted from mid June to mid August and control measures were necessary only for this first crop season. Singh *et al.* (1986) reported that sheath rot is becoming an important disease in rain fed low land rice, especially in delayed planting. Dhal and Choudhary (1987) reported that the disease incidence was high in delayed planting due to low temperature accompanied by low relative humidity during reproductive stage. Results of a two year experiment in Andhra Pradesh, Reddy *et al.* (2001) indicated that the incidence of sheath rot in rice caused by *Sarocladium oryzae* was more in the *kharif* than in *rabi* season. Correlation analysis showed that the relative humidity was positively correlated with disease index, whereas temperature and sunshine were negatively correlated. The influence of maximum relative humidity was significant on all the 22 trials, while that of the minimum temperature was significant for a few trials. The negative influence of minimum temperature was significant on all 22 trials, whereas that of maximum temperature and sunshine hours were significant in some trials only. Although disease development was observed at 50 per cent maximum relative humidity, it was rapid at above 80 per cent and slow between 60 - 80 per cent relative humidity.

Epidemiological studies conducted by Remadevi (1988) on major diseases of rice in Kuttanad during 1982-83 and 1983-84 revealed that sheath blight and sheath rot are the two serious diseases affecting rice both in *kharif* and *rabi* seasons. Correlation studies of weather parameters with sheath blight and sheath rot indicated that higher temperature significantly influenced the incidence of both these diseases. Occurrence of sheath blight was inversely correlated with rainfall. Correlation of sheath rot disease incidence with other weather parameters like relative humidity, rainfall and number of rainy days were not significant. Incidence of both these diseases were higher for October and November sowings. Wen and Qin (1995) reported that high temperature during May 1st to 5th and June 21st to 25th resulted in increased sheath blight disease index, but high temperature in July inhibited disease development. The disease index increased with increased relative humidity/ temperature value after June 20th when the rainy season began.

Bhatnagar and Saxena (1999) found that relatively higher number of leaf folder (*Cnaphalocrocis medinalis*) were trapped during October, with highest activity in the final week and they showed a significant negative correlation with minimum temperature, evening relative humidity and rainfall and a positive significant correlation with sunshine hours and maximum temperature. Path analysis revealed that sunshine hours and evening relative humidity were responsible for the population buildup of leaf folder.

2.3 Combined effect of weather parameters on growth, yield attributing characters and nutrient uptake

Tanaka and Vergara (1967) reported that during ripening period when solar radiation was not limiting, rice yield was negatively correlated with mean daily air temperature. Ghildayal and Jana (1967) found that the yield increased with decreasing relative humidity during reproductive phase. A low relative humidity of 43 per cent and a temperature range of 12 to 30°C were reported to be conducive for increased yield during grain formation stage.

The adverse temperatures acting either alone or through their interactions with day length and other factors during the period from sowing to floral initiation largely determined the potential number of florets per unit area. Suseqent conditions during the period from floral initiation to anthesis determined the proportion of florets producing seeds, and the conditions there after determined the efficiency of grain filling (Owen, 1971).

The relationship between weather parameters and rice yield was examined by Huda *et al.*(1975) using multiple regression techniques and found that above average weekly total rainfall was beneficial during the nursery period but had adverse effects during the vegetative phase and severe adverse effects during ripening. Above average maximum daily temperature was beneficial during the first three weeks of establishment and slightly detrimental during the next two weeks, then had an increasing adverse effect, which was greatest at maximum tillering and ear initiation and was still severe during flowering. A 1°C increase in average minimum daily temperature was beneficial during establishment and had a progressively increasing adverse effect through out flowering and ripening periods. Grain yields were decreased by increased maximum and minimum relative humidity and increased at low relative humidity.

In an analysis of yield and yield process in relation to specific weather situations Munakata *et al.*(1967) found that the yield process develops properly when the maximum and minimum temperatures were below 34°C and 22°C respectively and bright sunshine hours were more than 8 hours per day.

Murthy and Murthy (1980) in a study to find the spikelet sterility in rice varieties revealed that spikelet sterility depended on cultivar and weather conditions at the maturation stage and higher sterility in mid season cultivar was ascribed to the high rainfall and comparatively low solar radiation during the maturation stage, and in early cultivar to the high night temperature. In a correlation study between the height of two rice cultivar and weather elements at few stations in India, Shanker and Gupta (1981) observed statistically significant but negative correlations between the crop height and maximum, minimum and mean temperature and rainfall. Significant positive correlations were obtained between the crop height, evaporation and duration of sunshine.

In a study to find the influence of weather on growth and production of four rice varieties viz., Allikannan, Thonnooran, Jaya and IR-8 it was found that when planted during the first week of June, the local variety Alikkannan recorded higher yield than other varieties. When date of transplanting was delayed, considerable yield reduction was noticed in Alikkannan and Thonnooran. The high rainfall and relative humidity and low sunshine hours adversely affected the number of tillers of Allikkannan and Jaya. The total number of bright sunshine hours 45 days before harvest was found to have a profound influence on grain yields (Rao and Nair, 1986).

Shanker and Gupta (1988) derived a multiple linear regression equation to estimate and forecast rice yield using temperature, sunshine, rainfall, evaporation and yield data from some coordinated crop weather stations in Bihar and Orissa states.

Detailed correlation studies conducted by Sreelatha (1989) between grain yield and various weather elements observed that during vegetative growth period, maximum temperature and temperature range had a strong negative correlation whereas rainfall had a positive correlation. During reproductive stage, the relative humidity had a positive correlation whereas wind speed had a negative correlation. During grain filling stage, minimum temperature had a strong positive correlation and during maturity period, maximum temperature had a strong negative correlation. In a study conducted by Reddy and Reddy (1992) it was revealed that grain yield was negatively correlated with number of rainy days and humidity during the vegetative stage, and with maximum temperatures and humidity during the reproductive stage, but was positively correlated with sunshine hours during the pre and post flowering stages.

From a crop weather study conducted at the Regional Agricultural Research Station, Pattambi, Alexander *et al.* (1993) observed that yield of rice was profoundly affected by weather situation prevailed during the growth phases of rice. The influence of weather components was manifested more in the number of productive tillers per unit area, number of filled grains per panicles, sterility and weight of grains.

Rao (1993) in a study on the effect of weather variables on the yield performance of rice varieties observed that the effect of dates of planting on grain yield was remarkable and the decline in yield was as high as 44 percentage when the planting was delayed from 8th June to 20th July. He also observed that the variety Jaya was most susceptible to aberrations in weather and the total number of bright sunshine hours during 45 days before harvest had a positive influence on grain yield.

Matsui *et al.* (1997) reported that the fertility of spikelets, which flowered at 37.5^{0}C, was highest at 45 per cent relative humidity and lowest at 80 per cent relative humidity. Wind velocity above 0.85 ms^{-1} drastically decreased spikelet fertility at 37.5°C, mainly through reduction in the number of the pollen grain shed on stigma.

The nutrient uptake of rice is influenced by the various weather parameters prevailing during the growth season. Baba *et al.* (1953) observed an inhibition of salt absorption of rice plants at high temperature. The degree of inhibition of potassium was the highest among salts followed by phosphorus and nitrogen. Sato (1972) reported that the concentration of mineral element was increased with increase in temperature regime. The inhibition of nitrogen absorption was remarkable at 35°C day temperature and 30°C night temperature. Higher yields in rice cultivars were ascribed to the higher nitrogen uptake at the flowering stage (Sahu and Murty, 1975).

A negative response of potassium uptake to temperature and solar radiation was recorded by Krishnakumar and Subramanian (1991). Anilakumar and Menon (1992) observed that higher rainfall and higher flood water pH prevailed during *samba / thaladi* season induced greater utilization losses of NH_4^+-N in soil.

2.4 Effect of varieties on growth, yield attributing characters and incidence of pests and diseases

Sahu and Murty (1975) in a trial with six high yielding rice cultivars observed that nitrogen uptake in early maturing cultivars increased up to the primordial stage, while the reverse trend was observed in mid season cultivars. DMP at harvest was associated with paddy yields. The productivity per unit leaf area index and harvest index was high in early maturing cv Bala, while the highest yield in cv Jaya were ascribed to high 1000 grain weight, DMP and N uptake during the maturation stage.

Yoshida and Hara (1977) from trials with indica and japonica rice varieties revealed that optimum daily mean temperature to achieve maximum weight of grain was 19 to 25°C for the varieties IR 20 and 16 to 22°C for the varieties Fujiseka– 5.

Majumder and Pramanik (1979) in a study with 13 varieties and five mutants observed longer flowering period in photoperiod-insensitive varieties such as Marichbhati, Dular and IR8. They also observed that reduced rainfall during the vegetative period resulted in a little or no effect on the flowering period of photoperiod-sensitive varieties such as Rupsal and SR26B, resulting in inadequate grain filling. A large number of moist days during the ripening period of Ptb-1 varieties were found to exert a depressing effect on grain production (Prabhakaran, 1985).

Rosamma *et al.* (1994) revealed that the rice varieties Kairali (Ptb49) showed moderate to high levels of resistance to leaf and neck blast (*Magnaporthe grisea)*, sheath blight (*Rhizoctonia solani*), gall midge (*Orseolia oryzae*) and white backed plant hopper (*Sogatella furcifera*).

Kerala Agricultural University (KAU,1996) reported that the varieties Kanchana, Kairali and Ptb-10 were free from the incidence of gall midge and sheath blight and Kairali was free from the attack of leaf roller.

2.5 Effect of date of planting on growth, yield and yield attributing characters

It is now well established that within any season, long days and humid conditions with adequate rains or water supply help towards satisfactory vegetative growth of the rice plant while bright weather and short days with a diminishing supply of water favour flowering phase. Even a slight change in sowing time may substantially change yield and duration of rice crop.

Reduction in plant height in October planting was reported by Rajagopalan *et al.* (1973). In a study under taken to assess the inter-relationship between seasonal sowings and photoperiod, Mishra and Khan (1973) reported an inhibited tillering under short day treatment. Maximum tillering was recorded in February sown crop, which received heavy rains and high temperature.

In a study at Coimbatore Kempuchetty (1978) reported that February month planting recorded the maximum plant height followed by January 27th planting both at 60 and 75 DAS and there was steeper reduction in plant height for October and November planting at maturity. He also opined that tiller number per hill was significantly more in the 24th February planting and it was significantly low in 18th November, 2nd and 16th December planting. Minimum tillering occurred in August sown crop subjected to lower light intensity and temperature. Dixit and Singh (1980) reported that sowing on June 15th produced significantly higher grain yield as compared to sowing on July 25th during the *kharif* season of both 1975 and 1976. From the results of the experiment conducted at Thanjavoor it was revealed that sowing on June 6th gave a yield of 4036 kg ha^{-1} and yield was reduced when sown afterwards (MARC,1980).

From an experiment conducted at Pattambi with medium and short duration rice varieties, it was seen that all varieties gave maximum grain yield for sowing done on 3 rd of May during the *virippu* season. During *mundakan* season, all varieties gave poor yield when the nursery was raised in the 2nd week of October. During *puncha* season, sowing in the last week of December recorded highest grain yield. Sowing in the last week of January produced maximum grain yield for Jyothi. All other varieties gave good yields for earlier sowing (KAU,1980). Similar results were reported from an experiment conducted at Agricultural Research Station, Mannuthy,Kerala. (KAU, 1986).

In an experiment with two medium duration rice varieties Jaya and Sabari, Latif (1982) found that the time of planting at fortnightly intervals from September 25th to November 9th significantly influenced the crop growth at all stages of growth and delay in planting significantly reduced the plant height and tiller production. Early planting had a positive influence on yield and yield attributes. Delayed planting exhibited a decreasing trend on the number of total spikelets, filled grains, panicle length and number of branches per panicle. Total dry matter production, harvest index and grain yield showed a decreasing trend with delay in planting. Singh and Garg (1983) reported that the best time for direct seeding in Punjab is between May to first week of

June. Machhi *et al.* (1984) reported from a study at Navsariin in Gujarat that transplanting on June 20th recorded a high yield of 6.89 t ha^{-1}. Narayanasamy (1985) from a study at Thanjavoor reported a 22 per cent reduction in yield when planting was delayed by a fortnight from June 14th.

In field experiments with paddy seeds sown between 1st November and 15th December it was revealed that early sowing dates gave higher yields with older seedlings and late sowings gave higher yields with younger seedlings (Patel *et al.*, 1987).

Field trials conducted at Pattambi, Kerala, with four high yielding photo insensitive rice cultivars transplanted on seven dates between 22th August and 12th November, Viswambharan *et al.* (1989) revealed that the variations in yields between different transplanting dates were primarily due to the high spikelet sterility. Correlations of yields and spikelet sterility with weather factors showed that excessive wind velocity during flowering and maturation, low solar radiation and the occurrence of rainy days during maturation phase produced high spikelet sterility and low yields. Linear regression models were also developed by him to predict yields of the four cultivars in relation to these weather components.

Salam and Mackill (1993) in a study revealed that reductions in plant height, inter node number, flag leaf length, panicle length and grains per panicle were similar to the percentage reduction in days to flowering in the photoperiod sensitive lines at later sowing dates (i.e. shorter day length). The number of panicles per plant and spikelet sterility of photoperiod-sensitive lines increased under the latest sowing dates. Length of the last inter node, 100-grain weight and grain yield per plant were not affected by sowing dates or growth duration.

In experiments using the rice varieties Allikkannan at Pilicode, Rao (1994) found a drastic reduction in the number of days required for crop maturity when planted from early 8th June to late 20th July, which was to the tune of 8 days in 1984 to 27 days in 1987. The grain yield declined with late planting, which was 3.66 t ha^{-1} in June 8th planted crop whereas it was only 1.36 t ha^{-1} in July 20th planting.

Sinha and Chatterjee (1997) reported that lowland varieties sown after November exhibited significant varieties x sowing date interactions for flowering. They also reported that time taken to flowering decreased in successive sowings during November to January for rain fed low land rice varieties like IR42, Jaya and IR36. IR42 retained flowering synchrony under all three sowing dates.

The results of a field experiment in the *kharif* seasons of 1984 and 1985 at Ranchi, India with paddy revealed that delay in planting by 15 days, drastically affected tiller production, LAI and CGR of wetland rice. Timely planting (July 8-9) and correct plant protection were found essential for improving the growth variables responsible for high paddy yield (Ghosh and Singh, 1998).

According to Sunil (2000) crops planted on June 1st and 15th recorded the highest LAI in all growth stages except during beginning of grain filling stage. January 30th planting recorded lowest grain yield and straw yield.

2.6 Interaction effect of varieties and time of sowing

In a study on yield potential of some IRRI varieties under different dates of planting at Coimbatore, Rajagopalan *et al.* (1973) observed for the variety IR 20 the grain yields ranged from 4.17 to 7.78 t ha^{-1}, with the highest and lowest yields in April and October plantings, respectively. Yields of IR 22 showed similar trends of IR 20. The yield of IR 5 from the mid-October planting was 124 kg ha^{-1} and 8.28 t ha^{-1} from June-July plantings

Abdul Majid and Saeed Ahmad (1975) reported that the optimum planting date for Basmati (B) varietal series 197, 98 and 370 was June 16th, but B 197 could be transplanted between the beginning of May and the end of August, B 370 between mid-May and mid-July, and B 198 between mid-June and mid-July without much loss in yield.

In an experiment on the correlation co-efficient of plant characters on the yield of paddy cultivars Bhavani and IR 20, Ramadoss and Subramaniam (1981) observed that Bhavani was better than IR 20 for sowing in July, but IR 20 was better for sowing after mid August.

In a trial with 15 rice cultivars sown on July 11th, July 23rd or August 6th, Khan *et al.* (1990) reported that all cultivars except RWR 353, gave their highest yields when sown on 11th July. The cv. Tuljapur 1 gave the highest yield of 1.80 t ha^{-1} followed by cv. IET 7964 and IR 50 with a grain yield of 1.37-1.39 t ha^{-1}. The cultivar RWR 353 sown on 11th July and July 23rd gave yields of 0.29 and 0.84 t ha^{-1}, respectively.

Sinha and Chatterjee (1997) reported that lowland varieties sown after November exhibited significant varieties x sowing date interactions for flowering. They also reported that time taken to flowering decreased in successive sowings during November to January for rain fed low land rice varieties like IR 42, Jaya and IR 36. IR 42 retained flowering synchrony under all three sowing dates.

2.7 Crop weather models

Crop growth model is an effective tool for evaluating the consequences of different management strategies on its response to the environment leading to better crop production.

The models developed to forecast paddy yields of rice in Raipur district, Madhya Pradesh, using the yield data of 25 year and the weekly weather variables like maximum temperature, relative humidity, total rainfall and number of rainy days it was shown that the step-wise regression technique used to obtain the forecast equations at the 11th week (3rd week of August) after sowing was most suitable for forecasting rice yield (Agrawal *et. al.*,1980).

Mahajan and Rao (1981) made an attempt to study the behavior of occurrence of dry and wet days during the growth season of rice at Hyderabad and to determine the optimum sowing time by computing the weekly rainfall probabilities with the help of a Markov-chain model.

In a model for forecasting the yield of rice Agrawal and Jain (1982) observed that weather variables with time trend accounted for more than 70 per cent of the variation in yield at about 2.5 months before harvest, indicating that rice yield could be predicted from weather variables alone.

A dynamic model (SIMRIW) for simulating rice growth and yield in relation to weather and climate was developed by Horie (1991). The model did not predict the actual yield, but gave potential yield that may be expected under a given climate from the physiology of a given cultivar grown under optimal conditions.

In a new mathematical modelling approach to predict the local incidence of false smut in Punjab, Singh and Dhindsa (1993), could simulate the disease incidence and this could reduce the survey cost by 41.7 per cent. Yin (1994) reported that in a regression model the daily minimum temperature had a more significant effect on development than the daily maximum temperature.

According to Kropff *et a*l. (1995) the ORYZA 1 model was used to estimate rice potential production using daily weather data. Increasing CO_2 alone increased simulated yields but temperature increases of 1, 2 and 4°C decreased yield by 6.7, 14.1 and 29.4 per cent respectively.

A simulation study was conducted to assess the vulnerability of rice production in Bangladesh to potential climate change for high yielding rice cultivars at six locations for *Aus*, *Aman* and *Boro*, using the CERES-Rice model. Increased temperatures resulted in reduced yields at almost all locations and in all seasons, particularly pronounced with a 4°C increase (Karim *et al.*, 1996).

In a crop growth modelling for wetland rice at Ranchi it was identified that tiller number, LAI at flowering and CGR during panicle initiation to flowering are the major determinants of rice yield and a combination of growth variables explained variations in yield better than did any individual growth variable. The results further revealed that delay in planting by 15 days, 50 per cent reduction in fertilizer dose and minimum crop care drastically affected tiller production, LAI and CGR of wet land rice. Timely planting (July 8-9), adequate nutrition (100 kg N, 22 kg P and 25 kg K ha^{-1}) and computed plant protection were found essential for improving the growth variables responsible for high rice yield (Ghosh and Singh, 1998).

Materials and methods

MATERIALS AND METHODS

The present investigation was programmed as two experiments. The first experiment was to study the influence of weather parameters on the growth and yield of local and high yielding rice varieties. The experiment was carried out during three cropping seasons viz., *kharif*, *rabi* and *summer* with three times of planting in each season and this experiment was carried out at College of Agriculture, Vellayani, Thiruvananthapuram and Regional Agricultural Research Station (RARS), Pattambi, Palakkad. The second experiment was the correlation analysis of the data collected for a period of twenty five years (1960-1985) from a permanent manurial experiment at Regional Agricultural Research Station, Pattambi to develop the best fitting crop weather model using step wise regression

The details of materials used and methods adopted for the study are presented below.

Experiment I

3.1. Materials

3.1.1. Experimental site

The field experiments were conducted at the Instructional farm attached to the College of Agriculture, Vellayani in Kerala which, is located at 8.5^0N Latitude and 76.9^0E longitude and at an altitude of 29 m above mean sea level and at Regional Agricultural Research Station (RARS), Pattambi in Kerala, which is located at 10.48^0N Latitude and $76.12\,^0$E longitude and at an altitude of 25 m above mean sea level.

3.1.2 Soil

The soil of the experimental site both at Vellayani and Pattambi were sandy clay loam. The physico-chemical characteristics of the experimental site are presented in Table 1.

Table 1. Soil characteristics of the experimental site

Parameters	Unit	Content in soil						Method used
		Vellayani			Pattambi			
		Season			Season			
		I	II	III	I	II	III	
A.Mechanical composition								
Coarse sand	%	47.75	47.85	47.65	51.30	52.15	51.80	Bouyoucos Hydrometer method, (Bouyoucos, 1962)
Fine sand	%	10.65	11.85	10.95	6.65	6.75	6.95	
Silt	%	8.50	8.90	8.55	6.85	6.95	6.80	
Clay	%	32.60	31.05	32.40	34.70	33.80	34.10	
Texture		Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay loam	
B.Chemical properties								
Soil reaction (pH)		6.23	6.22	6.25	5.61	5.63	5.65	pH meter with glass electrode (Jackson,1973)
CEC	Cmol kg^{-1}	14.51	13.98	13.87	14.49	14.47	14.46	Ammonium saturation using neutral normal ammonium acetate (Jackson,1973)
Organic carbon	(%)	1.13	1.12	1.12	1.54	1.52	1.49	Walkley and Black's rapid Titration (Jackson,1973)
Available N	Kg ha^{-1}	305.25	316.07	309.25	245.35	250.25	240.65	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
Available P_2O_5	Kg ha^{-1}	27.35	25.45	26.35	15.75	17.95	16.65	Bray I method (Jackson,1973)
Available K_2O	Kg ha^{-1}	185.36	180.75	190.45	152.65	140.75	145.55	Ammonium acetate method (Jackson,1973)

3.1.3 Cropping history of the fields

The experimental fields at both locations were continuously cultivated with bulk crop of rice for the past few years.

3.1.4 Season

The experiment was conducted at the College of Agriculture, Vellayani during 1998 *kharif*, *rabi* and summer seasons and during the same seasons of 1999 at RARS, Pattambi

3.1.5 Weather conditions

The data on daily weather elements viz., maximum temperature (°C), minimum temperature (°C), relative humidity (%) (morning and afternoon), bright sunshine hours (day^{-1}), wind velocity (Kmh^{-1}), evaporation (mm) and rainfall (mm) were collected from the observatory attached to college of Agriculture, Vellayani and RARS, Pattambi. Weather condition was satisfactory for the proper growth and establishment of the crop. The data on weather parameters for the cropping period are given in Appendix 1a and 1b and graphically depicted in Figs1a and 1b.

3.1.6 Seeds materials

The rice varieties selected for the experiment viz., Thekkencheera (Ptb-10), Jyothi (Ptb-39), Matta Triveni (Ptb.45), Kairali (Ptb-49), Kanchana (Ptb-50) were released from RARS, Pattambi. Descriptions of the varieties are given in Table 2. The seeds for the study were obtained from RARS Pattambi.

3.1.7 Manures and fertilizers

Five tonnes ha^{-1} of cow dung and a fertilizer dose of 70:35:35 Kg NPK ha^{-1} was applied uniformly to all plots. Dry cow dung was having 0.35 per cent N, 0.60 per cent P_2O_5 and 0.24 per cent K_2O. N, P and K were applied as urea (46 per cent N), mussoriephos (20.5 per cent P_2O_5 and 0.1 per cent SO_4-S) and muriate of potash (60 per cent K_2O).

Fig.1a Weather parameters during the crop growth period-
Vellayani (1998 - 1999)

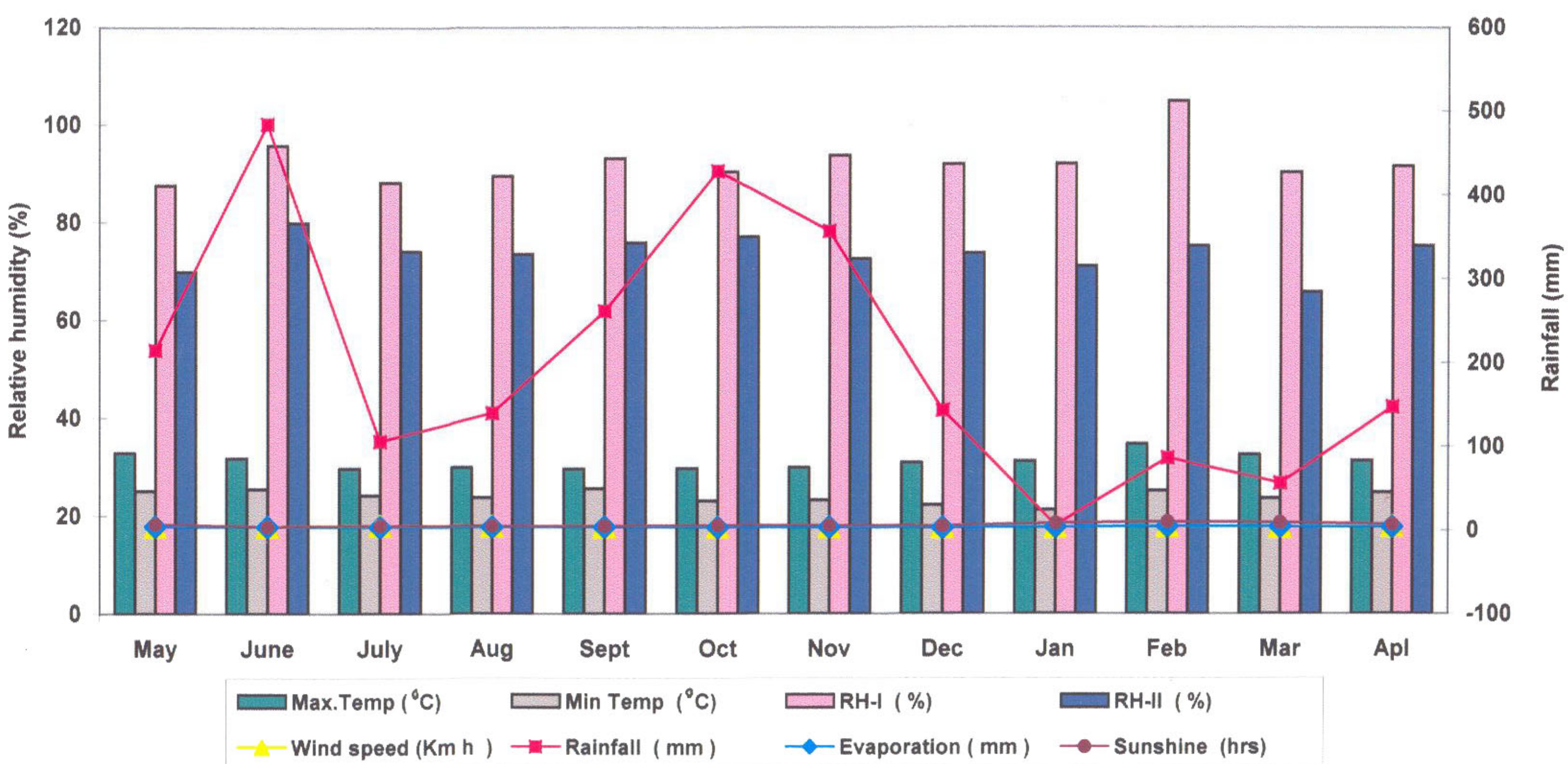
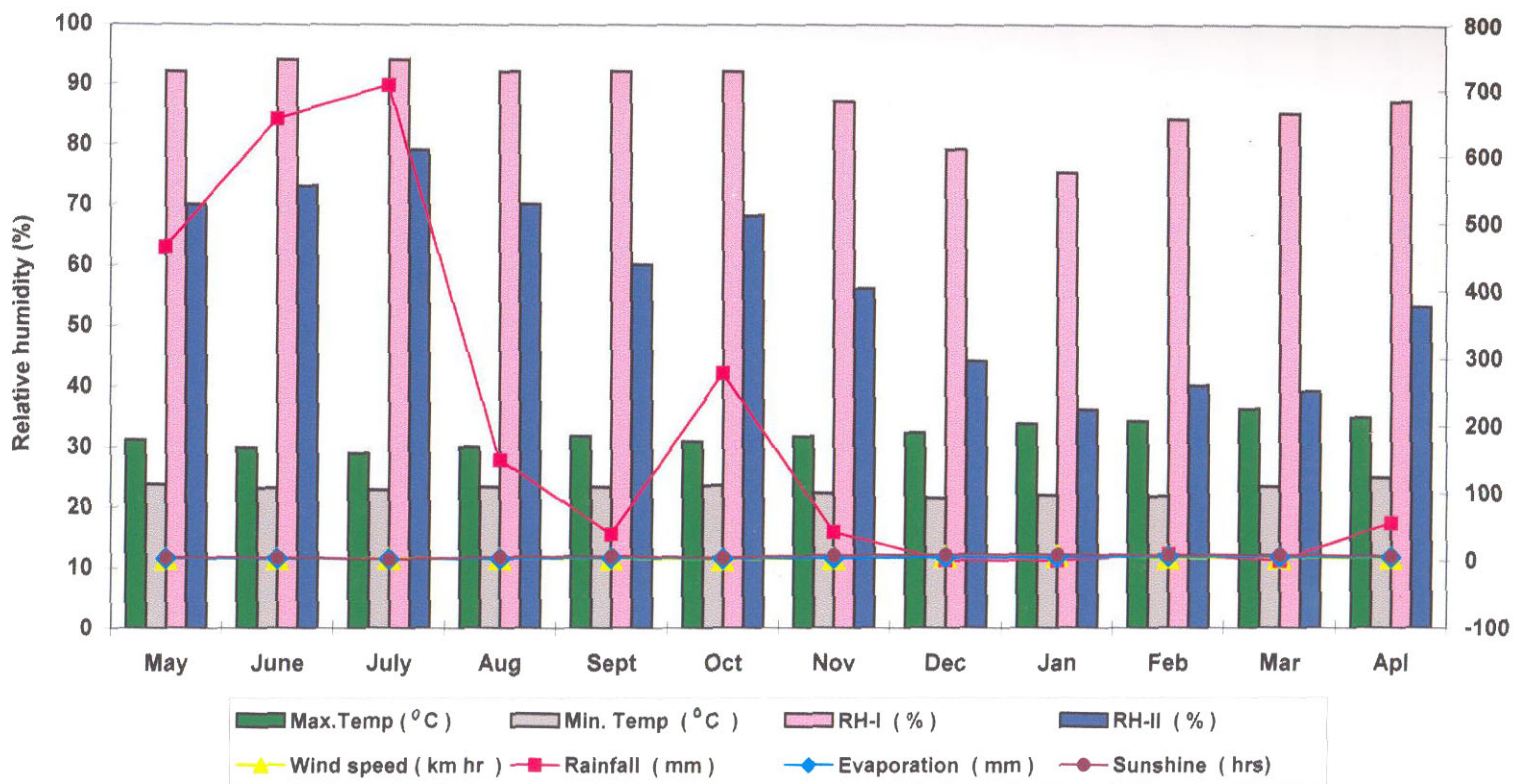


Fig.1 b Weather parameters during the crop growth period-
Pattambi (1999 - 2000)



Full dose of P and $^2/_3$ dose of N and $^1/_2$dose of K were applied as basal and $^1/_3$ dose of N and half dose of K as top dressing one week before panicle initiation.

3.2 Methods

3.2.1 Design and layout

The experiment was laid out in strip plot design at two locations viz., Vellayani and Pattambi. Fifteen treatment combinations were replicated thrice. The layout plan of the experiments is given in Fig. 2. The details of the layout are given below

Treatment combination	:	15
Number of plots per block	:	5
Plot size		
Gross	:	6 x 4.5 m^2
Net	:	4.8 x 4.1 m^2
Spacing	:	15 x 10 cm
Design	:	Strip Plot Design
Horizontal strip	:	Dates of transplanting
Vertical strip	:	Varieties
Replication	:	3
R I	:	Replication I
R II	:	Replication II
R III	:	Replication III

N

	Season I					Season II					Season III				
RI	d_1v_5	d_1v_3	d_1v_1	d_1v_4	d_1v_2	d_1v_2	d_1v_1	d_1v_3	d_1v_5	d_1v_4	d_1v_4	d_1v_2	d_1v_5	d_1v_1	d_1v_3
	d_3v_5	d_3v_3	d_3v_1	d_3v_4	d_3v_2	d_3v_2	d_3v_1	d_3v_3	d_3v_5	d_3v_4	d_3v_4	d_3v_2	d_3v_5	d_3v_1	d_3v_3
	d_2v_5	d_2v_3	d_2v_1	d_2v_4	d_2v_2	d_2v_2	d_2v_1	d_2v_3	d_2v_5	d_2v_4	d_2v_4	d_2v_2	d_2v_5	d_2v_1	d_2v_3
RII	d_2v_5	d_2v_3	d_2v_1	d_2v_4	d_2v_2	d_2v_2	d_2v_1	d_2v_3	d_2v_5	d_2v_4	d_2v_4	d_2v_2	d_2v_5	d_2v_1	d_2v_3
	d_1v_5	d_1v_3	d_1v_1	d_1v_4	d_1v_2	d_1v_2	d_1v_1	d_1v_3	d_1v_5	d_1v_4	d_1v_4	d_1v_2	d_1v_5	d_1v_1	d_1v_3
	d_3v_5	d_3v_3	d_3v_1	d_3v_4	d_3v_2	d_3v_2	d_3v_1	d_3v_3	d_3v_5	d_3v_4	d_3v_4	d_3v_2	d_3v_5	d_3v_1	d_3v_3
RIII	d_3v_5	d_3v_3	d_3v_1	d_3v_4	d_3v_2	d_3v_2	d_3v_1	d_3v_3	d_3v_5	d_3v_4	d_3v_4	d_3v_2	d_3v_5	d_3v_1	d_3v_3
	d_1v_5	d_1v_3	d_1v_1	d_1v_4	d_1v_2	d_1v_2	d_1v_1	d_1v_3	d_1v_5	d_1v_4	d_1v_4	d_1v_2	d_1v_5	d_1v_1	d_1v_3
	d_2v_5	d_2v_3	d_2v_1	d_2v_4	d_2v_2	d_2v_2	d_2v_1	d_2v_3	d_2v_5	d_2v_4	d_2v_4	d_2v_2	d_2v_5	d_2v_1	d_2v_3

Fig. 2 Layout of the experimental plot - Vellayani and Pattambi

Plate 1. General view of experiment (*virippu*) - Vellayani

Plate 2. General view of experiment (*virippu*) - Pattambi

Plate 3. General view of experiment (*mundakan*) - Vellayani

Plate 4. General view of experiment (*mundakan*) - Pattambi

Plate 5. General view of experiment (*puncha*) - Vellayani

Plate 6. General view of experiment (*puncha*) - Pattambi

Table.2. Varietal characteristics

Name of variety	Duration (days)	Bran colour, grain type	Characteristics
Kanchana (Ptb.50)	105 - 110	Red	Resistant to sheath blight, blast, stem borer and gall midge
Jyothi (Ptb.39)	110 - 115	Red, long bold	Moderately tolerant to brown plant hopper and blast, susceptible to sheath blight, excessive shedding of grains at maturity
Matta Triveni (Ptb.45)	100 - 105	Red, long bold	Susceptible to blast and sheath blight and tolerant to brown plant hopper
Kairali (Ptb.49)	110 - 115	Red	Resistant to blast, blight, gall midge, and leaf roller
Thekken cheera (Ptb.10)	90	Red, long bold	Resistant to sheath blight, blast, brown spot, tungro virus and to pests like stem borer, and gall midge

3.2.2 Treatments

Treatments included three dates of transplanting in three seasons and five varieties

Factor **A : Dates of transplanting**

Season I *(virippu)*

d_1 - 1st of June

d_2 - 15th of June

d_3 - 30th of June

Season II (*mundakan***)**

d_1 - 1st of October

d_2 - 15th of October

d_3 - 30th of October

Season III (*puncha***)**

d_1 - 1st of December

d_2 - 15th of December

d_3 - 30th of December

Factor B : Varieties

v_1. Kanchana (Ptb-50)

v_2 Jyothi (Ptb-39)

v_3. Matta Triveni (Ptb,45)

v_4. Kairali (Ptb-49)

v_5. Ptb-10

3.2.3 Treatment combinations

d_1v_1	d_1v_2	d_1v_3	d_1v_4	d_1v_5
d_2v_1	d_2v_2	d_2v_3	d_2v_4	d_2v_5
d_3v_1	d_3v_2	d_3v_3	d_3v_4	d_3v_5

3.2.4 Maintenance of the crop

Transplanting was done with a thin film of water in the field. Subsequently the water level was raised to 5 cm. Two hand weedings were done at all seasons at 20 and 45 days after transplanting

3.3 Observations

Observations on growth and yield parameters were recorded on randomly selected plants in each replication for each treatment after leaving the border rows. Growth observations were taken at different growth stages viz., transplantation, active tillering, panicle initiation, heading, beginning of grain filling and harvest

3.3.1 Growth characters of rice

3.3.1.1 Height of plants

Height of plants was recorded at 30, 60, and 90 days after transplanting (DAT). Twelve plants were selected diagonally from the sampling area for measuring the height. Height was measured from the base of the plant to the tip of the longest ear head or leaves whichever was taller.

3.3.1.2. Total number of tillers per hill^{-1}

Total number of tillers per unit area was recorded at 30 and 60 DAT and at harvest. Twelve hills were selected diagonally from the sampling area and tillers produced from each hill was counted and expressed as number of tillers per hill.

3.3.1.3. Leaf area index

Leaf area index at transplanting, active tillering, panicle initiation, heading, beginning of grain filling stages and harvest was recorded, using the formula suggested by Gomez (1972).

$$\text{LAI} = \frac{\text{K (L x B) x No. of leaves hill}}{\text{Land area occupied by the plant}}$$

Where

L - Leaf length (cm)

B - Maximum breadth of the leaf (cm)

K - 0.67 for seedling and harvest stages and 0.75 for all other stages

3.3.1.4 CGR

CGR between stages was worked out using the following relationship (Hunt,1982) and expressed in g m^{-2} day^{-1}

$$\text{CGR} = \frac{w_2 - w_1}{t_2 - t_1} \times \frac{1}{P}$$

Where w_2 and w_1 are dry weight of crops at time t_2 and t_1

3.3.1.5 RGR

RGR between stages was worked out using the following relationship (Blackman,1919) and expressed in g g^{-1} day^{-1}

$$\text{RGR} = \frac{\log_e w_1 - \log_e w_1}{t_2 - t_1}$$

Where w_2 and w_1 are dry weight of crops at time t_2 and t_1

3.3.1.6 Dry matter production

Dry matter production (DMP) of leaf, stem and total dry matter production(TDMP) were recorded at transplanting, active tillering, panicle initiation, heading, beginning of grain filling and harvest. The sample plants were dried at 70°C for 48 hours and weighed and expressed as kg ha^{-1}

3.3.1.7 Leaf number

Total number of leaves per hill was recorded at transplanting, active tillering, panicle initiation, heading, beginning of grain filling and harvest.

3.3.2 Yield and yield attributes

3.3.2.1 Days to 50 per cent flowering

Number of days from sowing the seeds until the date when approximately 50 per cent of the plants flowered were counted and recorded.

3.3.2.2 Days to physiological maturity

Number of days from sowing the seeds until the date when approximately 50 per cent of the plants reached physiological maturity were counted and recorded.

3.3.2.3 Number of panicles hill $^{-1}$

Number of panicles from twelve hills selected diagonally from the sampling area was counted before harvest. The mean panicle number per hill was then expressed as number of panicles m^{-2}.

3.3.2.4 Number of filled grains panicle $^{-1}$

The number of filled grains in ten panicles collected randomly from the sampling area in each plot was counted and the mean value was expressed as number of filled grains panicle $^{-1}$.

3.3.2.5 Grain chaff ratio

$$\text{Grain chaff ratio} = \frac{\text{Weight of dried grain}}{\text{Weight of chaff}}$$

3.3.2.6 Thousand grain weight

The weight of one thousand grains from the samples drawn from the cleaned produce from each plot was recorded in grams.

3.3.2.7 Yield of rice

3.3.2.7.1 Grain yield

The grains harvested from each net plot were cleaned, dried to 14 per cent moisture content, weighed and expressed as kg ha^{-1}.

3.3.2.7.2 Straw yield

The straw harvested from each net plot was dried to constant weight under sun and the weight was expressed as kg ha^{-1}

3.3.2.7.3 Harvest index

Harvest index was calculated using the formula,

$$\text{Harvest index (HI)} = \frac{\text{Economic yield}}{\text{Biological yield}}$$

3.4 Scoring of pest and diseases

3.4.1 Gall fly

The number of silver shoots in each observation unit of 1 x 0.5 m were recorded at active tillering and panicle initiation stages and expressed as the number of silver shoots m^{-2}

3.4.2 Leaf roller

Leaf roller incidence was recorded at active tillering, panicle initiation and heading stages. Ten hills were randomly selected from the plot and the total number of infected leaves from that hills were recorded and expressed as the number of damaged leaves hill $^{-1}$.

3.4.3 Rice bug

Sweep net count of rice bug was taken. Ten sweeps were made in each plot covering the maximum area by walking from one corner to the adjacent corner of the plot and expressed as the incidence of rice bug

3.4.4 Sheath blight and sheath rot

Ten hills were randomly selected from the plot and the total number of tillers and infected tillers per hill were recorded and per cent of infected tillers were worked out and expressed as per cent of infected tillers.

3.5 Chemical analysis.

3.5.1 Soil analysis

Composite soil samples were collected before planting, and continued at 30 days interval till harvest. The samples were analysed for pH,CEC and organic carbon content of soil.

3.5.2 Plant analysis

Plant samples collected at different growth stages and harvest were dried at 70°C separately in a hot air oven to constant weight, powdered and sieved. The biomass at different growth stages and grain and straw at harvest were analysed for nitrogen (modified microkjeldahl method), phosphorus (calorimetry triple acid digestion method)and potassium (flame photometry triple acid digestion method) Jackson (1973).

3.6 Statistical analysis

The data collected from the field experiments were subjected to scrutiny by employing the procedures of Panse and Sukhatme (1985). Wherever significant differences among treatments were observed, CD values at 5% level of significance were provided for effective comparison of means.

Experiment II

The yield data from a permanent manurial experiment at Regional Agricultural Research Station, Pattambi conducted for a period of 25 years (1960-1985) was collected. The weekly weather data for the crop season was also collected. Correlation analysis was done to identify the critical periods wherein the weather has significant influence. Prediction equations were developed using both linear and curvilinear regression analysis.

Results

RESULTS

The results of the investigation conducted for three seasons to study the influence of dates of transplanting on the growth and yield of rice varieties at two locations and the important findings of the correlation analysis of the data collected for a period of twenty five years (1960-1985) from a permanent manurial experiment at Regional Agricultural Research Station, Pattambi are presented in this chapter.

Experiment I

4.1 Experiment at Vellayani

4.1.1 Growth characters

4.1.1.1 Plant height (Table 3, 3a and 3b)

Season I

The main effect of dates of transplanting, varieties and their interactions were significant. However their interactions were consistent over various periods of observation. Late transplanting i.e on June 30th transplanting (d_3) showed a significant reduction in plant height. All the high yielding varieties registered a lesser plant height than local variety (Ptb-10) (v_5) in all dates of transplanting. However, no significant difference in plant height was seen among high yielding varieties except for a difference for Kanchana (v_1) on June 1st transplanting (d_1), which registered a significantly higher plant height than Jyothi (v_2) and Matta Triveni (v_3).

Season II

Dates of transplanting, varieties and their interactions significantly influenced the plant height. However these interactions were consistent over various periods of observation. Of all dates of transplanting and at all stages of observation local variety (v_5) showed increase in plant height. Among high yielding varieties, the following results were observed. At 30 DAT, the plant height of Kanchana (v_1) was significantly higher than that of Matta Triveni (v_3) for d_1 transplanting. No significant difference in plant height was observed when transplanted on June 15th (d_2) but, Kanchana (v_1) had significantly taller plants than remaining high yielding varieties when transplanted on June 30th (d_3). When observations were taken at 60 DAS and at harvest, Kairali (v_4) found taller than Matta Triveni (v_3) for June 1st transplanting (d_1) and Kanchana (v_1) found taller than Jyothi (v_2) when transplanted on d_2, while v_1 was the tallest variety when transplanted on June 30th (d_3).

Season III

Dates of transplanting, varieties and their interactions were significant and these interactions were consistent over various periods of observation. Of all dates of transplanting and at all stages of observation local variety (v_5) showed a marked increase in plant height. Among high yielding varieties at 30 DAS the plant height of Kanchana (v_1) was significantly higher than that of Matta Triveni (v_3) for June 1st (d_1) and June 30th (d_3) transplanting and no significant difference in plant height was observed among high yielding varieties when transplanted on d_2. When transplanted on d_1, v_1 was significantly taller than v_3 at 60 DAT and no significant difference in plant height was observed for d_2 and d_3 transplanting. At harvest v_4 was significantly taller than v_2 and v_3 for d_1 transplanting and, v_4 was significantly taller than other high yielding varieties for d_2 and for d_3 transplanting also, v_4 was reported to be taller than other high yielding varieties except v_1.

4.1.1.2. Total dry matter production (TDMP)

4.1.1.2.1 Total dry matter production at transplanting stage (Table 4)

Season I, II and III

Neither dates of transplanting nor did varieties produce any effect on TDMP at transplanting stage

4.1.1.2.2 Total dry matter production at active tillering stage (Table 5)

Season I

Varietal difference was seen. The varieties v_1, v_5 and v_4 were on par and registered more TDMP than v_2 and v_3, which were also on par.

Table 3 **Plant height (cm) as influenced by different dates of transplanting and varieties in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	73.86	71.22	70.42	72.37	104.69	78.51	D	0.295	1.157
d_2	72.36	70.75	72.56	72.11	104.64	75.40	V	0.252	0.823
d_3	68.86	67.92	67.94	68.64	95.94	72.55	DV	0.661	1.982
mean	71.69	69.96	70.31	71.04	101.76	75.49			
Season II									
d_1	76.64	74.11	73.33	75.67	104.61	80.87	D	0.283	1.112
d_2	72.83	69.50	70.92	70.89	98.00	75.40	V	0.379	1.235
d_3	71.69	65.33	65.72	67.00	102.67	72.55	DV	0.790	2.368
mean	73.72	69.65	69.99	71.19	101.76	76.27			
Season III									
d_1	66.94	65.81	63.78	67.11	94.92	71.71	D	0.425	1.668
d_2	65.00	64.89	65.56	67.33	97.78	72.11	V	0.421	1.373
d_3	64.75	63.19	63.72	65.14	96.67	70.69	DV	0.535	1.605
mean	65.56	64.63	64.35	66.53	96.46	71.51			

Table 3.a **Interaction effect of dates of transplanting and varieties on plant height (cm) at different growth stages during II nd season at Vellayani**

Varieties	dates of transplanting								
	d_1			d_2			d_3		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
v_1	54.83	83.67	89.00	50.33	83.50	85.17	50.67	81.08	83.33
v_2	52.33	82.67	87.33	49.83	79.33	79.33	47.00	74.00	75.00
v_3	49.50	82.00	88.50	47.25	80.33	82.00	46.17	74.67	76.33
v_4	52.67	85.33	91.42	50.33	80.33	84.67	47.00	76.67	77.33
v_5	71.50	120.00	122.33	69.00	109.67	115.33	67.67	114.00	136.33
Effect		SE			CD				
DVP		1.165			3.295				

Table 3.b Interaction effect of dates of transplanting and varieties on plant height (cm) at different growth stages during III rd season at Vellayani

Varieties	dates of transplanting								
	d_1			d_2			d_3		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
v_1	47.75	76.00	77.08	44.33	74.33	76.33	43.00	71.33	82.66
v_2	47.33	73.33	76.75	43.66	74.00	77.00	40.66	69.33	79.58
v_3	43.16	71.41	76.75	43.00	72.00	81.66	38.83	69.66	82.66
v_4	45.33	75.33	80.66	44.00	73.00	85.00	40.41	71.33	83.66
v_5	d_1	103.66	113.58	67.00	109.33	117.00	61.66	107.66	120.66
Effect			SE			CD			
DVP			1.145			3.239			

Table 4 Total dry matter production(g hill $^{-1}$) as influenced by different dates of transplanting and varieties at transplanting stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	2.13	1.83	2.00	1.86	1.88	1.94	D	0.022	-
d_2	1.85	1.96	1.91	1.88	1.82	1.89	V	0.020	-
d_3	1.89	1.79	1.82	1.96	1.99	1.89	DV	0.060	-
mean	1.96	1.86	1.91	1.90	1.90	1.91			
Season II									
d_1	1.99	1.94	1.87	1.89	1.77	1.89	D	0.020	-
d_2	1.81	1.77	1.88	1.87	1.83	1.83	V	0.030	-
d_3	1.93	1.84	1.87	1.85	1.87	1.87	DV	0.044	-
mean	1.91	1.85	1.87	1.87	1.82	1.86			
Season III									
d_1	1.87	1.88	1.90	1.85	1.82	1.86	D	0.020	-
d_2	1.84	1.93	1.99	2.07	1.95	1.96	V	0.026	-
d_3	1.94	2.13	1.88	1.89	1.80	1.93	DV	0.049	-
mean	1.88	1.98	1.92	1.94	1.86	1.92			

Season II

Dates of transplanting and varietal difference were found to influence TDMP. Maximum TDMP was obtained when planted on d_1 and minimum on d_3. Varieties v_5 and v_1 were on par and produced more TDMP than v_4, v_2 and v_3, which were also on par.

Season III

Total dry matter production was significantly influenced by dates of transplanting, varieties and their interactions. Transplanting on d_1 resulted in no significant difference between all varieties except v_2, which had recorded a lower TDMP. But when transplanted on d_2, v_5, v_1 and v_4 were on par and significant reduction in TDMP for v_3 was observed only in comparison with v_5. When transplanted on d_3, TDMP of v_5 was significantly higher than v_4, v_3 and v_2 but v_5 was on par with v_1, which was on par with v_4. v_3 and v_2 were also on par.

4.1.1.2.3 Total dry matter production at panicle initiation stage (Table 6)

Season I

Dates of transplanting and varieties significantly influenced the TDMP. Earlier transplanting (d_1) resulted in higher TDMP and no significant difference was observed between d_2 and d_3. Maximum TDMP was recorded by v_5, and minimum by v_3. v_4 and v_2 were on par, but their TDMP was significantly lesser than that of v_1.

Season II

Total dry matter production was significantly influenced by dates of transplanting, varieties and their interactions. Ptb-10 registered maximum and v_3 registered the minimum TDMP on all dates of transplanting. When transplanted on d_1, v_1 and v_4 were on par, but their TDMP were higher than that of v_2 and v_3. Ptb-10 followed by v_1 gave more TDMP

Table 5 **Total dry matter production(g hill $^{-1}$) as influenced by different dates of transplanting and varieties at active tillering stage in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	3.36	2.85	2.83	3.14	3.11	3.06	D	0.054	-
d_2	2.88	2.71	2.76	2.90	3.34	2.92	V	0.073	0.236
d_3	3.17	2.86	2.68	3.11	3.32	3.03	DV	0.156	-
mean	3.14	2.81	2.76	3.05	3.26	3.00			
Season II									
d_1	3.37	2.95	2.93	2.98	3.35	3.11	D	0.022	0.087
d_2	3.08	2.77	2.80	2.96	3.31	2.98	V	0.044	0.142
d_3	2.91	2.65	2.72	2.74	3.13	2.83	DV	0.077	-
mean	3.12	2.79	2.81	2.89	3.26	2.98			
Season III									
d_1	2.95	2.48	3.19	2.94	3.14	2.94	D	0.039	0.151
d_2	2.84	2.77	2.61	2.80	3.00	2.80	V	0.042	0.136
d_3	2.88	2.34	2.38	2.67	3.05	2.66	DV	0.077	0.231
mean	2.89	2.53	2.73	2.81	3.06	2.80			

Table 6 **Total dry matter production(g hill $^{-1}$) as influenced by different dates of transplanting and varieties at panicle initiation stage in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	6.38	5.80	5.50	6.13	6.61	6.08	D	0.037	0.146
d_2	5.73	5.47	4.91	5.35	6.13	5.52	V	0.053	0.171
d_3	5.60	5.45	4.84	5.47	5.91	5.45	DV	0.073	-
mean	5.91	5.57	5.09	5.65	6.22	5.69			
Season II									
d_1	6.17	5.82	5.40	6.11	6.51	6.00	D	0.052	0.203
d_2	5.90	5.64	5.39	5.55	6.22	5.74	V	0.053	0.173
d_3	5.91	5.48	5.07	5.50	6.05	5.60	DV	0.055	0.163
mean	5.99	5.65	5.29	5.72	6.26	5.78			
Season III									
d_1	5.78	5.20	4.69	5.67	6.12	5.49	D	0.089	0.289
d_2	5.50	5.00	4.88	5.10	6.00	5.30	V	0.101	0.330
d_3	5.42	4.85	4.51	5.29	5.92	5.20	DV	0.051	-
mean	5.57	5.02	4.70	5.35	6.01	5.33			

than v_2, v_4 and v_3 for d_2 transplanting and the TDMP of v_2 was significantly higher than that of v_3. No significant difference in TDMP was seen between v_5 and v_1 when transplanted on d_3 but significantly higher than that of the remaining varieties. Jyothi and Kairali also did not differ in their TDMP and the least value was registered by v_3.

Season III

Dates of transplanting and varieties significantly influenced the TDMP. Late transplanting was found to result in low TDMP. On all dates of transplanting v_5 registered maximum TDMP, followed by v_1, and v_4. Lowest TDMP was registered by v_3 and it was on par with v_2.

4.1.1.2.4 Total dry matter production at heading stage (Table7)

Season I

Only varietal difference was seen. Maximum TDMP was registered by v_5 and minimum by v_3. Among high yielding varieties, v_1 recorded higher TDMP in comparison with v_3.

Season II

Varieties and its interaction with dates of transplanting significantly influenced the TDMP at this stage. On all dates of transplanting maximum TDMP was registered by v_5 and minimum by v_3. Transplanting on d_1 gave high TDMP for v_1 among the high yielding varieties and v_2 and v_4 were on par. Transplanting on d_2 resulted in no significant difference between v_1 and v_4. The variety v_3 registered a significantly lower TDMP than other varieties. Transplanting on d_3 gave highest TDMP for v_1 and lowest for v_3.

Season III

Varieties and its interaction with dates of transplanting significantly influenced the TDMP at this stage. Maximum TDMP was recorded by v_5 and minimum by v_3 on all dates of transplanting. Transplanting on d_1 gave more TDMP for v_1 in comparison with v_2 and v_3 and the varieties v_4 and v_2 were on par. For d_2 transplanting, v_1 and v_4 were on par. When transplanted on d_3, v_1 registered higher TDMP than remaining high yielding varieties of which v_2 and v_4 were on par.

4.1.1.2.5 Total dry matter production at beginning of grain filling stage (Table 8)

Season I

Total dry matter production was significantly influenced by varieties and its interactions with dates of transplanting . Maximum TDMP was registered by v_5 and minimum by v_3 on all dates of transplanting. No significant difference was observed between v_4 and v_2 when transplanted on d_1, but TDMP was significantly higher than v_3 but less than v_1. When transplanted on d_2, v_1 and v_4 was on par and reported a significantly higher value than v_2. Transplanting on d_3 recorded an insignificant difference in TDMP among v_1, v_2 and v_4.

Season II

Varieties and its interaction with dates of transplanting significantly influenced the TDMP at this stage. Maximum TDMP was recorded by v_5 and minimum by v_3 on all dates of transplanting. When transplanted on d_1, v_1 gave more TDMP than the remaining high yielding varieties of which v_2 and v_4 were on par. But on d_2, v_1 and v_4 were on par and were significantly higher than that of v_3 and v_2. When transplanted on d_3, v_1 had a higher TDMP than other varieties in comparison with v_2 and v_3.

Season III

Only varietal difference was seen. Maximum TDMP was reported in v_1 and it was on par with v_4 and minimum TDMP was registered by v_5. TDMP of v_3 and v_2 were on par.

4.1.1.2.6 Total dry matter production at harvest (Table 9)

Season I

Dates of transplanting, varieties and their interactions significantly influenced the TDMP. Earlier transplanting resulted in higher TDMP and the lowest TDMP was produced by d_3. On all dates of transplanting v_1 produced higher TDMP and was on par with v_4. No significant difference was observed between v_4 and v_2. Local variety recorded the lowest TDMP and it was on par with v_2 and v_3 on d_3.

Table 7 **Total dry matter production(g hill^{-1}) as influenced by different dates of transplanting and varieties at heading stage in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	8.26	7.98	7.42	7.96	8.98	8.12	D	0.370	-
d_2	8.08	8.00	7.42	7.84	8.72	8.01	V	0.071	0.231
d_3	8.04	7.87	7.34	8.03	9.07	8.07	DV	0.083	-
mean	8.13	7.95	7.39	7.95	8.92	8.07			
Season II									
d_1	8.13	7.64	6.91	7.64	8.88	7.84	D	0.064	-
d_2	7.75	7.49	7.33	7.74	9.16	7.89	V	0.048	0.061
d_3	8.05	7.42	6.74	7.71	8.99	7.78	DV	0.104	0.079
mean	7.98	7.52	6.99	7.70	9.01	7.84			
Season III									
d_1	7.29	7.01	6.42	7.07	8.46	7.25	D	0.026	
d_2	7.26	7.01	6.62	7.08	8.27	7.25	V	0.061	0.200
d_3	7.56	7.21	6.68	7.16	8.09	7.34	DV	0.079	0.237
mean	7.37	7.07	6.57	7.10	8.27	7.28			

Table 8 **Total dry matter production(g hill^{-1}) as influenced by different dates of transplanting and varieties at beginning of grain fillingstage in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	8.47	8.03	7.74	8.10	9.09	8.29	D	0.055	-
d_2	8.19	7.88	7.55	8.17	8.84	8.12	V	0.059	0.191
d_3	8.09	7.95	7.42	8.14	9.20	8.16	DV	0.078	0.234
mean	8.25	8.05	7.57	8.04	9.04	8.19			
Season II									
d_1	8.08	7.65	6.92	7.49	8.89	7.80	D	0.063	-
d_2	7.84	7.58	7.39	7.83	9.18	7.96	V	0.041	0.082
d_3	8.12	7.50	6.81	7.79	9.10	7.86	DV	0.110	0.116
mean	8.01	7.57	7.04	7.70	9.06	7.88			
Season III									
d_1	7.61	7.27	6.78	7.25	8.20	7.42	D	0.057	-
d_2	7.34	7.06	6.67	7.12	8.73	7.38	V	0.082	0.269
d_3	7.38	7.02	6.49	7.16	8.52	7.31	DV	0.116	-
mean	7.45	7.12	6.64	7.18	8.48	7.37			

Season II

Dates of transplanting, varieties and their interactions significantly influenced the TDMP. Transplanting on d_1 resulted in higher TDMP and lowest was recorded by d_3. On all dates of transplanting v_1 registered higher TDMP and it was on par with v_4. Kairali was on par with v_2 and v_3 on d_1 transplanting. On d_2 and d_3 lower TDMP was registered by v_5 which was on par with v_3.

Season III

Only varietal difference was seen. Maximum TDMP was registered by v_1 and it was on par with v_4. Minimum TDMP was registered by v_5.

4.1.1.3 Dry matter production (DMP) of leaf

4.1.1.3.1 Dry matter production of leaf at transplanting stage (Table 10)

Seasons I, II and III

Neither dates of transplanting nor varieties significantly influenced the DMP of leaf at this stage.

4.1.1.3.2 Dry matter production of leaf at active tillering stage (Table 11)

Season I

Only varietal difference was observed. DMP of leaf was high for v_1 and low for v_5 and v_3, which were on par. The varieties v_4 and v_2 also were on par.

Season II

Dry matter production of leaf was significantly influenced by dates of transplanting and varieties. Transplanting on d_1 gave maximum and d_3 gave minimum DMP of leaf. v_1, v_4 and v_3 were on par and had more DMP of leaf than v_2 and v_5. Local variety recorded lowest DMP of leaf.

Season III

Dates of transplanting, varieties and their interactions significantly influenced the DMP of leaf. When transplanted on d_1, maximum DMP of leaf was observed for v_1. v_4 and v_3 were

Table 9 Total dry matter production(g $hill^{-1}$) as influenced by different dates of transplanting and varieties at harvest in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	32.92	30.20	28.54	31.27	23.50	29.29	D	0.319	1.251
d_2	31.53	29.10	27.99	30.53	22.72	28.37	V	0.562	1.835
d_3	25.38	23.28	22.78	24.91	21.94	23.66	DV	0.656	1.951
mean	29.94	27.53	26.44	28.90	22.72	27.11			
Season II									
d_1	28.29	26.20	25.85	27.45	22.58	26.07	D	0.256	0.207
d_2	27.73	25.11	22.91	25.76	21.78	24.66	V	0.316	0.438
d_3	25.49	23.30	22.81	24.84	22.02	23.69	DV	0.697	2.073
mean	27.17	24.87	23.86	26.02	22.13	24.81			
Season III									
d_1	26.45	24.20	23.09	25.95	21.70	24.28	D	0.232	-
d_2	25.26	24.36	22.53	25.59	21.88	23.92	V	0.438	1.430
d_3	25.47	23.16	23.81	25.17	21.39	23.80	DV	0.555	-
mean	25.73	23.91	23.14	25.57	21.66	24.00			

Table10 Dry matter production of leaf (g $hill^{-1}$)as influenced by different dates of tranplanting and varieties at transplanting stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.0277	0.0277	0.0237	0.0270	0.0243	0.0261	D	0.00102	-
d_2	0.0270	0.0273	0.0250	0.0273	0.0240	0.0261	V	0.00108	-
d_3	0.0277	0.0277	0.0237	0.0277	0.0243	0.0262	DV	0.00155	-
mean	0.0274	0.0276	0.0241	0.0273	0.0242	0.0261			
Season II									
d_1	0.0277	0.0277	0.0237	0.0277	0.0243	0.0262	D	0.00077	-
d_2	0.0273	0.0277	0.0243	0.0277	0.0237	0.0261	V	0.00122	-
d_3	0.0270	0.0273	0.0240	0.0273	0.0240	0.0259	DV	0.00158	-
mean	0.0273	0.0276	0.0240	0.0276	0.0240	0.0261			
Season III									
d_1	0.0280	0.0280	0.0240	0.0280	0.0240	0.0264	D	0.00067	-
d_2	0.0273	0.0273	0.0243	0.0273	0.0247	0.0262	V	0.00066	-
d_3	0.0280	0.0280	0.0240	0.0280	0.0240	0.0264	DV	0.00114	-
mean	0.0278	0.0278	0.0241	0.0278	0.0242	0.0263			

on par and had higher DMP of leaf than v_5 and v_2, which were also on par. When transplanted on d_2 minimum DMP of leaf was recorded by v_5 and highest by v_1, which were on par with v_2 and v_4. Transplanting on d_3 resulted in an insignificant difference among v_1, v_2 and v_4 but the DMP of leaf of v_1, v_2 and v_4 were significantly higher than v_5 and v_3, v_3 being the variety having lowest DMP of leaf.

4.1.1.3.3 Dry matter production of leaf at panicle initiation stage (Table 12)

Season I

Dates of transplanting, varieties and their interactions significantly influenced the DMP of leaf. When transplanted on d_1 high DMP of leaf was reported by v_1 and v_4 but significantly higher than that of v_2, v_3 and v_5. DMP of leaf of v_5 was significantly lower than v_2. Transplanting on d_2 also gave higher DMP of leaf for v_1 followed by v_2, which was significantly higher than that of v_5. Transplanting on d_3 gave more or less similar DMP of leaf for v_1, v_2 and v_4 but DMP of leaf of v_1 and v_2 were significantly higher than that of v_3. The lowest DMP of leaf was recorded by v_5.

Season II

DMP of leaf was significantly influenced by dates of transplanting, varieties and their interactions. Early transplanting gave better DMP of leaf. No significant difference between d_2 and d_3 was observed. When transplanted on d_1 maximum DMP of leaf was recorded by v_1 and minimum by v_5, which was on par with v_3. DMP of leaf of v_4 as higher than that of v_3 and v_5. When transplanted on d_2, v_1, v_2 and v_3 were on par but DMP of v_1 and v_2 were significantly higher than that of v_4 and v_5. v_2, v_1 and v_4 were on par and had higher DMP of leaf than v_3 and v_5, which were also on par when transplanted on d_3.

Season III

Only main effects were significant. Transplanting on d_1 gave higher DMP of leaf and d_2 and d_3 were on par. Higher DMP of leaf was recorded by v_1 and v_4, which were on par in comparison with v_2, v_3 and v_5, which were also on par.

Table 11 Dry matter production of leaf (g hill^{-1}) as influenced by different dates of transplanting and varieties at active tillering stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.033	0.957	0.903	0.943	0.873	0.942	D	0.0297	-
d_2	1.147	0.880	0.660	0.860	0.660	0.841	V	0.0237	0.0773
d_3	1.017	0.847	0.820	0.983	0.827	0.899	DV	0.0431	-
mean	1.066	0.894	0.794	0.929	0.787	0.894			
Season II									
d_1	1.170	0.953	1.013	1.143	0.877	1.031	D	0.0097	0.0066
d_2	1.053	0.857	0.970	0.920	0.783	0.917	V	0.0283	0.0129
d_3	0.933	0.803	0.887	0.877	0.857	0.871	DV	0.0652	-
mean	1.052	0.871	0.957	0.980	0.839	0.940			
Season III									
d_1	1.073	0.727	0.973	0.920	0.770	0.893	D	0.0066	0.0259
d_2	0.953	0.937	0.867	0.907	0.723	0.877	V	0.0129	0.0420
d_3	0.973	0.953	0.637	0.910	0.773	0.849	DV	0.0254	0.0763
mean	0.967	0.812	0.859	0.912	0.816	0.873			

Table 12 Dry matter production of leaf (g hill^{-1}) as influenced by different dates of transplanting and varieties at panicle initiation stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	2.02	1.85	1.78	1.99	1.68	1.86	D	0.027	0.104
d_2	1.75	1.62	1.54	1.52	1.44	1.57	V	0.023	0.076
d_3	1.71	1.74	1.59	1.68	1.43	1.63	DV	0.037	0.110
mean	1.82	1.74	1.64	1.73	1.52	1.69			
Season II									
d_1	2.24	1.85	1.75	1.91	1.64	1.88	D	0.020	0.024
d_2	1.81	1.75	1.73	1.63	1.59	1.70	V	0.037	0.030
d_3	1.78	1.81	1.57	1.70	1.48	1.67	DV	0.037	0.067
mean	1.84	1.80	1.68	1.86	1.57	1.75			
Season III									
d_1	1.83	1.66	1.62	1.71	1.50	1.66	D	0.024	0.094
d_2	1.64	1.43	1.48	1.73	1.39	1.54	V	0.030	0.099
d_3	1.69	1.55	1.42	1.49	1.45	1.52	DV	0.067	-
mean	1.72	1.54	1.51	1.64	1.45	1.57			

4.1.1.3.4 Dry matter production of leaf at heading stage (Table 13)

Season I

Varieties and its interaction with dates of transplanting were found to influence DMP of leaf. Transplanting on d_1 and d_2 gave low DMP of leaf for v_5. No significant difference was observed for high yielding varieties for d_1, but had significantly higher values than v_5. When transplanted on d_2, DMP of leaf of v_1 was significantly higher than v_2, v_3 and v_4 which were on par. For d_3 transplanting v_4 gave significantly higher DMP of leaf than v_2 and v_3 while DMP of leaf of v_1 was significantly higher than v_3.

Season II

Both the main effects and their interactions were significant on all dates of transplanting and lowest DMP of leaf was recorded by v_5. Transplanting on d_1 and d_3 gave high DMP of leaf for v_1 and v_4. More DMP of leaf was recorded by v_3 and v_2 compared to v_5. Kanchana registered maximum DMP of leaf on d_2. v_4, v_3 and v_2 were on par but registered significantly higher DMP of leaf than v_5.

Season III

Only main effects were significant. Transplanting on d_1 and d_2 resulted in more or less similar DMP of leaf, but higher than d_3. Kanchana had higher DMP of leaf than v_3, v_2 and v_5 while DMP of leaf of v_4 was significantly higher than that of v_5.

4.1.1.3.5 Dry matter production of leaf at beginning of grain filling stage (Table 14)

Season I

Dates of transplanting, varieties and their interactions significantly influenced the DMP of leaf. All the high yielding varieties were on par and registered high DMP of leaf than v_5 for d_1 transplanting. When transplanted on d_2 maximum DMP of leaf was recorded by v_1 and minimum by v_5. No significant difference was observed between v_2, v_3 and v_4 with respect to DMP of leaf but they were significantly lesser than v_1 and higher than v_5. When transplanted on d_3, v_1 registered a high DMP of leaf than v_2 and v_3.

Season II

Dates of transplanting, varieties and their interactions significantly influenced the DMP of leaf. On all dates of transplanting higher DMP of leaf was observed for v_1 and v_4, which were on par and significantly higher than other varieties. v_3 and v_2 were also on par and significantly higher than v_5.

Season III

Only varietal difference was seen. The varieties v_1, v_3 and v_4 were on par and DMP of leaf of v_1 and v_3 were significantly higher than that of v_2 and v_5.

4.1.1.3.6 Dry matter production of leaf at harvest (Table 15)

Season I

DMP of leaf was significantly influenced by dates of transplanting, varieties and their interactions. Transplanting on d_1 gave high DMP of leaf for v_1, v_4 and v_2, which were on par but higher than that of v_3 and v_5, which were also on par. Transplanting on d_2 give high DMP of leaf for v_1 in comparison with v_2, v_3 and v_5 while DMP of v_4 was higher than that of v_3 and v_5. When transplanted on d_3 maximum DMP of leaf was registered by v_1 and was significantly higher than that of remaining varieties. Higher DMP of leaf was registered by v_4 compared to v_3, v_2 and v_5, while that of v_5 was significantly lower than other varieties.

Season II

Only varietal difference was seen. More or less similar DMP of leaf was registered by v_1, v_4 and v_2 but recorded higher value than v_3 and v_5, which were also on par.

Season III

DMP of leaf was significantly influenced by dates of transplanting, varieties and their interactions. On all dates of transplanting, maximum DMP of leaf was recorded by v_1. No significant difference between v_4, v_2 and v_3 were observed on all dates of transplanting. Lowest DMP was recorded by v_5. But it was on par with v_2 when transplanted on d_2 and d_3.

Table 13 Dry matter production of leaf (g hill^{-1}) as influenced by different dates of transplanting and varieties at heading stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	2.95	2.91	2.88	2.91	2.73	2.88	D	0.013	-
d_2	3.02	2.85	2.88	2.87	2.63	2.85	V	0.032	0.104
d_3	2.96	2.86	2.83	2.98	2.87	2.90	DV	0.037	0.111
mean	2.98	2.88	2.86	2.92	2.74	2.88			
Season II									
d_1	3.11	2.66	2.74	3.03	2.31	2.77	D	0.020	0.019
d_2	2.86	2.64	2.65	2.71	2.33	2.64	V	0.055	0.035
d_3	2.88	2.59	2.65	2.79	2.27	2.64	DV	0.044	0.060
mean	2.88	2.63	2.75	2.84	2.30	2.68			
Season III									
d_1	2.71	2.49	2.60	2.57	2.27	2.53	D	0.019	0.076
d_2	2.71	2.36	2.47	2.60	2.41	2.51	V	0.035	0.113
d_3	2.60	2.44	2.37	2.41	2.29	2.42	DV	0.060	-
mean	2.67	2.43	2.48	2.53	2.32	2.49			

Table 14 Dry matter production of leaf (g hill^{-1})as influenced by different dates of transplanting and varieties at beginning of grain filling stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	2.90	2.85	2.83	2.86	2.69	2.83	D	0.011	0.042
d_2	2.96	2.80	2.80	2.80	2.57	2.79	V	0.028	0.091
d_3	2.93	2.79	2.78	2.89	2.82	2.84	DV	0.039	0.116
mean	2.91	2.82	2.80	2.87	2.69	2.82			
Season II									
d_1	3.04	2.60	2.68	2.88	2.23	2.68	D	0.023	0.047
d_2	2.81	2.50	2.54	2.71	2.24	2.56	V	0.056	0.052
d_3	2.79	2.58	2.57	2.65	2.25	2.57	DV	0.054	0.102
mean	2.81	2.56	2.67	2.75	2.24	2.60			
Season III									
d_1	2.65	2.40	2.53	2.49	2.21	2.46	D	0.047	-
d_2	2.54	2.36	2.64	2.36	2.20	2.42	V	0.052	0.169
d_3	2.64	2.24	2.40	2.50	2.34	2.42	DV	0.102	-
mean	2.61	2.33	2.52	2.45	2.25	2.43			

4.1.1.4 Dry matter production (DMP) of stem

4.1.1.4.1 Dry matter production of stem at transplanting stage (Table 16)

Season I, II and III

Neither dates of transplanting nor could varieties produce any effect on DMP of stem.

4.1.1.4.2 Dry matter production of stem at active tillering stage (Table17)

Season I

Transplanting on d_1 resulted in significantly higher DMP of stem for v_4 and v_1 against v_3. DMP of stem of v_2 was also significantly lesser than that of v_4 but 15th transplanted varieties showed a higher DMP of stem for v_1 in comparison with other high yielding varieties, v_4 also reported a high DMP of stem value than v_2. Transplanting on d_3 resulted in high DMP of stem for v_4 in comparison with v_3.

Season III

Only varietal difference was observed. Maximum DMP of stem was recorded for local variety. Among high yielding varieties, v_1 registered high DMP of stem and was on par with v_4 and v_3 and significantly superior to v_2.

4.1.1.4.3 Dry matter production of stem at panicle initiation stage (Table 18)

Season I

DMP of stem was significantly influenced by dates of transplanting and varieties. Early transplanting resulted in high DMP of stem. Maximum DMP of stem was observed for local variety on all dates of transplanting and among high yielding varieties, maximum DMP of stem was registered for v_1 and minimum for v_3. v_4 and v_2 were on par.

Season II

Dates of transplanting, varieties and their interactions significantly influenced DMP of stem. Local variety recorded high DMP of stem on all dates of transplanting. Among high

Table 15 Dry matter production of leaf (g $hill^{-1}$) as influenced by different dates of transplanting and varieties at harvest in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.68	1.53	1.30	1.63	1.12	2.46	D	0.052	0.204
d_2	1.75	1.51	1.33	1.66	1.18	2.42	V	0.066	0.217
d_3	1.87	1.02	1.06	1.42	0.80	2.42	DV	0.066	0.199
mean	1.77	1.35	1.23	1.57	1.03	2.43			
Season II									
d_1	1.87	1.69	1.74	2.35	1.45	1.82	D	0.064	-
d_2	1.69	1.82	1.36	1.78	1.31	1.59	V	0.058	0.113
d_3	2.18	1.76	1.16	1.48	1.35	1.59	DV	0.165	-
mean	1.91	1.76	1.42	1.87	1.37	1.67			
Season III									
d_1	2.87	1.78	1.95	1.78	1.30	1.94	D	0.008	0.031
d_2	2.35	1.69	1.74	1.87	1.45	1.82	V	0.113	0.367
d_3	2.35	1.69	1.74	1.87	1.45	1.82	DV	0.092	0.275
mean	2.53	1.72	1.81	1.84	1.40	1.86			

Table 16 Dry matter production of stem (g $hill^{-1}$) as influenced by different dates of transplanting and varieties at transplanting stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.0437	0.0437	0.0440	0.0460	0.0443	0.0443	D	0.00249	-
d_2	0.0457	0.0440	0.0450	0.0440	0.0430	0.0443	V	0.00102	-
d_3	0.0433	0.0450	0.0447	0.0430	0.0423	0.0437	DV	0.00265	-
mean	0.0442	0.0442	0.0446	0.0443	0.0432	0.0441			
Season II									
d_1	0.0440	0.0453	0.0440	0.0443	0.0427	0.0441	D	0.00209	-
d_2	0.0433	0.0450	0.0420	0.0447	0.0437	0.0437	V	0.00179	-
d_3	0.0430	0.0423	0.0447	0.0427	0.0427	0.0431	DV	0.00256	-
mean	0.0434	0.0442	0.0436	0.0439	0.0430	0.0436			
Season III									
d_1	0.0443	0.0413	0.0440	0.0433	0.0423	0.0431	D	0.00102	-
d_2	0.0410	0.0410	0.0410	0.0413	0.0417	0.0412	V	0.00070	-
d_3	0.0413	0.0423	0.0423	0.0413	0.0417	0.0418	DV	0.00122	-
mean	0.0422	0.0416	0.0424	0.0420	0.0419	0.0420			

yielding varieties, DMP of stem of v_1 was maximum and v_3 was minimum on d_1 and d_2. On d_3 transplanting v_1 and v_4 were on par and v_2 recorded lowest DMP.

Season III

Only varietal difference was seen. All high yielding varieties recorded significantly lower values than local variety. Among high yielding varieties, v_1 and v_2 were on par and had more DMP of stem than v_4 and v_3. The minimum DMP of stem was reported by v_3.

4.1.1.4.4 Dry matter production of stem at heading stage (Table 19)

Season I

Dates of transplanting and varieties significantly influenced DMP of stem. Transplanting on d_3 resulted in lowest DMP of stem. All the high yielding varieties recorded lower DMP of stem than local variety. No significant difference was seen among v_1, v_2 and v_4. But v_3 registered a lower DMP of stem than other varieties.

Season II

Both the main effects were significant. Transplanting on d_1 and d_2 gave similar DMP of stem but significantly higher than that of d_3. Local variety registered maximum DMP of stem. Among high yielding varieties, v_1 had registered significantly higher and v_3 had registered significantly lower DMP of stem, v_2 and v_4 were on par.

Season III

Only varietal difference was seen. Local variety registered high DMP of stem. Among high yielding varieties, v_1, v_2 and v_4 were on par and had significantly higher DMP of stem that v_3.

4.1.1.4.5 Dry matter production of stem at beginning of grain filling stage (Table 20)

Season I

DMP of stem was significantly influenced by dates of transplanting and varieties.

Table 17 Dry matter production of stem (g hill^{-1}) as influenced by different dates of transplanting and varieties at active tillering stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.63	1.28	1.25	1.35	1.84	1.47	D	0.007	0.028
d_2	1.39	1.34	1.40	1.41	1.82	1.47	V	0.008	-
d_3	1.54	1.52	1.37	1.48	1.81	1.54	DV	0.005	0.146
mean	1.52	1.38	1.34	1.41	1.82	1.49			
Season II									
d_1	1.42	1.35	1.31	1.47	1.80	1.47	D	0.01	0.04
d_2	1.56	1.28	1.33	1.39	1.83	1.47	V	0.01	-
d_3	1.25	1.20	1.17	1.27	1.81	1.34	DV	0.03	0.07
mean	1.41	1.28	1.27	1.38	1.81	1.43			
Season III									
d_1	1.44	1.22	1.59	1.44	1.85	1.51	D	0.04	-
d_2	1.32	1.25	1.19	1.33	1.74	1.37	V	0.04	0.12
d_3	1.41	1.13	1.29	1.25	1.62	1.34	DV	0.07	-
mean	1.39	1.20	1.36	1.34	1.74	1.41			

Table 18 Dry matter production of stem (g hill^{-1}) as influenced by different dates of transplanting and varieties at panicle initiation stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	2.89	2.77	2.37	2.81	3.56	2.88	D	0.021	0.083
d_2	2.76	2.62	2.24	2.63	3.44	2.74	V	0.032	0.106
d_3	2.66	2.53	2.29	2.53	3.15	2.63	DV	0.060	-
mean	2.77	2.64	2.30	2.66	3.38	2.75			
Season II									
d_1	2.91	2.69	2.32	2.56	3.55	2.81	D	0.018	0.029
d_2	2.84	2.63	2.30	2.66	3.33	2.75	V	0.029	0.065
d_3	2.59	2.28	2.34	2.58	3.32	2.62	DV	0.039	0.051
mean	2.78	2.54	2.32	2.60	3.40	2.73			
Season III									
d_1	2.58	2.55	2.07	2.50	3.14	2.57	D	0.029	-
d_2	2.49	2.35	2.09	2.32	3.24	2.50	V	0.065	0.212
d_3	2.50	2.41	2.20	2.32	3.18	2.52	DV	0.051	-
mean	2.52	2.44	2.12	2.38	3.19	2.53			

Transplanting on d_1 resulted in maximum DMP of stem. High yielding varieties recorded less DMP of stem than local variety. v_1, v_2 and v_4 were on par, and had higher DMP of stem than that of v_3.

Season II

Dates of transplanting and varieties significantly influenced DMP of stem. Those transplanted on d_1 gave a higher DMP of stem. Local variety gave maximum DMP of stem. Among high yielding varieties, DMP of stem of v_1 was significantly higher and v_3 was on par with other varieties.

Season III

Varietal difference alone was observed. Local variety registered maximum DMP of stem. v_1 was on par with v_4, which was on par with v_2. v_1, v_2 and v_4 had a high DMP of stem in comparison with v_3.

4.1.1.4.6 Dry matter production of stem at harvest (Table 21)

Season I

Dates of transplanting, varieties and their interactions significantly influenced DMP of stem. Local variety gave more DMP of stem on all dates of transplanting. Transplanting on d_1 gave a low DMP of stem for v_3 in comparison with v_1 and v_4 and it was on par with v_2. DMP of stem was significantly higher for v_1 when transplanted on d_2 and it was on par with v_4 and v_2. Transplanting on d_3 resulted in no significant difference in DMP of stem for v_1 and v_4 but their DMP of stem was higher than v_2 and v_3, which were on par.

Season II

Only varietal difference was observed. All the high yielding varieties had lower DMP of stem than local variety. Among high yielding varieties, DMP of stem of v_1 was significantly higher and v_3 was significantly lower than other varieties.

Season III

Both the main effects were significant. Late transplanting resulted in lower DMP

Table 19 Dry matter production of stem (g hill^{-1}) as influenced by different dates of transplanting and varieties at heading stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	3.40	3.39	2.78	3.34	4.52	3.48	D	0.038	0.027
d_2	3.36	3.43	2.83	3.29	4.42	3.47	V	0.046	0.150
d_3	3.35	3.36	2.78	3.29	4.39	3.43	DV	0.066	-
mean	3.37	3.39	2.80	3.31	4.44	3.46			
Season II									
d_1	3.47	3.31	2.99	3.31	4.56	3.53	D	0.047	0.034
d_2	3.41	3.21	3.25	3.26	4.62	3.55	V	0.064	0.060
d_3	3.17	3.05	2.72	2.99	4.57	3.30	DV	0.087	-
mean	3.35	3.19	2.99	3.19	4.58	3.46			
Season III									
d_1	2.92	2.79	2.39	2.83	4.20	3.03	D	0.019	-
d_2	2.95	2.82	2.52	2.87	4.11	3.06	V	0.034	0.111
d_3	3.04	2.94	2.57	2.91	4.01	3.10	DV	0.060	-
mean	2.97	2.85	2.49	2.87	4.11	3.06			

Table 20 Dry matter production of stem (g hill^{-1}) as influenced by different dates of transplanting and varieties at beginning of grain filling stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	3.50	3.43	3.03	3.47	4.61	3.61	D	0.047	0.025
d_2	3.44	3.52	2.95	3.33	4.52	3.55	V	0.036	0.116
d_3	3.42	3.44	2.87	3.39	4.51	3.53	DV	0.048	-
mean	3.46	3.47	2.95	3.40	4.55	3.56			
Season II									
d_1	3.51	3.29	3.31	3.36	4.60	3.61	D	0.036	0.019
d_2	3.39	3.35	2.93	3.02	4.61	3.46	V	0.059	0.029
d_3	3.23	3.12	2.80	3.14	4.68	3.40	DV	0.097	-
mean	3.38	3.25	3.02	3.17	4.63	3.49			
Season III									
d_1	3.10	3.01	2.64	3.00	4.14	3.18	D	0.019	-
d_2	3.02	2.89	2.59	2.92	4.25	3.13	V	0.029	0.093
d_3	2.99	2.86	2.46	2.92	4.29	3.10	DV	0.054	-
mean	3.04	2.92	2.56	2.95	4.23	3.14			

of stem. v_5 registered maximum DMP of stem. DMP of stem of v_1 was significantly higher than that of other high yielding varieties of which v_2 and v_4 were on par. The lowest DMP of stem was recorded by v_3.

4.1.1.5 Tiller number (Table 22)

Season I

Interactions of dates of transplanting and varieties were consistent over different periods of observation. Tiller number was significantly lower for late transplanting. Tiller number was significantly higher in v_1 compared to v_2 and v_3, and lowest tiller number was registered by v_5.

Season II

Interactions of dates of transplanting and varieties were not significant in this season. Only varietal difference was observed. All the high yielding varieties produced more number of tillers than local variety. Among high yielding varieties, v_3 was the one having lowest number of tillers, while v_1 had the maximum tillers but on par with that of v_4.

Season III

Only varietal difference was seen. All the high yielding varieties had more tillers than local variety. The tiller number was not significantly different among v_1, v_2 and v_4 but significantly higher than that of v_3.

4.1.1.6 Leaf area index (LAI)

4.1.1.6.1 Leaf area index at transplanting stage (Table 23)

Season I

Only varietal difference was observed in this stage. Maximum LAI was registered by local variety. LAI was significantly low in high yielding varieties and no significant difference among themselves was seen.

Season II

Both dates of transplanting and varieties significantly influenced LAI. Those

Table 21 Dry matter production of stem (g hill^{-1}) as influenced by different dates of transplanting and varieties at harvest in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	5.11	5.05	4.92	5.10	5.49	5.13	D	0.025	0.099
d_2	4.94	4.83	4.78	4.86	5.34	4.95	V	0.041	0.134
d_3	4.94	4.13	4.02	4.80	5.37	4.65	DV	0.050	0.150
mean	4.99	4.67	4.57	4.92	5.40	4.91			
Season II									
d_1	4.98	4.88	4.84	5.01	5.52	5.05	D	0.053	-
d_2	4.95	4.87	4.82	4.92	5.46	5.01	V	0.068	0.038
d_3	4.85	4.58	4.46	4.72	5.42	4.81	DV	0.125	-
mean	4.93	4.78	4.71	4.88	5.47	4.95			
Season III									
d_1	5.16	4.82	4.88	4.78	5.49	5.03	D	0.041	0.159
d_2	4.93	4.67	4.40	4.62	5.34	4.79	V	0.038	0.123
d_3	4.87	4.61	4.24	4.59	5.41	4.74	DV	0.075	-
mean	4.99	4.70	4.51	4.66	5.41	4.85			

Table 22 Tiller number as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	9.11	8.47	8.41	8.83	7.16	8.40	D	0.106	0.415
d_2	8.96	8.27	8.04	8.81	7.22	8.26	V	0.147	0.481
d_3	8.28	8.25	8.03	8.18	7.10	7.97	DV	0.196	-
mean	8.78	8.33	8.16	8.61	7.16	8.21			
Season II									
d_1	8.65	8.19	7.89	8.56	7.08	8.07	D	0.090	-
d_2	8.39	8.05	7.75	8.37	7.35	7.98	V	0.340	0.339
d_3	8.39	8.20	7.70	8.38	7.11	7.96	DV	0.153	-
mean	8.48	8.15	7.78	8.44	7.18	8.00			
Season III									
d_1	8.63	8.21	7.69	8.50	6.81	7.97	D	0.209	-
d_2	8.01	8.09	7.32	8.19	6.42	7.61	V	0.143	0.468
d_3	8.00	7.56	7.57	7.75	7.06	7.58	DV	0.216	-
mean	8.21	7.95	7.53	8.15	6.76	7.72			

Table 22.a **Interaction effect of dates of transplanting and varieties on tiller number at different growth stages during I st season at Vellayani**

Varieties	dates of transplanting								
	d_1			d_2			d_3		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
v_1	9.17	9.50	8.56	8.89	9.33	8.67	8.83	8.25	7.75
v_2	8.75	8.22	8.11	8.39	8.50	7.92	8.67	8.25	7.83
v_3	8.22	9.00	8.00	8.19	8.25	7.67	8.10	8.42	7.58
v_4	8.71	9.25	8.51	8.34	9.42	8.67	8.86	8.00	7.69
v_5	7.53	7.08	6.86	7.08	7.75	6.83	7.64	7.08	6.58
Effect		SE			CD				
DVP		0.236			0.667				

Table 23 **Leaf area index as influenced by different dates of transplanting and varieties at transplanting stage in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.303	0.353	0.320	0.300	0.573	0.370	D	0.0081	-
d_2	0.293	0.343	0.310	0.317	0.643	0.381	V	0.0231	0.0752
d_3	0.287	0.327	0.303	0.307	0.587	0.362	DV	0.0174	-
mean	0.294	0.341	0.311	0.308	0.601	0.371			
Season II									
d_1	0.247	0.303	0.293	0.287	0.600	0.346	D	0.0036	0.0139
d_2	0.230	0.280	0.267	0.253	0.577	0.321	V	0.0297	0.0969
d_3	0.203	0.277	0.270	0.257	0.563	0.314	DV	0.0069	-
mean	0.227	0.287	0.277	0.266	0.580	0.327			
Season III									
d_1	0.227	0.317	0.257	0.257	0.570	0.325	D	0.0030	-
d_2	0.223	0.267	0.270	0.253	0.563	0.315	V	0.0276	0.0900
d_3	0.210	0.263	0.253	0.263	0.593	0.317	DV	0.0154	-
mean	0.220	0.282	0.260	0.258	0.576	0.319			

transplanted on d_1 recorded higher LAI than transplanting on d_2 and d_3 and these were on par. A comparison of varieties revealed that high yielding varieties had a significantly lower LAI in comparison with local variety and no significant difference among themselves were observed.

Season III

Only varietal difference was observed. High yielding varieties had a lesser LAI than local variety and no variation among themselves were also noticed.

4.1.1.6.2 Leaf area index at active tillering stage (Table 24)

Season I

The main effect of dates of transplanting and varieties were found significant. Early dates of transplanting resulted in plants with higher LAI. No significant difference was observed with respect to d_2 and d_3 as far as LAI was concerned. Among high yielding varieties, v_1 and v_4 were on par and had more LAI than v_3 and v_2, while maximum LAI was recorded by v_5.

Season II

Only varietal difference was observed in this stage. There was no significant difference in LAI among high yielding varieties, but was significantly low in comparison with local variety.

Season III

The main effect of dates of transplanting and varieties were found significant. Transplanting on d_1 and d_2 had significantly higher LAI than that of d_3. Among high yielding varieties, v_1 and v_4 had more LAI than v_2 and v_3 but significantly lesser than v_5.

4.1.1.6.3 Leaf area index at panicle initiation stage (Table25)

Season I

Only varietal difference was observed. LAI was significantly higher for local variety. Among the high yielding varieties v_1 and v_4 were on par but LAI of v_1 was significantly higher than that of v_2 and v_3

Season II

Both the main effects were significant. Early transplanting resulted in more LAI comparison with d_2 and d_3 which were on par. Local variety registered maximum LAI, while high yielding variety v_1 was on par with v_2 and v_4, but had a higher LAI than v_3.

Season III

Varieties and its interaction with dates of transplanting significantly influenced LAI in this season. When transplanted on d_1 and d_2, v_5 recorded maximum LAI. Among the high yielding varieties, v_1 had plants with more LAI than v_4 when transplanted on d_1 but when transplanted on d_2 LAI of v_1 was significantly higher than that of v_2, v_4 and v_3. Transplanting on d_3 resulted in no significant difference among v_1, v_2 , v_3 and v_5, but LAI of v_4 was significantly lower than that of v_1, v_2 and v_5.

4.1.1.6.4 Leaf area index at heading stage (Table26)

Season I

Only varietal difference in LAI was seen. The high yielding variety v_1 and local variety v_5 had more or less similar LAI and v_3 had a significantly low LAI in comparison with v_1 and v_5 and v_2. No significant difference was observed among v_4 and v_3 which were also on par.

Season II

Both the main effects were significant. Early transplanting resulted in more LAI and local variety had significantly higher LAI than other high yielding varieties. Among high yielding varieties, v_3 registered significantly low LAI in comparison with v_1, v_4 and v_2 which were on par.

Season III

Only varietal difference was seen. No significant difference was observed among high yielding varieties, but had a lesser LAI than local variety.

4.1.1.6.5 Leaf area index at beginning of grain filling stage (Table 27)

Season I

Only varietal difference was observed. The local variety registered maximum LAI, and was on par with v_1, which recorded a higher LAI than v_4 and v_3.

Table 24 **Leaf area index as influenced by different dates of transplanting and varieties at active tillering stage in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.53	1.42	1.17	1.45	1.61	1.44	D	0.013	0.081
d_2	1.34	1.23	1.18	1.32	1.69	1.35	V	0.017	0.055
d_3	1.26	1.21	1.06	1.27	1.62	1.28	DV	0.026	-
mean	1.38	1.29	1.14	1.35	1.64	1.36			
Season II									
d_1	1.31	1.28	1.23	1.31	1.64	1.35	D	0.013	-
d_2	1.29	1.36	1.28	1.23	1.64	1.36	V	0.019	0.062
d_3	1.33	1.31	1.26	1.23	1.52	1.33	DV	0.032	-
mean	1.31	1.32	1.26	1.26	1.60	1.35			
Season III									
d_1	1.36	1.24	1.24	1.27	1.58	1.34	D	0.012	0.048
d_2	1.25	1.23	1.15	1.27	1.64	1.31	V	0.013	0.044
d_3	1.22	1.14	1.11	1.20	1.60	1.25	DV	0.027	-
mean	1.28	1.20	1.17	1.25	1.61	1.30			

Table 25 **Leaf area index as influenced by different dates of transplanting and varieties at panicle initiation stage in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	4.58	4.46	4.42	4.41	4.63	4.50	D	0.013	-
d_2	4.53	4.44	4.32	4.47	4.73	4.50	V	0.028	0.092
d_3	4.53	4.42	4.35	4.50	4.63	4.49	DV	0.040	-
mean	4.55	4.44	4.36	4.46	4.66	4.49			
Season II									
d_1	4.40	4.38	4.28	4.27	4.67	4.40	D	0.019	0.076
d_2	4.08	4.15	4.05	4.05	4.47	4.16	V	0.012	0.039
d_3	4.15	4.00	4.13	4.22	4.45	4.19	DV	0.052	-
mean	4.21	4.18	4.16	4.18	4.53	4.25			
Season III									
d_1	4.07	4.01	3.97	3.95	4.43	4.08	D	0.033	-
d_2	4.13	4.00	3.93	4.00	4.37	4.09	V	0.025	0.081
d_3	4.15	4.13	4.05	3.97	4.13	4.09	DV	0.037	0.110
mean	4.12	4.05	3.98	3.97	4.31	4.09			

Season II

LAI was significantly influenced by both different dates of transplanting and varieties. Transplanting on d_1 recorded more LAI than those planted on d_2 and d_3 which were on par. All the high yielding varieties did not show any differentiation in LAI, but significantly lower than that of v_5.

Season III

Only varietal difference was seen in this season. All the high yielding varieties did not show any differentiation in LAI, but significantly lower than that of v_5.

4.1.1.6.6 Leaf area index at harvest (Table 28)

Season I

LAI was significantly influenced by different dates of transplanting, and varieties and their interactions. When transplanted on d_1, v_3, v_4 and v_2 were on par with v_5, but LAI of v_3 was higher than that of v_1, which was on par with v_4, v_2 and v_5. When transplanted on d_2, v_1 and v_5 recorded maximum LAI followed by v_2 and v_4, which were on par with v_3. Transplanting on d_3 showed a higher LAI for v_2 and v_5 against v_4 and v_3.

Seasons II and III

Neither the dates of transplanting nor varieties did exhibit any significant influence on LAI in these seasons.

4.1.1.7 CGR (Crop growth rate)

4.1.1.7.1 Crop growth rate between active tillering to panicle initiation stage (Table28a)

Season I

Dates of transplanting and varieties significantly influenced the CGR. Earlier transplanting resulted in higher CGR and d_3 transplanting resulted in lower CGR. Maximum CGR was recorded by local variety. Among high yielding varieties,v_1 had higher CGR than other varieties

Table 26 Leaf area index as influenced by different dates of transplanting and varieties at heading stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	5.00	4.81	4.86	4.86	5.03	4.91	D	0.024	-
d_2	4.92	4.92	4.72	4.85	4.99	4.88	V	0.041	0.134
d_3	4.80	4.76	4.66	4.77	5.06	4.81	DV	0.069	-
mean	4.91	4.83	4.74	4.83	5.02	4.87			
Season II									
d_1	4.75	4.68	4.52	4.74	5.12	4.76	D	0.022	0.086
d_2	4.67	4.62	4.57	4.64	4.90	4.68	V	0.020	0.064
d_3	4.57	4.52	4.51	4.56	4.95	4.62	DV	0.055	-
mean	4.66	4.61	4.54	4.65	4.99	4.69			
Season III									
d_1	4.63	4.69	4.64	4.64	4.76	4.67	D	0.038	-
d_2	4.55	4.49	4.56	4.52	4.87	4.60	V	0.032	0.105
d_3	4.45	4.39	4.53	4.48	4.88	4.55	DV	0.062	-
mean	4.55	4.53	4.58	4.55	4.84	4.61			

Table 27 Leaf area index as influenced by different dates of transplanting and varieties at beginning of grain filling stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	5.01	4.85	4.85	4.86	5.00	4.91	D	0.037	-
d_2	4.95	4.96	4.76	4.89	4.97	4.91	V	0.038	0.122
d_3	4.83	4.76	4.56	4.76	5.07	4.80	DV	0.088	-
mean	4.93	4.86	4.72	4.84	5.01	4.87			
Season II									
d_1	4.78	4.70	4.52	4.76	5.12	4.78	D	0.019	0.075
d_2	4.56	4.55	4.54	4.55	4.98	4.64	V	0.024	0.079
d_3	4.70	4.65	4.55	4.65	4.94	4.70	DV	0.038	-
mean	4.68	4.63	4.54	4.65	5.01	4.70			
Season III									
d_1	4.50	4.42	4.50	4.51	4.88	4.56	D	0.030	-
d_2	4.59	4.55	4.57	4.50	4.85	4.61	V	0.030	0.096
d_3	4.70	4.71	4.65	4.65	4.78	4.70	DV	0.056	-
mean	4.60	4.56	4.58	4.56	4.84	4.63			

Season II

Dates of transplanting, varieties and their interactions significantly influenced the CGR. Local variety registered maximum CGR than other varieties and v_1 registered the minimum CGR than v_2, v_4 and v_3 on all dates of transplanting.

Season III

Varieties significantly influenced the CGR. Ptb-10 recorded maximum CGR. Late transplanting was found to result in low CGR. On all dates of transplanting v_5 registered maximum CGR, v_1 and v_4 were on par and recorded higher CGR than other varieties.

4.1.1.7.2 Crop growth rate between panicle initiation stage to harvest (Table 28b)

Season I

Both dates of transplanting and varieties were significant. No significant difference in CGR was seen among plants transplanted on d_1 and d_2. Local variety registered minimum CGR, while high yielding variety v_1 registered maximum CGR and was on par with v_4.

Season II

Varieties significantly influenced CGR and the varieties v_1 and v_4 were on par and recorded higher CGR than v_3 and v_5.

Season III

Varieties significantly influenced CGR and the varieties v_1 and v_4 were on par and recorded higher CGR than v_3 and v_5.

4.1.1.8 Relative growth rate (RGR)

4.1.1.8.1 Relative growth rate between active tillering to panicle initiation stage

(Table28 c)

Seasons I and II

RGR was not significantly influenced by different dates of transplanting and varieties

Season III

Varieties significantly influenced the RGR. Higher RGR was registered by v_5 and it was on par with v_1 and significantly superior to v_2 and v_3 which were also on par.

Table 28 **Leaf area index as influenced by different dates of transplanting and varieties at harvest in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.19	1.25	1.30	1.28	1.25	1.25	D	0.178	0.070
d_2	1.38	1.19	0.89	1.19	1.30	1.19	V	0.033	0.108
d_3	1.16	1.22	1.01	1.08	1.20	1.13	DV	0.036	0.108
mean	1.24	1.22	1.07	1.18	1.25	1.19			
Season II									
d_1	1.19	1.14	1.09	1.13	1.12	1.13	D	0.013	-
d_2	1.10	1.04	1.13	1.11	1.16	1.11	V	0.016	-
d_3	1.18	1.15	1.05	1.14	1.06	1.12	DV	0.070	-
mean	1.16	1.11	1.09	1.13	1.11	1.12			
Season III									
d_1	1.03	1.04	1.07	1.11	1.16	1.08	D	0.015	-
d_2	1.08	0.95	1.03	1.02	1.04	1.02	V	0.024	-
d_3	1.07	1.00	1.01	1.03	1.04	1.03	DV	0.038	-
mean	1.06	1.00	1.04	1.05	1.08	1.05			

Table 28 a **CGR (g m^{-2} day^{-1}) between active tillering to panicle initiation stage as influenced by different dates of transplanting and varieties in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	9.507	8.851	7.824	9.536	12.667	9.677	D	0.0979	0.3847
d_2	8.658	7.832	6.700	7.750	11.542	8.496	V	0.1045	0.3405
d_3	8.293	8.174	6.737	7.854	10.506	8.313	DV	0.2134	-
mean	8.819	8.286	7.087	8.380	11.572	8.829			
Season II									
d_1	9.320	8.657	7.900	9.417	12.707	9.600	D	0.0902	0.3544
d_2	9.133	8.657	7.840	8.210	11.767	9.121	V	0.1434	0.4673
d_3	8.893	8.130	7.140	8.150	11.213	8.705	DV	0.1298	0.3891
mean	9.115	8.481	7.627	8.592	11.896	9.142			
Season III									
d_1	8.733	7.413	6.223	8.540	11.533	8.488	D	0.1522	-
d_2	8.173	6.836	6.460	6.770	10.847	7.817	V	0.1822	0.5937
d_3	7.767	6.083	5.890	7.580	11.023	7.669	DV	0.2640	-
mean	8.224	6.777	6.191	7.630	11.134	7.991			

Table 28 b CGR (g m^{-2} day^{-1}) between panicle initiation to harvest as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	23.213	20.613	18.953	21.513	12.617	19.382	D	0.3839	1.5085
d_2	22.323	19.683	19.007	21.563	12.210	18.957	V	0.6694	2.1813
d_3	14.980	12.620	12.747	14.563	11.467	13.275	DV	0.8470	-
mean	20.172	17.639	16.902	19.213	12.098	17.205			
Season II									
d_1	16.619	15.722	15.803	15.669	11.505	15.063	D	0.6228	-
d_2	17.484	14.605	12.233	15.510	10.835	14.133	V	0.3790	1.2350
d_3	13.951	12.599	12.501	15.238	11.384	13.135	DV	0.8691	-
mean	16.018	14.308	13.513	15.472	11.241	14.111			
Season III									
d_1	14.625	14.239	11.401	15.161	11.098	13.305	D	0.8699	-
d_2	16.412	14.284	11.852	16.290	11.018	13.971	V	0.4893	1.5944
d_3	15.320	13.192	13.184	15.108	10.714	13.504	DV	0.6883	-
mean	15.452	13.905	12.145	15.520	10.944	13.593			

Table 28 c RGR (g $g^{-1}day^{-1}$) between active tillering to panicle initiation stage as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.0367	0.0384	0.0338	0.0398	0.0503	0.0398	D	0.0139	-
d_2	0.0376	0.0342	0.0314	0.0349	0.0376	0.0351	V	0.0178	-
d_3	0.0363	0.0372	0.0325	0.0343	0.0342	0.0349	DV	0.0318	-
mean	0.0369	0.0366	0.0326	0.0363	0.0407	0.0366			
Season II									
d_1	0.0360	0.0370	0.0350	0.0390	0.0520	0.0398	D	0.0139	-
d_2	0.0390	0.0390	0.0350	0.0360	0.0490	0.0396	V	0.0180	-
d_3	0.0370	0.0360	0.0330	0.0360	0.0490	0.0382	DV	0.0318	-
mean	0.0373	0.0373	0.0343	0.0370	0.0500	0.0392			
Season III									
d_1	0.0380	0.0340	0.0300	0.0370	0.0490	0.0376	D	0.0006	-
d_2	0.0360	0.0320	0.0300	0.0300	0.0450	0.0346	V	0.0005	0.0016
d_3	0.0340	0.0270	0.0290	0.0340	0.0480	0.0344	DV	0.0012	-
mean	0.0360	0.0310	0.0297	0.0337	0.0473	0.0355			

4.1.1.8.2 Relative growth rate between panicle initiation stage and harvest (Table28d)

Seasons I, II and III

Varieties significantly influenced the RGR. All high yielding varieties were on par and produced higher RGR than local variety.

4.1.1.9 Leaf number hill^{-1}

4.1.1.9.1 Leaf number at transplanting stage (Table 29)

Seasons I and II

Neither dates of transplanting nor did varieties have any influence on leaf number

Season III

Varietal difference was observed. The minimum number of leaves was recorded by v_5 compared to other varieties, which were on par.

4.1.1.9.2 Leaf number at active tillering stage (Table 30)

Season I

Varietal difference was observed with respect to leaf number at active tillering stage. Local variety recorded the least number of leaves and all the high yielding varieties were on par and registered significantly higher number of leaves.

Season II

Dates of transplanting or varieties did not produce any influence on leaf number at active tillering stage.

Season III

Varietal difference was observed with respect to leaf number. Local variety recorded the least number of leaves and all the high yielding varieties were on par and registered significantly higher number of leaves.

4.1.1.9.3 Leaf number at panicle initiation stage (Table 31)

Season I

Difference in leaf number was observed only with varying dates of transplanting but not varietal wise. The plants transplanted at d_1 produced more number of leaves in comparison with those planted on d_3.

Table 28 d **RGR (g g^{-1}day^{-1}) between panicle initiation to harvest as influenced by different dates of transplanting and varieties in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.0281	0.0281	0.0279	0.0278	0.0220	0.0268	D	0.0005	-
d_2	0.0292	0.0284	0.0296	0.0298	0.0230	0.0280	V	0.0007	0.0023
d_3	0.0252	0.0239	0.0255	0.0252	0.0250	0.0250	DV	0.0010	-
mean	0.0275	0.0268	0.0277	0.0276	0.0233	0.0266			
Season II									
d_1	0.0249	0.0251	0.0262	0.0239	0.0220	0.0244	D	0.0003	-
d_2	0.0261	0.0248	0.0238	0.0256	0.0220	0.0244	V	0.0004	0.0013
d_3	0.0237	0.0238	0.0247	0.0256	0.0230	0.0242	DV	0.0007	-
mean	0.0249	0.0246	0.0249	0.0250	0.0223	0.0243			
Season III									
d_1	0.0240	0.0260	0.0250	0.0250	0.0220	0.0244	D	0.0007	-
d_2	0.0260	0.0260	0.0250	0.0270	0.0230	0.0254	V	0.0004	0.0013
d_3	0.0258	0.0258	0.0268	0.0260	0.0230	0.0255	DV	0.0006	-
mean	0.0253	0.0259	0.0256	0.0260	0.0227	0.0251			

Table 29 **Leaf number as influenced by different dates of of transplanting and varieties at transplanting stage in different season at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	7.33	6.67	7.67	7.33	8.00	7.40	D	0.147	-
d_2	7.50	8.00	8.00	7.50	8.00	7.80	V	0.170	-
d_3	7.33	7.17	8.00	7.67	8.00	7.63	DV	0.206	-
mean	7.39	7.28	7.89	7.50	8.00	7.61			
Season II									
d_1	7.33	7.33	8.00	7.67	7.67	7.60	D	0.088	-
d_2	7.50	6.83	8.00	7.33	7.67	7.47	V	0.252	-
d_3	7.17	6.67	7.83	7.67	7.83	7.43	DV	0.235	-
mean	7.33	6.94	7.94	7.56	7.72	7.50			
Season III									
d_1	7.50	7.83	8.00	7.50	6.83	6.17	D	0.055	-
d_2	7.33	7.67	8.00	7.50	6.75	6.10	V	0.219	0.716
d_3	7.33	7.67	8.00	7.50	6.58	6.10	DV	0.160	-
mean	7.39	7.72	8.00	7.50	6.72	6.12			

Season II

Leaf number at panicle initiation stage during this season was found to vary with respect to dates of transplanting and varieties, but their joint effect was not significant. Those plants transplanted on d_1, produced more number of leaves in comparison with d_3. No Significant difference in number of leaves produced with d_2 and d_3. Among varieties, local variety produced less number of leaves compared to high yielding varieties. Among high yield varieties, v_3, v_1 and v_2 were on par but leaf number of v_3 was higher than that of v_4.

Season III

Significant variation in leaf number was observed with respect to different dates of transplanting and varieties. Number of leaves per hill when planted on d_1 and d_2 were on par and significantly higher than that for plants transplanted on d_3. Local variety produced less number of leaves per hill, but was on par with high yielding variety v_1, while v_4, v_2 and v_3 had more number of leaves that local variety.

4.1.1.9.4 Leaf number at heading stage (Table 32)

Season I

Leaf number was significantly influenced by dates of transplanting and varieties. At heading stage, leaf number was significantly less in d_3 transplanting in comparison with d_1 and d_2 which were on par. All the high yielding varieties produced more number of leaves in comparison with local variety, however no significant differences were observed among high yielding varieties.

Season II

Dates of transplanting did not result in any significant variation in leaf number at this stage. But varietal wise differences were observed. Number of leaves was significantly less in local variety in comparison with high yielding varieties. Among high yielding varieties, number of leaves in v_1 was significantly higher than that of v_4, but v_1 was on par with v_3 and v_2.

Season III

Dates of transplanting and varieties significantly influenced the leaf number. Those plants transplanted on d_1 and d_2 registered more number of leaves in comparison with those planted

Table 30 Leaf number as influenced by different dates of of transplanting and varieties at active tillering stage in different season at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	26.00	24.50	24.33	23.00	21.33	23.83	D	0.892	-
d_2	23.67	23.83	24.67	23.33	20.33	23.17	V	0.504	1.643
d_3	23.33	23.33	24.67	23.67	20.33	23.07	DV	1.589	-
mean	24.33	23.89	24.56	23.33	20.67	23.36			
Season II									
d_1	23.42	23.67	25.00	23.50	23.00	23.72	D	1.074	-
d_2	19.33	20.00	20.00	20.33	18.67	19.67	V	0.811	-
d_3	25.33	23.33	26.00	24.33	21.33	24.07	DV	1.391	-
mean	22.69	22.33	23.67	22.72	21.00	22.48			
Season III									
d_1	25.67	21.67	26.00	25.33	21.00	23.93	D	0.596	-
d_2	25.00	24.33	26.00	27.00	23.00	25.07	V	0.617	2.011
d_3	26.33	27.00	26.33	27.33	24.00	26.20	DV	0.767	-
mean	25.67	24.33	26.11	26.56	22.67	25.07			

Table 31 Leaf number as influenced by different dates of of transplanting and varieties at panicle initiation stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	42.08	40.75	41.97	40.44	39.33	40.92	D	0.403	1.583
d_2	41.00	37.06	39.70	39.47	38.22	39.09	V	0.988	-
d_3	39.30	41.92	36.72	42.94	33.44	38.87	DV	1.972	-
mean	40.80	39.91	39.46	40.95	37.00	39.62			
Season II									
d_1	44.81	43.11	46.44	42.64	37.72	42.95	D	0.608	2.386
d_2	38.28	39.67	45.72	38.14	32.08	38.78	V	1.010	3.294
d_3	41.00	39.97	36.80	36.14	34.75	37.73	DV	1.775	-
mean	41.36	40.92	42.99	38.97	34.85	39.82			
Season III									
d_1	45.72	46.72	47.64	47.56	43.75	46.28	D	0.841	3.303
d_2	44.00	47.86	45.83	49.72	43.89	46.26	V	0.834	2.719
d_3	37.11	37.11	36.86	36.00	31.86	35.79	DV	1.313	-
mean	42.28	43.90	43.44	44.43	39.83	42.78			

on d_3. But no significant difference in number of leaves was observed between d_1 and d_2. Leaf number of local variety was significantly lesser than high yielding varieties, which were on par.

4.1.1.9.5 Leaf number at beginning of grain filling stage (Table 33)

Season I

Leaf number was significantly influenced by dates of transplanting and varieties. When transplanting was done on d_1 and d_2 number of leaves was found to be significantly higher than those transplanted on d_3. All the high yielding varieties produced more leaves than local variety.

Season II

Only varietal difference in leaf number was observed. All the high yielding varieties had more number of leaves than local variety and no significant difference in leaf number among themselves were observed.

Season III

Dates of transplanting, varieties and their interactions were found to influence leaf number per hill at this stage. Those transplanted on d_1 and d_2 had more number of leaves than those transplanted on d_3. On all dates of transplanting leaf production was significantly low in v_5. Among the high yielding varieties those transplanted on d_2 and d_3 had no significant difference in the leaf production per plant. But when transplanted on d_1, v_3 and v_4 were on par and produced more number of leaves than v_1 and v_2.

4.1.1.9.6 Leaf number at harvest (Table 34)

Season I

Only varietal difference in leaf number was observed. All high yielding varieties except v_3 were on par and had more number of leaves than local variety.

Season II

Only varietal difference in leaf number was observed. All high yielding varieties except v_3 were on par and had more number of leaves than local variety.

Table 32 Leaf number as influenced by different dates of transplanting and varieties at heading stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	39.36	38.61	34.14	39.00	32.61	36.74	D	0.374	1.468
d_2	37.86	36.64	37.86	38.61	30.70	36.33	V	0.743	2.422
d_3	33.39	36.06	38.25	35.61	29.64	34.59	DV	1.716	-
mean	36.87	37.10	36.75	37.74	30.98	35.89			
Season II									
d_1	41.25	40.50	41.25	38.25	28.50	37.95	D	0.901	-
d_2	39.00	37.50	37.89	34.14	29.25	35.56	V	0.815	2.657
d_3	36.36	34.14	34.50	33.78	31.50	34.06	DV	1.222	3.334
mean	38.87	37.38	37.88	35.39	29.75	35.85			
Season III									
d_1	38.25	42.19	42.00	46.50	34.53	40.69	D	0.908	3.567
d_2	41.61	39.39	44.64	42.75	31.89	40.06	V	1.096	3.574
d_3	36.08	36.97	36.00	37.00	29.22	35.06	DV	1.433	-
mean	38.65	39.52	40.88	42.08	31.88	38.60			

Table 33 Leaf number as influenced by different dates of transplanting and varieties at beginning of grain filling stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	37.50	35.25	37.50	38.58	30.45	35.86	D	0.499	1.96
d_2	33.14	35.78	37.78	35.28	29.42	34.28	V	0.662	2.16
d_3	35.17	35.19	32.14	32.50	29.28	32.86	DV	1.349	-
mean	35.27	35.41	35.81	35.45	29.71	34.33			
Season II									
d_1	36.61	35.00	36.06	36.25	28.31	34.44	D	0.986	-
d_2	38.61	34.55	34.08	35.44	27.67	34.07	V	0.805	2.625
d_3	34.81	33.75	34.08	33.42	31.28	33.47	DV	1.224	-
mean	36.68	34.43	34.74	35.04	29.08	33.99			
Season III									
d_1	34.33	39.03	44.20	42.55	30.53	38.13	D	0.5	1.965
d_2	38.14	40.30	39.19	41.25	34.14	38.61	V	0.622	2.028
d_3	35.56	36.61	35.61	36.75	28.83	34.67	DV	1.092	3.273
mean	36.01	38.65	39.67	40.19	31.17	37.14			

Season III

Varieties and its interaction with dates of transplanting significantly influenced the leaf number. v_1, v_4 and v_2 were on par and produced significantly higher number of leaves than local variety on d_1 while on d_2, v_3 and local variety were on par and produced less number of leaves than other varieties, which were on par. All high yielding varieties except v_2 were on par and produced more number of leaves than local variety for d_3 transplanting.

4.1.2 Yield attributing characters and yield

4.1.2.1 Maximum leaf area index (Table35)

Season I

Only varietal difference was seen on LAI. Maximum LAI was registered by v_5. Among high yielding varieties, the lowest LAI was recorded by v_3. LAI of v_1 was significantly higher than that of v_3 and v_4.

Season II

Both dates of transplanting and varieties influenced LAI. Transplanting on d_1 gave a significantly higher LAI than d_3, but on par with d_2. Maximum LAI was recorded by v_5. Among high yielding varieties, LAI of v_1 was on par with v_4 and v_2 and significantly higher than v_3.

Season III

Only varietal difference was seen. All the high yielding varieties registered a significantly lower LAI than local variety.

4.1.2.2 Days to 50 per cent flowering (Table 36)

Season I

Dates of transplanting and varieties significantly influenced the days to 50 per cent flowering while their interactions were absent. Plants transplanted on d_1 took more number of days to 50 per cent flowering than d_2 and d_3, which were on par. Local variety recorded the least number of days to 50 per cent flowering. Among the high yielding varieties, v_3 took less number of days in comparison with v_1, v_2 and v_4, which were on par.

Table 34 Leaf number as influenced by different dates of transplanting and varieties at harvest in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	17.33	16.17	16.50	17.00	13.75	16.15	D	0.307	-
d_2	17.33	15.83	15.33	17.33	13.67	15.90	V	0.382	1.246
d_3	15.50	15.50	14.67	15.42	13.17	14.85	DV	0.538	-
mean	16.72	15.83	15.50	16.58	13.53	15.63			
Season II									
d_1	16.33	15.67	14.67	16.17	13.33	15.23	D	0.302	-
d_2	15.50	14.83	14.17	16.17	14.17	14.97	V	0.205	0.668
d_3	15.83	15.83	14.33	16.17	14.00	15.23	DV	0.441	-
mean	15.89	15.44	14.39	16.17	13.83	15.14			
Season III									
d_1	16.50	15.83	14.83	16.33	13.83	15.47	D	0.427	-
d_2	15.00	15.67	13.67	15.67	12.83	14.57	V	0.360	1.173
d_3	14.83	13.50	14.67	14.67	13.33	14.20	DV	0.351	1.052
mean	15.44	15.00	14.39	15.56	13.33	14.74			

Table 35 Maximum leaf area index as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	5.08	4.92	4.90	4.91	5.15	4.99	D	0.031	-
d_2	5.04	5.01	4.83	4.93	5.04	4.97	V	0.031	0.102
d_3	4.89	4.81	4.62	4.82	5.14	4.86	DV	0.085	-
mean	5.00	4.92	4.78	4.89	5.11	4.94			
Season II									
d_1	4.82	4.75	4.58	4.83	5.19	4.83	D	0.020	0.077
d_2	4.75	4.71	4.65	4.74	5.01	4.77	V	0.023	0.074
d_3	4.64	4.61	4.63	4.65	5.05	4.72	DV	0.045	-
mean	4.74	4.69	4.62	4.74	5.08	4.77			
Season III									
d_1	4.55	4.47	4.60	4.57	4.94	4.63	D	0.037	-
d_2	4.64	4.59	4.64	4.60	4.93	4.68	V	0.032	0.104
d_3	4.74	4.78	4.73	4.71	4.82	4.76	DV	0.063	-
mean	4.64	4.61	4.66	4.63	4.90	4.69			

Season II.

Days to 50 per cent flowering was influenced by dates of transplanting and varieties. Transplanting on d_1 resulted in more number of days and d_3 took less number of days to 50 per cent flowering. Local variety took minimum number of days to 50 per flowering. Among high yielding varieties, v_3 was the early flowering one followed by v_2. Late flowering was reported by v_1 and v_2.

Season III.

Dates of transplanting, varieties and their interactions significantly influenced the days to 50 per cent flowering. Whatever be the date of transplanting v_5 was the early flowering variety followed by v_3. v_1, v_2 and v_4 were on par and were late flowering than v_3 and v_5.

4.1.2.3 Days to physiological maturity (Table 37)

Season I

Dates of transplanting and varieties significantly influenced the days to physiological maturity. Transplanting on d_2 and d_3 resulted in lesser number of days to physiological maturity (101 days), while d_1 took 106 days. A comparison of varieties revealed the following, on all dates of transplanting, local variety took less number of days to physiological maturity, followed by v_3. Among high yielding varieties, v_1, v_2 and v_4 were on par on all dates of transplanting.

Season II

Dates of transplanting, varieties and their interactions were significant. Local variety followed by high yielding variety v_3, required less number of days to physiological maturity. The varieties v_1 and v_4 took maximum days to physiological maturity when transplanted on d_1 and d_2 while v_1, v_2 and v_4 were on par and took maximum days for physiological maturity, when planted on d_3.

Table 36 Days to 50 per cent flowering as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	83.67	82.00	82.33	84.00	72.33	80.87	D	0.181	0.711
d_2	79.00	79.00	77.00	79.00	66.67	76.13	V	0.337	1.098
d_3	78.67	78.00	76.67	78.67	66.00	75.60	DV	0.545	-
mean	80.44	79.67	78.67	80.56	68.33	77.53			
Season II									
d_1	79.67	78.33	76.33	80.00	66.67	76.20	D	0.214	0.840
d_2	78.33	78.00	75.00	78.00	65.67	75.00	V	0.257	0.838
d_3	76.67	76.00	73.67	76.33	64.67	73.47	DV	0.470	-
mean	78.22	77.44	75.00	78.11	65.67	74.89			
Season III									
d_1	75.67	75.33	73.00	76.33	62.33	72.53	D	0.266	1.043
d_2	74.67	74.00	71.67	74.67	62.33	71.47	V	0.211	0.688
d_3	73.67	73.00	71.67	73.00	62.33	70.73	DV	0.390	1.170
mean	74.67	74.11	72.11	74.67	62.33	71.58			

Table 37 Days to physiological maturity as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	108.67	109.00	107.33	107.67	97.33	106.00	D	0.208	0.816
d_2	104.00	103.33	102.00	103.67	91.33	100.87	V	0.183	0.596
d_3	103.67	103.33	102.00	103.00	92.00	100.80	DV	0.545	-
mean	105.44	105.22	103.78	104.78	93.56	102.56			
Season II									
d_1	105.00	103.33	101.67	105.33	91.67	101.40	D	0.072	0.283
d_2	103.33	102.33	99.67	103.67	91.00	100.00	V	0.169	0.552
d_3	101.33	101.67	98.67	101.00	89.67	98.47	DV	0.324	0.971
mean	103.22	102.44	100.00	103.33	90.78	99.96			
Season III									
d_1	101.00	100.33	97.33	100.00	87.67	97.27	D	0.239	0.940
d_2	99.67	99.33	96.67	99.67	87.67	96.60	V	0.163	0.531
d_3	98.67	98.67	96.67	98.33	87.00	95.87	DV	0.250	0.750
mean	99.78	99.44	96.89	99.33	87.44	96.58			

Season III

Days to physiological maturity was significantly influenced by dates of transplanting, varieties and their interactions. Local variety took least number of days to physiological maturity followed by v_3. More number of days was taken by v_1, when planted on d_1, and v_1, v_2 and v_4 took more number of days to physiological maturity when planted on d_2 and d_3.

4.1.2.4. Number of panicle hill^{-1} (Table38)

Season I

Number of panicle hill^{-1} was significantly influenced by varietal difference only. None of the high yielding varieties showed any significant difference in number of panicle hill^{-1}, but they were superior to local variety.

Season II

Only varietal difference was observed. Number of panicle hill^{-1} was significantly low in v_5. Among high yielding varieties, v_1 gave a significantly higher number of panicles hill^{-1} than v_3.

Season III

Varietal difference alone was observed. High yielding varieties produced more number of panicles hill^{-1} but v_3 was on par with v_5.

4.1.2.5 Filled grains panicle^{-1} (Table 39)

Season I.

Filled grains panicle^{-1} was significantly influenced by varieties, dates of transplanting and their interactions. Local variety recorded a significantly lower filled grains panicle^{-1} for d_1 transplanting. The same trend of response was also observed when planted on d_2. But when planted on d_3, differential response was seen. Though there was a significant reduction in the number of filled grain panicle^{-1}, v_3 registered more or less same number of filled grain panicle^{-1} as local variety and v_1 and v_4 were on par.

Season II

Varieties, dates of transplanting and their interactions significantly influenced the filled grains panicle^{-1}. When transplanted on d_1 number of filled grains panicle^{-1} were on par among v_1, v_3 and v_4 and local variety registered lowest number of filled grains panicle^{-1}. When transplanted on d_2, local variety registered lowest number of filled grains panicle^{-1}. v_1 and v_4 were on par, but v_1 was superior to the remaining varieties. Also v_4 was on par with v_2 and v_3. Transplanting on d_3 gave the following result, the maximum number of filled grains panicle^{-1} was produced by v_1, v_2 and v_4 and were more than that of v_3 and v_5, which were on par.

Season III

The main effect of varieties and dates of transplanting were significant. Planting on d_1 resulted in higher number of filled grains panicle^{-1} and it was significantly higher than d_2 and d_3 which were on par. Number of filled grains per panicle was highest for v_1 followed by and v_2 and v_4, which were on par. Lowest number of filled grains panicle^{-1} was observed in v_5 and it was on par with v_3.

4.1.2.6 Thousand grain weight (Table 40)

Season I

Only varietal wise difference was seen. Higher thousand grain weight was produced by v_1 and it was on par with v_4. Lowest grain weight was produced by v_3. Jyothi was significantly inferior to v_1 and v_4 and superior to v_5 and v_3.

Season II

Dates of transplanting, varieties and their interactions significantly influenced the thousand grain weight. Kanchana and Kairali were on par and significantly superior to other varieties on d_1 and d_2 and there was no significant difference among varieties for d_3 transplanting.

Season III

Thousand grain weight was significantly influenced by dates of transplanting, varieties

Table 38 Number of panicles hill^{-1} as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	8.47	7.25	7.19	7.88	6.58	7.47	D	0.112	-
d_2	8.19	7.72	7.36	7.86	6.39	7.50	V	0.236	0.771
d_3	7.33	7.08	7.33	7.17	6.25	7.03	DV	0.223	-
mean	8.00	7.35	7.29	7.64	6.41	7.34			
Season II									
d_1	7.47	7.39	7.11	7.42	6.06	7.09	D	0.217	-
d_2	7.36	7.11	6.69	7.11	6.00	6.85	V	0.116	0.377
d_3	7.17	6.89	6.86	7.11	6.19	6.84	DV	0.339	-
mean	7.33	7.13	6.89	7.21	6.08	6.93			
Season III									
d_1	7.36	7.11	6.75	7.14	6.17	6.91	D	0.272	-
d_2	7.22	6.89	6.39	7.17	5.67	6.67	V	0.246	0.801
d_3	7.03	6.42	6.83	7.03	6.00	6.66	DV	0.195	-
mean	7.20	6.81	6.66	7.11	5.95	6.75			

Table 39 Number of filled grains panicle^{-1} as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	104.00	105.00	102.00	103.00	84.00	99.60	D	0.873	3.426
d_2	102.00	98.00	100.00	101.00	84.67	97.13	V	0.954	3.110
d_3	85.00	81.00	75.00	85.00	77.00	80.60	DV	1.203	3.606
mean	97.00	94.67	92.33	96.33	81.89	92.44			
Season II									
d_1	92.00	86.00	89.67	89.33	85.00	88.40	D	0.325	1.277
d_2	91.00	87.00	86.00	88.00	81.00	86.60	V	0.563	1.836
d_3	88.00	84.00	81.00	84.00	81.00	83.60	DV	1.191	3.572
mean	90.33	85.67	85.56	87.11	82.33	86.20			
Season III									
d_1	93.67	87.33	84.33	89.00	85.00	87.87	D	0.573	2.251
d_2	88.33	87.33	81.00	85.67	80.00	84.47	V	0.650	2.118
d_3	87.00	86.00	80.00	86.00	80.00	83.80	DV	1.652	-
mean	89.67	86.89	81.78	86.89	81.67	85.38			

and their interactions. Kanchana registered maximum thousand grain weight and it was on par with v_4 on d_1, and with v_4 and v_2 on d_2 and with all varieties except v_3 on d_3.

4.1.2.7 Grain chaff ratio (Table 41)

Season I

Dates of transplanting, varieties and their interactions significantly influenced the grain chaff ratio. Higher grain chaff ratio was registered by v_2 on d_1 transplanting and it was on par with v_3. v_3 was on par with v_4 and v_1 and the lowest grain chaff ratio was registered by v_5. v_3, v_4 and v_1 were on par and had higher grain chaff ratio than v_5 on d_2. On d_3, v_4, v_1 and v_2 were on par and lowest grain chaff ratio was registered by v_3 which was on par with v_5 and v_2.

Season II

Grain chaff ratio was significantly influenced by dates of transplanting, varieties and their interactions. Earlier transplanting resulted in higher grain chaff ratio and the lowest grain chaff ratio was registered by d_3. On d_1 significantly higher grain chaff ratio was registered by v_3 and all other varieties were on par. On d_2, lowest grain chaff ratio was registered by v_5 and all other varieties were on par. On d_3, highest grain chaff ratio was registered by v_4 which was on par with all other high yielding varieties and significantly higher than v_5.

Season III

Both main effects were significant. Higher grain chaff ratio was obtained at d_1 transplanting and the other dates of transplanting were on par. Significantly lower grain chaff ratio was registered by local variety and all other varieties were on par.

4.1.2.8 Grain yield (Table 42)

Season I

Dates of transplanting, varieties and their interactions significantly influenced the grain yield. For d_1 and d_2 transplanting, v_1 registered maximum grain yield followed by v_4. Jyothi and Matta Triveni were on par and significantly higher than local variety (v_5) which registered

Table 40 Thousand grain weight(g) as influenced by different dates of transplantin and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	28.60	27.53	26.97	28.10	28.10	22.24	D	0.159	-
d_2	27.33	27.87	26.43	28.03	27.50	21.93	V	0.182	0.594
d_3	28.60	28.23	27.60	28.27	28.03	22.54	DV	0.409	-
mean	28.18	27.88	27.00	28.13	27.88	22.24			
Season II									
d_1	28.07	26.83	27.40	28.07	27.23	27.52	D	0.620	0.243
d_2	28.13	26.80	26.23	28.33	27.13	27.33	V	0.240	0.781
d_3	26.50	26.33	26.57	26.67	26.77	26.57	DV	0.199	0.596
mean	27.57	26.66	26.73	27.69	27.04	27.14			
Season III									
d_1	27.07	26.50	26.50	26.83	26.77	26.73	D	0.593	0.233
d_2	27.17	26.67	26.17	26.83	26.43	21.37	V	0.112	0.366
d_3	27.30	26.10	24.73	26.80	25.97	20.99	DV	0.216	0.647
mean	27.18	26.42	25.80	26.82	26.39	23.03			

Table 41 Grain chaff ratio as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	4.13	4.38	4.29	4.16	3.56	4.10	D	0.469	0.184
d_2	4.12	4.00	4.28	4.28	3.51	4.04	V	0.390	0.153
d_3	3.51	3.38	3.20	3.53	3.24	3.37	DV	0.063	0.188
mean	3.92	3.92	3.92	3.99	3.44	3.84			
Season II									
d_1	3.74	3.84	3.90	3.56	3.71	3.75	D	0.020	0.076
d_2	3.79	3.68	3.85	3.73	3.50	3.71	V	0.027	0.087
d_3	3.59	3.56	3.65	3.69	3.51	3.60	DV	0.058	0.171
mean	3.71	3.69	3.80	3.66	3.57	3.69			
Season III									
d_1	3.94	3.64	3.88	3.85	3.65	3.79	D	0.033	0.130
d_2	3.68	3.72	3.65	3.63	3.48	3.63	V	0.444	0.145
d_3	3.63	3.80	3.64	3.57	3.42	3.61	DV	0.078	-
mean	3.75	3.72	3.72	3.68	3.52	3.68			

lowest grain yield. While on d_3, v_1, v_4 and v_2 were on par and registered higher grain yield than v_3 and the lowest grain yield was recorded by local variety.

Season II

Grain yield was significantly influenced by dates of transplanting and varieties. Higher grain yield was registered by early transplanting (d_1) than d_2 and d_3 which were on par. v_1 registered maximum grain yield followed by v_4. v_2 and v_3 were on par and the lowest grain yield was reported by v_5 (local variety).

Season III

Dates of transplanting, varieties and their interactions significantly influenced the grain yield. On all dates of transplanting highest grain yield was registered by v_1 followed by v_4 and the lowest grain yield was produced by v_5. On d_1, v_3 was significantly superior than v_2 while on d_2, v_2 was on par with v_3 and on d_3, v_2 was significantly superior than v_3.

4.1.2.9 Straw yield (Table43)

Season I

Straw yield was significantly influenced by dates of transplanting, varieties and their interactions. On all dates of transplanting maximum straw yield was obtained from v_5 followed by v_1, and minimum by v_3, which was on par with v_2. Straw yield of v_1 and v_4 were on par on d_3, while v_1 was superior to v_4 on d_1 and d_2.

Season II

Only varietal difference was observed. Maximum straw yield was registered by v_5. v_1 and v_4 which were on par, and were significantly superior to v_3 and v_2 which were also on par.

Table 42 Grain yield (kg ha^{-1}) as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	5587	4978	4858	5245	3462	4826	D	30.8	121.0
d_2	5466	4810	4703	5117	3380	4695	V	49.6	161.7
d_3	4023	3864	3575	3900	3050	3682	DV	73.0	219.0
mean	5025	4551	4379	4754	3297	4401			
Season II									
d_1	4757	4237	4127	4617	3470	4242	D	43.0	169.0
d_2	4710	4153	4103	4570	3463	4200	V	45.4	147.9
d_3	4603	4097	3880	4380	3357	4063	DV	101.1	-
mean	4690	4162	4037	4522	3430	4168			
Season III									
d_1	4627	3917	4040	4428	3507	4104	D	17.7	69.5
d_2	4543	3917	3937	4343	3276	4003	V	37.2	121.2
d_3	4413	3767	3660	3887	3330	3811	DV	35.0	-
mean	4528	3867	3879	4219	3371	3973			

Table 43 Straw yield (kg ha^{-1}) as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	5717	4947	4788	5400	5987	5368	D	40.3	158.1
d_2	5514	5171	4940	5049	5903	5315	V	75.6	246.5
d_3	4773	4423	4227	4757	5477	4731	DV	80.8	242.3
mean	3429	3198	3056	3268	3793	3349			
Season II									
d_1	4833	4467	4667	5067	4833	4773	D	113.4	-
d_2	5100	4527	4513	4960	4567	4733	V	91.5	298.4
d_3	4840	4450	4433	4937	4950	4722	DV	163.3	-
mean	4924	4481	4538	4988	4783	4743			
Season III									
d_1	4650	4292	4167	4843	5213	4559	D	32.7	-
d_2	4700	4215	4411	4473	4810	4522	V	71.9	234.5
d_3	4555	4325	4493	4387	4843	4675	DV	140.4	-
mean	4768	4277	4357	4568	4956	4585			

Season III

Only varietal difference was observed. Maximum straw yield was produced by v_5, which was on par with v_1, but significantly higher than that of v_4, v_3 and v_2. Jyothi produced the lowest straw yield and it was on par with v_3.

4.1.2.10 Harvest index (HI) (Table 44)

Season I

HI was profoundly influenced by varieties and dates of transplanting and their interactions. On all dates of transplanting v_5 recorded lowest HI. HI was high for v_4 and was on par with v_1 and these varieties were significantly higher than v_3 and v_2 which were also on par when transplanted on d_1. When transplanted on d_2, all high yielding varieties were on par. For d_3 transplanting, v_2 recorded higher HI than v_4 and was on par with other high yielding varieties.

Season II

Varietal difference alone was observed. Kanchana registered maximum HI and it was on par with v_2 and v_4 and significantly higher than v_3 and local varieties. Local variety recorded the lowest HI.

Season III

Both main effects were found significant. Earlier transplanting resulted in higher HI. Among high yielding varieties v_1 produced maximum HI and it was on par with v_4 which was on par with v_2 and v_3. Local variety recorded the lowest HI.

4.1.3. Nutrient uptake

4.1.3.1 Nitrogen uptake

4.1.3.1.1 Nitrogen uptake at transplanting stage (Table45)

Season I

Dates of transplanting and varieties significantly influenced the nitrogen uptake. Earlier transplanting resulted in higher nitrogen uptake. Local variety registered higher nitrogen uptake values in comparison with v_2, v_4 and v_3 but on par with v_1.

Season II

Variation in nitrogen uptake was seen both with respect to dates of transplanting and varieties. When transplanted on d_1 and d_2 nitrogen uptake was high. Higher nitrogen uptake was recorded by local variety. Among high yielding varieties, v_1, v_2 and v_4 were on par and recorded more uptake than v_3.

Season III

Nitrogen uptake was significantly influenced by dates of transplanting, varieties and their interactions. When transplanted on d_1, v_5 recorded more nitrogen uptake than v_1, v_2 and v_3 but on par with v_4. When transplanted on d_2, maximum uptake was recorded by local variety. Among high yielding varieties, v_1 and v_2 were on par but recorded high uptake values than v_3 and v_4, which were on par. When transplanted on d_3, v_5 showed maximum nitrogen uptake and among high yielding varieties, uptake of v_4, v_1 and v_3 were on par, but v_4 recorded higher value than that of v_2, which was on par with v_1 and v_3.

4.1.3.1.2 Nitrogen uptake at active tillering stage (Table 46)

Season I

Nitrogen uptake was significantly influenced by dates of transplanting and varieties. Nitrogen uptake was significantly higher and was on par when transplanted on d_1 and d_2. Maximum uptake was registered by v_5. Among high yielding varieties, nitrogen uptake of v_1 was significantly higher than v_3, which were on par with v_4 and v_2.

Season II

Nitrogen uptake was significantly influenced by dates of transplanting and varieties. Maximum nitrogen uptake was recorded by those planted on d_1 followed by d_2 and a minimum by d_3. High yielding varieties in general recorded lower uptake values than local variety. Among high yielding varieties v_1 and v_4 were on par but recorded more uptake than v_2 and v_3, which were on par.

Table 44 **Harvest index as influenced by different dates of transplanting and varieties in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.507	0.493	0.497	0.510	0.367	0.475	D	0.0040	0.0159
d_2	0.497	0.493	0.490	0.487	0.360	0.465	V	0.0022	0.0071
d_3	0.457	0.467	0.457	0.450	0.357	0.437	DV	0.0054	0.0162
mean	0.487	0.484	0.481	0.482	0.361	0.459			
Season II									
d_1	0.497	0.483	0.483	0.483	0.403	0.470	D	0.0044	-
d_2	0.497	0.477	0.453	0.477	0.420	0.465	V	0.0043	0.0139
d_3	0.473	0.483	0.477	0.467	0.433	0.467	DV	0.0084	-
mean	0.489	0.481	0.471	0.476	0.419	0.467			
Season III									
d_1	0.497	0.483	0.480	0.493	0.423	0.475	D	0.0020	0.0080
d_2	0.497	0.477	0.487	0.480	0.403	0.469	V	0.0037	0.0121
d_3	0.470	0.463	0.450	0.470	0.390	0.449	DV	0.0086	-
mean	0.488	0.474	0.472	0.481	0.406	0.464			

Table 45 **Nitrogen uptake (kg ha^{-1}) at transplanting stage as influenced by differen dates of transplanting and varieties in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.498	1.590	1.314	1.528	1.595	1.505	D	0.0504	0.2900
d_2	1.584	1.311	1.383	1.449	1.615	1.468	V	0.0355	0.1160
d_3	1.279	1.321	1.169	1.240	1.440	1.290	DV	0.0674	-
mean	1.454	1.408	1.289	1.406	1.550	1.421			
Season II									
d_1	1.250	1.291	1.237	1.331	1.617	1.345	D	0.0213	0.0834
d_2	1.345	1.337	1.161	1.271	1.474	1.318	V	0.0211	0.0689
d_3	1.169	1.186	1.115	1.246	1.344	1.212	DV	0.0484	-
mean	1.255	1.271	1.171	1.283	1.478	1.292			
Season III									
d_1	1.263	1.165	1.181	1.315	1.421	1.269	D	0.0091	0.0356
d_2	1.212	1.194	1.050	1.046	1.351	1.170	V	0.0309	0.1006
d_3	1.102	1.064	1.079	1.205	1.390	1.168	DV	0.0423	0.1268
mean	1.192	1.141	1.104	1.189	1.387	1.203			

Season III

Dates of transplanting and its interaction with dates of transplanting were significant. When transplanted on d_1, v_5 recorded maximum nitrogen uptake and significantly higher than other varieties, which were on par. Transplantation on d_2 also resulted in higher uptake values for v_5. v_2 was on par with v_1 but uptake of v_2 was higher than that of v_3 and v_4. When transplanted on d_3, again v_5 registered maximum nitrogen uptake. Here v_4, v_2 and v_1 were on par but uptake of v_4 and v_2 were significantly higher than that of v_3.

4.1.3.1.3 Nitrogen uptake at panicle initiation stage (Table 47)

Season I

Nitrogen uptake was significantly different with different dates of transplanting and varieties. Varieties transplanted on d_1 registered higher uptake, but those transplanted on d_3 registered a significantly lower uptake. All the high yielding varieties were on par, having significantly low uptake value than local variety.

Season II

Nitrogen uptake was significantly influenced by dates of transplanting and varieties. In this season transplanting on d_1 resulted in high nitrogen uptake compared to d_2 and d_3 which were on par. All high yielding varieties were on par having low uptake values than local variety.

Season III

Nitrogen uptake was significantly influenced by dates of transplanting, varieties and their interactions. Transplanting on d_1 resulted in higher uptake values for v_5. Among high yielding varieties, v_1 registered higher uptake and it was on par with all other varieties except v_2. Transplanting on d_2 gave higher nitrogen uptake values for v_5 and it was on par with v_4. When transplanted on d_3, v_5 was on par with v_4 and v_3 with respect to nitrogen uptake and was higher than that of v_1 and v_2, while the uptake of v_4 was significantly higher than that of v_2.

Table 46 **Nitrogen uptake (kg ha $^{-1}$) at active tillering stage as influenced by different dates of transplanting and varieties in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	33.17	31.43	29.60	29.77	34.20	31.63	D	0.644	2.527
d_2	31.00	28.33	28.27	29.77	33.10	30.09	V	0.574	1.872
d_3	25.53	24.33	23.33	25.90	31.93	26.21	DV	0.808	-
mean	29.90	28.03	27.07	28.48	33.08	29.31			
Season II									
d_1	26.43	25.83	25.60	26.27	31.60	27.15	D	0.256	1.006
d_2	25.63	24.67	24.27	24.80	29.57	25.79	V	0.245	0.799
d_3	24.20	23.50	22.83	24.70	27.97	24.64	DV	0.489	1.465
mean	25.42	24.67	24.23	25.26	29.71	25.86			-
Season III									
d_1	24.80	24.53	24.50	25.63	28.57	25.61	D	0.245	0.960
d_2	24.27	25.27	23.57	23.13	28.97	25.04	V	0.422	-
d_3	23.17	24.00	22.57	24.47	28.63	24.57	DV	0.424	1.302
mean	24.08	24.60	23.54	24.41	28.72	25.07			

Table 47 **Nitrogen uptake (kg ha $^{-1}$) at panicle initiation stage as influenced by different dates of transplanting and varieties in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	48.11	44.27	45.31	50.63	64.77	50.62	D	0.592	2.325
d_2	45.30	42.87	42.17	43.00	63.40	47.35	V	1.021	3.330
d_3	41.07	39.00	39.53	38.70	60.63	43.79	DV	1.588	-
mean	44.83	42.04	42.34	44.11	62.93	47.25			
Season II									
d_1	44.40	43.50	40.10	42.70	63.70	46.88	D	0.249	0.977
d_2	39.57	39.27	40.30	41.80	61.23	44.43	V	0.940	3.065
d_3	41.00	39.90	37.63	40.10	62.23	44.17	DV	1.009	-
mean	41.66	40.89	39.34	41.53	62.39	45.16			
Season III									
d_1	41.63	38.03	39.90	41.13	57.50	43.64	D	0.362	1.422
d_2	37.93	37.67	39.20	40.80	45.30	40.18	V	0.928	3.028
d_3	39.57	38.57	40.33	41.40	42.07	40.39	DV	0.664	1.990
mean	39.71	38.09	39.81	41.11	48.29	41.40			

4.1.3.1.4 **Nitrogen uptake at heading stage** (Table 48)

Season I

Nitrogen uptake was significantly influenced by dates of transplanting and varieties. Those transplanted on d_1 and d_2 registered more or less same nitrogen uptake values but higher than those planted on d_3. High yielding varieties recorded a significantly lower nitrogen uptake value than local variety. Nitrogen uptake of v_1 was on par with v_4 and v_3 and significantly higher than v_2.

Season II

Dates of transplanting did not influence nitrogen uptake in this season. All the high yielding varieties were on par and recorded significantly lower nitrogen uptake than local variety.

Season III

Only varietal difference influenced nitrogen uptake at this stage. All high yielding varieties were on par and significantly inferior to v_5.

4.1.3.1.5 **Nitrogen uptake at beginning of grain filling stage** (Table 49)

Season I

Varietal influence alone was observed. All the high yielding varieties were on par and recorded lower nitrogen uptake values than v_5.

Season II

Dates of transplanting had no influence on nitrogen uptake at beginning of grain filling stage. Varieties and its interaction with dates of transplanting were significant. When transplanted on d_1 maximum uptake was registered by v_5. Among high yielding varieties, v_4, v_1 and v_3 were on par and had a higher uptake value than v_2. Transplanting on d_2 resulted in higher nitrogen uptake values for v_5 and v_4, which were on par and significantly higher than that of v_3, v_1 and v_2, which were also on par. Transplanting on d_3 resulted maximum uptake for v_5 and minimum for v_3.

Table 48 **Nitrogen uptake (kg ha $^{-1}$) at heading stage as influenced by different dates of transplanting and varieties in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	68.67	61.03	63.30	65.40	69.80	65.64	D	1.378	5.408
d_2	62.53	59.73	59.20	62.47	68.97	62.58	V	1.028	3.352
d_3	55.40	54.90	55.10	56.33	63.83	57.11	DV	1.284	-
mean	62.20	58.56	59.20	61.40	67.53	61.78			
Season II									
d_1	59.17	55.23	57.50	59.23	67.23	59.67	D	0.577	-
d_2	58.10	57.73	58.60	60.73	65.70	60.17	V	0.789	2.571
d_3	58.47	58.30	56.27	58.33	60.77	58.43	DV	1.148	-
mean	58.58	57.09	57.46	59.43	64.57	59.42			
Season III									
d_1	54.17	53.90	54.00	55.87	61.97	55.98	D	0.365	-
d_2	53.83	53.63	53.47	53.67	62.57	55.43	V	0.648	2.112
d_3	57.80	53.37	54.63	54.57	63.73	56.82	DV	0.995	-
mean	55.27	53.63	54.03	54.70	62.76	56.08			

Table 49 **Nitrogen uptake(kg ha $^{-1}$) at beginning of grain filling stage as influenced by different dates of transplanting and varieties in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	70.47	62.77	63.97	65.90	75.73	67.77	D	1.862	-
d_2	63.30	61.97	60.87	62.23	73.23	64.32	V	1.268	4.136
d_3	57.37	56.77	57.13	58.63	61.03	58.19	DV	2.406	-
mean	63.71	60.50	60.66	62.26	70.00	63.42			
Season II									
d_1	61.33	57.07	59.97	61.70	66.27	61.27	D	0.391	-
d_2	60.60	60.13	60.70	63.30	63.40	61.63	V	0.814	2.655
d_3	60.50	59.77	58.40	60.23	61.23	60.03	DV	0.818	2.452
mean	60.81	58.99	59.69	61.74	63.63	60.97			
Season III									
d_1	63.33	58.63	60.00	59.10	63.60	60.93	D	0.166	0.651
d_2	59.47	59.03	59.10	60.87	62.10	60.11	V	0.709	2.311
d_3	59.50	58.43	59.00	59.10	63.77	59.96	DV	0.903	-
mean	60.77	58.70	59.37	59.69	63.16	60.34			

Season III

In this season both dates of transplanting and varieties, responded differently in nitrogen uptake. Transplanting on d_1 registered a higher nitrogen uptake values than d_2 and d_3 which were on par. All the high yielding varieties were on par and recorded lower nitrogen uptake values than v_5.

4.1.3.1.6 Nitrogen uptake by straw (Table 50)

Season I

The main effect of dates of transplanting, varieties and their interactions were significant. Transplanting on d_1 registered a higher nitrogen uptake value. Kanchana registered significantly higher nitrogen uptake by straw and was on par with v_2 and v_4. Local variety reported lesser uptake and was on par with v_2 and v_3.

Season II

Dates of transplanting and varieties significantly influenced nitrogen uptake by straw. Only varietal difference was observed in nitrogen uptake. Transplanting on d_1 registered a higher nitrogen uptake value. Kairali registered a higher nitrogen uptake in comparison with other varieties, which were on par.

Season III

Dates of transplanting and varieties significantly influenced nitrogen uptake by straw. Transplanting on d_1 registered a higher nitrogen uptake value. Here also all the high yielding varieties registered a significantly higher nitrogen uptake than local variety, however no significant difference was observed among high yielding varieties.

4.1.3.1.7 **Nitrogen uptake by grain** (Table 51)

Season I

Dates of transplanting significantly influenced nitrogen uptake by grain. Transplanting on d_3 resulted in lower uptake of nitrogen by grain.

Season II

Nitrogen uptake by grain was significantly influenced by dates of traısplanting. Early transplanting reulted in higher nitrogen uptake.

Season III

Dates of transplanting significantly influenced nitrogen uptake by grain. Transplanting on d_3 resulted in lower uptake of nitrogen by grain.

4.1.3.2. Phosphorus uptake

4.1.3.2.1 **Phosphorus uptake at transplanting stage** (Table 52)

Season I

Only varietal difference was observed. Maximum phosphorus uptake was registered by v_5, which was significantly higher than that of high yielding varieties. Among the high yielding varieties, v_1 and v_4 were on par, but uptake of phosphorus by v_1 was significantly higher than that of v_2 and v_3. Lowest phosphorus uptake was registered by v_3.

Season II

There was inconsistency in phosphorus uptake by varieties in different transplanting dates. When transplanted on d_1, maximum uptake was by v_5, which was significantly higher than that of high yielding varieties. Among high yielding varieties, v_1 and v_4 were on par, but uptake of phosphorus by v_1 was higher than that of v_2 and v_3. The lowest uptake was registered by v_3. When transplanted on d_2, uptake of v_5 was on par with v_1, but significantly higher than that of remaining high yielding varieties. The variety v_3 recorded

Table 50 Nitrogen uptake by straw (kg ha^{-1}) as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	41.91	39.65	38.63	41.35	38.25	32.31	D	0.908	3.563
d_2	38.68	37.69	38.20	38.44	37.10	30.60	V	0.618	2.015
d_3	37.97	36.37	34.07	36.72	34.62	27.03	DV	1.388	-
mean	39.52	37.90	36.96	38.84	36.66	29.98			
Season II									
d_1	39.89	39.06	37.84	36.60	37.50	23.36	D	0.508	1.993
d_2	37.38	36.79	36.20	37.14	37.20	22.07	V	0.303	0.989
d_3	37.31	35.66	35.62	31.50	36.83	21.72	DV	0.495	
mean	38.19	37.17	36.55	35.08	37.18	22.38			
Season III									
d_1	38.56	38.23	37.45	37.99	35.86	37.62	D	0.334	1.310
d_2	36.91	36.12	35.54	36.50	35.27	36.07	V	0.320	1.044
d_3	36.22	36.19	35.55	36.70	33.82	35.70	DV	0.496	-
mean	37.23	36.85	36.18	37.06	34.98	36.46			

Table 51 Nitrogen uptake of by grain (kg ha^{-1}) as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	51.23	48.46	47.28	50.55	46.14	48.73	D	1.067	4.187
d_2	47.28	47.20	46.68	47.80	44.71	46.73	V	0.859	-
d_3	43.12	43.16	42.63	42.72	45.50	43.43	DV	1.601	-
mean	47.21	46.27	45.53	47.02	45.45	46.30			
Season II									
d_1	45.43	47.74	47.32	48.75	45.21	46.89	D	0.643	2.523
d_2	45.75	46.07	45.32	46.00	45.82	45.79	V	0.388	-
d_3	42.47	41.22	42.45	45.17	44.02	43.07	DV	0.838	-
mean	30.39	31.27	30.88	31.58	30.34	30.89			
Season III									
d_1	48.40	45.08	47.30	46.07	44.82	46.34	D	0.294	1.153
d_2	45.93	46.44	46.75	44.61	44.84	45.71	V	0.612	-
d_3	44.91	45.40	44.34	44.20	43.07	44.38	DV	0.664	
mean	30.28	30.61	30.36	29.60	29.30	30.03			

significantly lower uptake compared to remaining varieties. Transplanting on d_3 also registered a significantly higher phosphorus uptake value for v_5. Among high yielding varieties, v_1 and v_4 were on par, but registered a higher uptake value than v_3 and v_2. Phosphorus uptake by v_4 was significantly higher than v_2.

Season III

Both dates of transplanting, varietal difference and their interactions had significant effect on phosphorus uptake. Maximum uptake was seen in plants transplanted on d_1, followed by d_2 and d_3. Whatever be the date of transplanting phosphorus uptake of v_5 was significantly higher than that of high yielding varieties. When transplanted on d_1, uptake of v_4, v_2 and v_3 were on par, but v_1 had higher phosphorus uptake than v_2 and v_3. When transplanted on d_2 and d_3, v_1, v_4 and v_2 were on par and had a higher uptake values than v_3.

4.1.3.2.2 Phosphorus uptake at active tillering stage (Table 53)

Season I

Both dates of transplanting and varieties significantly influenced the phosphorus uptake, but no interactions were observed. Early transplanting resulted in more phosphorus uptake. Transplanting on d_3 resulted in lowest phosphorus uptake. Local variety recorded the maximum phosphorus uptake. Among high yielding varieties, uptake by v_4 was significantly higher than that of v_3.

Season II

Varieties and their interaction with dates of transplanting significantly influenced the phosphorus uptake. Under different dates of transplanting, v_5 registered maximum phosphorus uptake. Among high yielding varieties, phosphorus uptake of v_1 and v_4 were on par and significantly higher than that of v_2 and v_3, when transplanted either on d_1 and d_3. But transplanting on d_2 resulted in higher phosphorus uptake by v_1 in comparison with remaining high yielding varieties.

Table 52 **Phosphorus uptake (kg ha^{-1}) at transplanting stage as influenced by different dates of transplanting and varieties in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.561	0.528	0.500	0.575	0.627	0.558	D	0.1750	-
d_2	0.512	0.485	0.488	0.532	0.619	0.527	V	0.0078	0.0254
d_3	0.511	0.483	0.419	0.461	0.574	0.489	DV	0.0288	-
mean	0.528	0.499	0.469	0.522	0.607	0.525			
Season II									
d_1	0.526	0.493	0.448	0.513	0.604	0.517	D	0.0083	-
d_2	0.512	0.478	0.444	0.487	0.528	0.490	V	0.0089	0.0290
d_3	0.498	0.451	0.456	0.491	0.574	0.494	DV	0.0105	0.0314
mean	0.512	0.474	0.449	0.497	0.569	0.500			
Season III									
d_1	0.470	0.444	0.439	0.464	0.563	0.476	D	0.0019	0.0070
d_2	0.463	0.437	0.411	0.455	0.573	0.468	V	0.0062	0.0200
d_3	0.467	0.464	0.427	0.464	0.499	0.464	DV	0.0095	0.0290
mean	0.467	0.448	0.426	0.461	0.545	0.469			

Table 53 **Phosphorus uptake (kg ha^{-1}) at active tillering stage as influenced by different dates of transplanting and varieties in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	13.50	13.13	12.97	13.87	16.48	13.99	D	0.253	0.992
d_2	12.43	12.27	12.00	13.40	16.00	13.22	V	0.192	0.628
d_3	12.50	11.47	10.53	11.33	14.73	12.11	DV	0.581	-
mean	12.81	12.29	11.83	12.87	15.74	13.11			
Season II									
d_1	12.83	11.73	11.47	12.37	15.33	12.75	D	0.145	-
d_2	12.40	11.50	11.43	11.70	13.37	12.08	V	0.140	0.458
d_3	12.33	11.20	11.50	12.10	14.73	12.37	DV	0.160	0.480
mean	12.52	11.48	11.47	12.06	14.48	12.40			
Season III									
d_1	11.80	11.23	11.40	11.53	14.23	12.04	D	0.032	0.125
d_2	11.23	11.30	10.33	11.07	14.60	11.71	V	0.125	0.407
d_3	11.63	11.33	10.97	11.50	13.17	11.72	DV	0.182	0.546
mean	11.56	11.29	10.90	11.37	14.00	11.82			

Season III

Phosphorus uptake was significantly influenced by dates of transplanting, varieties and their interactions. Here also v_5 registered higher uptake values on all dates of transplanting. When transplanted on d_1, v_1, v_2 and v_4 were on par and registered higher phosphorus uptake than v_3. Transplanting on d_2 registered a higher phosphorus uptake for v_1 against v_2. While transplanting on d_3 resulted in high uptake by v_1 in comparison with v_3.

4.1.3.2.3 Phosphorus uptake at panicle initiation stage (Table 54)

Season I

Varietal difference alone was observed. Maximum phosphorus uptake was registered by v_5. Among high yielding varieties, v_1 and v_4 were on par and recorded higher uptake value than v_2 and v_3.

Season II

Varietal difference alone was observed. Maximum uptake was recorded by v_5. Among high yielding varieties, v_1 and v_4 were on par, but registered higher uptake values than v_2 and v_3, which were also on par.

Season III

Varietal difference alone was observed. Maximum uptake was recorded by v_5. Among high yielding varieties, v_1 registered maximum uptake followed by v_4 and these varieties registered higher uptake values than v_2 and v_3, which were on par.

4.1.3.2.4 Phosphorus uptake at heading stage (Table 55)

Season I

Dates of transplanting, varieties and their interactions influenced the phosphorus uptake. For d_1 transplanting maximum phosphorus uptake was reported by v_5 followed by v_1, which was significantly higher than that of v_3. When transplanted on d_2, phosphorus uptake was more or less similar in the case of v_5 and v_1, but significantly higher than remaining varieties. Kairali (v_4) also registered higher uptake values than v_2 and v_3. No significant difference in phosphorus uptake was seen among high yielding varieties, when transplanted on d_3, but significantly lesser than that of v_5.

Season II

Varietal difference alone was observed. Maximum phosphorus uptake was registered by v_5 followed by v_1, which was significantly higher than that of v_2 and v_3.

Season III

Varietal difference alone was observed. Maximum phosphorus uptake was registered by v_5 followed by v_1, which was significantly higher than that of v_2 and v_3.

4.1.3.2.5 Phosphorus uptake at beginning of grain filling stage (Table 56)

Season I

Phosphorus uptake was significantly influenced by dates of transplanting and varieties. Early transplanting resulted in higher phosphorous uptake. A significant reduction in phosphorous uptake was seen when transplanted on d_3. Local variety recorded higher phosphorous uptake followed by v_1, which was superior to v_2 and v_3.

Season II

Varietal difference alone was observed. Local variety registered higher phosphorus uptake followed by v_1, which was significantly superior to v_3.

Season III

Varietal difference alone was observed. Among varieties, v_5 was found superior followed by v_1, which was significantly higher than other varieties.

4.1.3.2.6 Phosphorus uptake by straw (Table 57)

Season I

Both main effects significantly influenced phosphorus uptake by straw. Transplanting on d_3 resulted in significant reduction in phosphorus uptake. Local variety

Table 54 Phosphorus uptake (kg ha^{-1}) at panicle initiation stage as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	15.60	14.87	14.87	14.97	17.80	15.62	D	0.186	-
d_2	15.47	14.47	13.97	15.70	18.53	15.63	V	0.174	0.567
d_3	14.20	13.73	13.50	15.03	18.10	14.91	DV	0.476	-
mean	15.09	14:36	14.11	15.23	18.14	15.39			
Season II									
d_1	15.17	14.10	14.03	14.50	18.43	15.25	D	0.215	-
d_2	14.90	14.33	14.33	14.67	18.33	15.31	V	0.233	0.760
d_3	14.60	13.77	13.33	14.47	18.60	14.95	DV	0.418	-
mean	14.89	14.07	13.90	14.54	18.46	15.17			
Season III									
d_1	14.43	13.67	13.80	14.27	18.47	14.93	D	0.059	-
d_2	14.47	13.87	13.73	14.30	18.70	15.01	V	0.111	0.361
d_3	14.63	13.70	13.70	13.80	18.30	14.83	DV	0.182	-
mean	14.51	13.74	13.74	14.12	18.49	14.92			

Table 55 Phosphorus uptake (kg ha^{-1}) at heading stage as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	18.40	17.70	17.30	17.87	20.30	18.31	D	0.203	0.797
d_2	19.33	16.63	16.57	18.33	20.13	18.20	V	0.198	0.645
d_3	16.23	16.13	15.97	16.27	19.33	16.79	DV	0.317	0.950
mean	17.99	16.82	16.61	17.49	19.92	17.77			
Season II									
d_1	17.90	17.17	17.40	17.90	19.30	17.93	D	0.237	-
d_2	17.50	16.70	16.57	16.77	19.40	17.39	V	0.225	0.735
d_3	17.60	16.90	16.23	16.70	19.37	17.36	DV	0.430	-
mean	17.67	16.92	16.73	17.12	19.36	17.56			
Season III									
d_1	17.00	16.43	16.67	17.13	19.57	17.36	D	0.072	-
d_2	17.00	16.63	16.77	16.43	19.73	17.31	V	0.123	0.401
d_3	17.10	16.13	16.30	16.40	19.53	17.09	DV	0.355	-
mean	17.03	16.40	16.58	16.66	19.61	17.26			

recorded least phosphorus uptake. Among high yielding varieties, uptake of v_3 was significantly lesser than others, which in turn were on par.

Season II

Phosphorus uptake was significantly influenced by dates of transplanting and varieties. Transplanting on d_3 resulted in significant reduction in phosphorus uptake and it was on par with d_2. All the high yielding varieties were on par in their phosphorus uptake but were significantly higher than that of v_5.

Season III

Only varietal difference was seen. Maximum phosphorus uptake was registered by d_1 transplanting. All the high yielding varieties were on par in their phosphorus uptake but were significantly higher than that of v_5.

4.1.3.2.7 Phosphorus uptake by grain (Table 58)

Season I

Phosphorus uptake was significantly influenced by dates of transplanting and varieties. Early transplanting resulted in higher phosphorus uptake. But no significant difference was observed between phosphorus uptake of plants transplanted on d_1 and d_2. v_5 recorded the lowest phosphorus uptake value. Among high yielding varieties, v_3 registered the lowest phosphorus uptake and maximum phosphorus uptake was reported from v_1, which was on par with v_2. Both of them were superior to v_3.

Season II

Dates of transplanting significantly influenced phosphorus uptake by grain with maximum uptake by d_1 transplanting.

Season III

Phosphorus uptake was significantly influenced by dates of transplanting and varieties. Maximum uptake was registered by d_1 transplanting. All high yielding varieties were on par and had higher phosphorus uptake value than local variety.

Table 56 Phosphorus uptake (kg ha^{-1}) at beginning grain filling stage as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	19.43	18.20	17.77	18.97	20.67	19.01	D	0.115	0.451
d_2	19.77	17.10	17.27	18.83	20.77	18.75	V	0.246	0.802
d_3	16.73	17.00	16.43	16.67	19.83	17.33	DV	0.411	-
mean	18.64	17.43	17.16	18.16	20.42	18.36			
Season II									
d_1	18.23	17.53	17.87	18.40	19.67	18.34	D	0.215	-
d_2	17.97	17.10	16.90	17.37	19.77	17.82	V	0.225	0.734
d_3	18.03	17.43	16.63	17.13	19.83	17.81	DV	0.415	-
mean	18.08	17.36	17.13	17.63	19.76	17.99			
Season III									
d_1	17.53	16.93	16.97	17.53	20.07	17.81	D	0.086	-
d_2	17.57	17.20	17.30	16.97	19.87	17.78	V	0.132	0.429
d_3	17.57	16.63	16.77	16.80	19.93	17.54	DV	0.358	-
mean	17.56	16.92	17.01	17.10	19.96	17.71			

Table 57 Phosphorus uptake by straw (kg ha^{-1}) as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	10.52	10.35	9.65	10.51	9.37	10.08	D	0.074	2.898
d_2	10.43	9.98	9.82	10.46	9.47	10.03	V	0.115	3.961
d_3	9.75	9.95	9.54	9.39	8.96	9.52	DV	0.222	-
mean	10.23	10.10	9.67	10.12	9.26	9.88			
Season II									
d_1	10.42	10.35	10.24	9.81	9.40	10.04	D	0.193	0.757
d_2	9.85	9.65	9.47	9.61	9.27	9.57	V	0.165	0.540
d_3	9.47	9.57	9.31	9.55	8.38	9.26	DV	0.261	-
mean	6.44	6.41	6.26	6.39	5.88	6.28			
Season III									
d_1	9.92	10.13	10.05	10.02	8.53	9.73	D	0.0656	0.257
d_2	10.02	9.83	9.54	9.22	8.64	9.45	V	0.1767	0.576
d_3	9.25	9.35	9.43	9.38	8.51	9.18	DV	0.218	-
mean	6.42	6.39	6.32	6.20	5.71	6.21			

4.1.3.3 Potassium uptake

4.1.3.3.1 **Potassium uptake at transplanting stage** (Table 59)

Season I

Dates of transplanting, varieties and their interactions influenced the potassium uptake. When transplanted on d_1, v_5 registered maximum potassium uptake. Among the high yielding varieties, potassium uptake of v_4 was significantly higher than v_3.. Transplanting on d_2 also gave high potassium uptake value for v_5. Here the uptake of v_1 was significantly higher than v_3 and v_2 while that of v_4 was higher than v_2. Late transplanting on d_3 resulted in high uptake value for v_5 only against v_4.

Season II

Dates of transplanting, varieties and their interactions influenced the potassium uptake. Transplanting on d_1 did not result in any significant difference among high yielding varieties, with respect to potassium uptake, but uptake was significantly lesser than that of v_5. When transplanted on d_2, potassium uptake of v_5 was on par with v_1 and significantly higher than that of remaining high yielding varieties. Potassium uptake of v_3 was significantly lesser than that of v_1 and v_4. Transplanting on d_3 also registered a higher potassium uptake by local variety than high yielding varieties, which were on par.

Season III

Both the main effects were significant. Early transplanting resulted in high potassium uptake. Maximum potassium uptake was registered by v_5 while uptake of v_1 was significantly higher than that of v_2 and v_3.

4.1.3.3.2 **Potassium uptake by plants at active tillering stage** (Table 60)

Season I

Dates of transplanting and varieties significantly influenced potassium uptake. High yielding varieties showed significantly lesser potassium uptake than local variety.

Table 58 Phosphorus uptake by grain(kg ha -1) as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	21.25	20.71	19.33	20.68	19.15	20.22	D	0.142	0.556
d_2	20.53	19.98	19.32	20.57	18.82	19.84	V	0.204	0.665
d_3	19.18	19.58	18.76	18.48	17.25	18.65	DV	0.436	-
mean	20.32	20.09	19.14	19.91	18.41	19.57			
Season II									
d_1	19.29	20.37	23.48	20.50	18.53	20.44	D	0.519	2.037
d_2	19.56	18.99	18.63	19.38	18.62	19.04	V	0.599	-
d_3	13.38	18.43	18.90	18.23	18.53	17.49	DV	1.039	-
mean	10.98	12.47	12.51	12.54	12.38	12.18			
Season III									
d_1	20.00	19.93	19.51	18.46	17.36	15.05	D	0.195	0.765
d_2	19.78	18.88	19.71	19.71	16.37	14.93	V	0.644	1.122
d_3	18.60	18.84	19.01	17.63	17.18	14.53	DV	0.389	-
mean	19.63	19.38	19.58	18.77	16.97	18.87			

Table 59 Potassium uptake(kg ha $^{-1}$) at transplanting stage as influenced by different dates of planting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.545	1.489	1.366	1.687	1.906	1.598	D	0.2400	0.0943
d_2	1.684	1.344	1.399	1.584	1.928	1.588	V	0.0309	0.1010
d_3	1.396	1.436	1.396	1.299	1.559	1.417	DV	0.0704	0.2110
mean	1.542	1.423	1.387	1.523	1.798	1.535			
Season II									
d_1	1.464	1.334	1.412	1.447	2.024	1.536	D	0.0388	0.1520
d_2	1.578	1.529	1.354	1.549	1.767	1.555	V	0.0496	0.1620
d_3	1.135	1.251	1.180	1.305	1.875	1.349	DV	0.0641	0.1920
mean	1.392	1.371	1.315	1.434	1.889	1.480			
Season III									
d_1	1.478	1.322	1.273	1.463	1.936	1.494	D	0.0170	0.0667
d_2	1.422	1.325	1.215	1.314	1.708	1.397	V	0.0329	0.1070
d_3	1.273	1.172	1.259	1.271	1.778	1.351	DV	0.0556	
mean	1.391	1.273	1.249	1.349	1.808	1.414			

Plant transplanted on d_1, gave higher uptake value than plants transplanted on d_3. Among high yielding varieties, potassium uptake in v_1 was significantly higher than v_2 and v_3 while v_4 also reported a higher uptake value than v_2.

Season II

Potassium uptake was significantly influenced by dates of transplanting, varieties and their interactions. All the high yielding varieties recorded more or less similar potassium uptake values but significantly lesser value than v_5.

Season III

Potassium uptake was significantly influenced by dates of transplanting and varieties. Plant transplanted on d_1 gave higher uptake values than plants transplanted on d_3. Among high yielding varieties uptake of v_1 was significantly higher than that of v_3.

4.1.3.3.3 Potassium uptake by plants at panicle initiation stage (Table 61)

Season I

Potassium uptake was significantly influenced by dates of transplanting and varieties. Potassium uptake was not significantly different when transplanted on d_1 and $_2$ and significantly higher than d_3. All the high yielding varieties registered lesser uptake than local variety, while v_1 having higher uptake value than v_2 and v_3.

Season II

Potassium uptake was significantly influenced by dates of transplanting and varieties. Maximum uptake was registered by plants transplanted on d_1 and minimum uptake was recorded by d_3. Among the high yielding varieties, v_1 gave high uptake value than v_2 and v_3, while v_4 reported a higher uptake value than v_3.

Season III

Varieties and their interactions with dates of transplanting influenced the potassium uptake. Local variety registered maximum uptake on all dates of transplanting. Transplanting on d_1 gave higher uptake value for v_1 than v_2, while on d_2, v_2 registered a higher value than v_3 and no significant difference was seen among high yielding varieties.

Table 60 **Potassium uptake (kg ha $^{-1}$) at active tillering stage as influenced by different dates of transplanting and varieties in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	34.27	29.40	30.67	32.77	40.93	33.61	D	0.514	2.019
d_2	32.97	29.10	28.53	32.53	39.50	32.53	V	0.485	1.580
d_3	28.10	26.47	27.90	27.20	34.60	28.85	DV	1.023	-
mean	31.78	28.32	29.03	30.83	38.34	31.66			
Season II									
d_1	30.97	26.63	29.20	28.53	39.57	30.98	D	0.472	1.854
d_2	30.07	28.33	28.33	30.27	35.43	30.49	V	0.756	2.466
d_3	23.50	24.73	24.17	25.87	39.00	27.45	DV	1.254	3.759
mean	28.18	26.57	27.23	28.22	38.00	29.64			
Season III									
d_1	29.03	27.83	26.33	28.50	38.93	30.13	D	0.326	1.280
d_2	28.47	28.00	27.30	29.03	36.63	29.89	V	0.356	1.161
d_3	26.77	26.43	26.33	25.87	36.67	28.41	DV	0.813	-
mean	28.09	27.42	26.66	27.80	37.41	29.48			

Table 61 **Potassium uptake (kg ha $^{-1}$) at panicle initiation stage as influenced by different dates of transplanting and varieties in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	57.90	54.50	55.03	55.13	76.27	59.77	D	0.410	1.608
d_2	59.70	53.30	54.53	56.47	77.00	60.20	V	0.790	2.576
d_3	49.57	48.73	46.60	50.17	72.03	53.42	DV	0.847	-
mean	55.72	52.18	52.06	53.92	75.10	57.80			
Season II									
d_1	54.87	54.20	54.30	55.47	71.33	58.03	D	0.390	1.531
d_2	55.00	51.35	49.93	54.73	70.07	56.22	V	0.751	2.450
d_3	53.93	49.83	49.30	52.50	69.07	54.93	DV	0.106	-
mean	54.60	51.79	51.18	54.23	70.16	56.39			
Season III									
d_1	54.03	50.13	52.03	51.00	72.73	55.99	D	0.560	-
d_2	52.63	54.73	50.97	53.97	65.30	55.52	V	1.197	3.904
d_3	55.13	51.63	51.60	51.90	63.67	54.79	DV	1.175	3.522
mean	53.93	52.17	51.53	52.29	67.23	55.43			

4.1.3.3.4 **Potassium uptake by plants at heading stage** (Table 62)

Season I

Potassium uptake was significantly influenced by dates of transplanting and varieties. d_1 transplanting resulted in higher potassium uptake while d_3 registered least uptake. Potassium uptake by high yielding varieties was lower than local variety and among high yielding varieties, v_1 and v_4 gave higher uptake values than v_2 and v_3.

Season II

Only varietal difference was seen. Potassium uptake by v_5 was not found to be higher than that of v_1 and v_4. Uptake of v_1 was significantly higher than that of v_2 and v_3 and on par with v_4.

Season III

Varietal difference alone was observed. In this season also, v_1 and v_5 were on par and significantly higher than that of v_2, v_3 and v_4. Lowest uptake was registered by v_3. Uptake of v_4 was significantly higher than that of v_2 and v_3.

4.1.3.3.5 Potassium uptake by plants at beginning of grain filling stage (Table 63)

Season I

Potassium uptake was significantly influenced by dates of transplanting and varieties. Transplanting on d_1 resulted in maximum and d_3 resulted in minimum potassium uptake. Uptake of v_1 was on par with v_5 and significantly higher than other varieties. Among the high yielding varieties, v_4 reported a higher value that v_2 and v_3.

Season II

Only varietal difference was seen. Kanchana, v_4 and v_5 were on par and uptake of v_4 and v_5 are significantly higher than that of v_2 and v_3. Jyothi and v_4 were also not significantly different.

Table 62 Potassium uptake (kg ha^{-1}) at heading stage as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	83.07	77.57	77.30	79.33	91.70	81.79	D	0.770	3.024
d_2	82.00	73.10	73.80	78.53	86.00	78.69	V	1.076	3.509
d_3	77.03	67.07	65.20	77.23	84.13	74.13	DV	1.757	-
mean	80.70	72.58	72.10	78.37	87.28	78.20			
Season II									
d_1	85.60	78.00	76.47	79.67	81.47	80.24	D	0.960	-
d_2	80.67	75.73	74.30	79.47	82.67	78.57	V	1.274	4.155
d_3	79.73	75.40	70.70	75.87	82.97	76.93	DV	2.895	-
mean	82.00	76.38	73.82	78.33	82.37	78.58			
Season III									
d_1	87.60	84.10	82.23	85.67	86.40	85.20	D	0.374	-
d_2	87.43	81.87	77.47	82.17	88.80	83.55	V	0.522	1.704
d_3	86.83	82.03	79.57	86.53	87.13	84.42	DV	1.829	-
mean	87.29	82.67	79.76	84.79	87.44	84.39			

Table 63 Potassium uptake (kg ha^{-1})at beginning of grain filling stage as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	92.93	85.20	81.63	84.93	92.47	87.43	D	0.506	1.987
d_2	88.40	78.43	79.67	83.77	87.63	83.58	V	1.340	4.372
d_3	84.00	73.13	72.13	81.93	85.00	79.24	DV	1.688	-
mean	88.44	78.92	77.81	83.54	88.37	83.42			
Season II									
d_1	87.60	84.10	82.23	85.67	86.40	85.20	D	1.059	-
d_2	86.83	82.03	79.57	86.53	87.13	84.42	V	1.244	4.058
d_3	87.43	81.87	77.47	82.17	88.80	83.55	DV	3.320	-
mean	87.29	82.67	79.76	84.79	87.44	84.39			
Season III									
d_1	82.43	81.13	78.23	82.47	91.67	83.19	D	0.510	-
d_2	86.83	79.33	76.63	81.67	87.47	82.39	V	0.519	1.693
d_3	83.57	79.87	78.77	83.53	88.10	82.77	DV	1.939	-
mean	84.28	80.11	77.88	82.56	89.08	82.78			

Season III

Varietal difference alone was seen. Local variety reported higher uptake value. Among high yielding varieties, maximum uptake was recorded by v_1 followed by v_4, which was on par with v_2. The lowest uptake was recorded by v_3.

4.1.3.3.6 Potassium uptake by straw (Table 64)

Season I

Potassium uptake by straw was significantly influenced by dates of transplanting only. Early transplanting resulted in better uptake values.

Season II

Potassium uptake by straw was significantly influenced by both dates of transplanting and varieties. Early transplanting resulted in better uptake values. Among varieties maximum potassium uptake was recorded by $v_{1.}$ Lower uptake was registered by v_3 and it was on par with v_4.

Season III

Only varietal difference was seen. Local variety registered the lowest potassium uptake. Among high yielding varieties, v_1 registered significantly higher potassium uptake value than the remaining varieties and v_5 registered lowest uptake.

4.1.3.3.7 Potassium uptake by grain (Table 65)

Season I

Both the main effects were significant. Early transplanting resulted in higher uptake values. Among varieties, maximum potassium uptake was shown by v_1 which, was significantly higher than that of remaining varieties.

Season II

Only varietal difference was observed. Uptake of v_1 was on par with v_4 and v_2, but significantly higher that of v_3 and v_5.

Season III

Only varietal difference was seen. Local variety registered the lowest potassium uptake. Among high yielding varieties, v_1 registered significantly higher potassium uptake value than the remaining varieties, which were on par.

4.1.4 Incidence of pests and diseases

4.1.4.1 Incidence of gall midge

4.1.4.1.1 Gall midge incidence at active tillering stage (Table 66)

Season I

Dates of transplanting, varieties and their interactions influenced the gall midge incidence at this stage. Transplanting on d_1 resulted in less gall midge population. On all dates of transplanting, v_1, v_4 and v_5 were resistant to gall midge while v_2 and v_3 were affected by gall midge attack.

Season II

Gall midge incidence was significantly influenced by dates of transplanting, varieties and their interactions. In this season, less attack was seen on d_1 and d_2 transplanting . Whatever be the date of transplanting, v_1, v_4 and v_5 were resistant to this pest.

Season III

Incidence of gall midge was significantly influenced by dates of transplanting, varieties and their interactions. In this season, less attack was seen on plots transplanted on d_1 and d_2. On all dates of transplanting, v_1, v_4 and v_5 were resistant to this pest.

4.1.4.1.2 Gall midge incidence at panicle initiation stage (Table 67)

Season I

Gall midge incidence was significantly influenced by dates of transplanting,

Table 64 Potassium uptake by straw (kg ha $^{-1}$) as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	90.73	88.53	87.01	90.42	87.66	88.87	D	0.916	3.596
d_2	88.28	83.30	82.27	84.16	88.15	85.23	V	1.290	-
d_3	83.44	81.14	81.20	84.14	79.36	81.86	DV	1.816	-
mean	87.48	84.32	83.49	86.24	85.06	85.32			
Season II									
d_1	89.22	82.54	82.17	81.28	81.32	83.31	D	0.322	1.262
d_2	81.37	79.56	76.16	78.01	80.36	79.09	V	0.234	0.761
d_3	81.12	81.86	80.72	80.89	80.46	81.01	DV	0.427	-
mean	83.90	81.32	79.68	80.06	80.71	81.13			
Season III									
d_1	83.34	81.20	80.47	78.53	73.34	79.38	D	0.210	-
d_2	75.98	78.86	76.24	78.37	74.26	76.74	V	0.149	0.485
d_3	78.74	74.59	71.95	75.02	72.63	74.59	DV	0.386	-
mean	79.35	78.22	76.22	77.31	73.41	76.90			

Table 65 Potassium uptake by grain (kg ha $^{-1}$) as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	22.94	21.53	20.38	21.54	20.88	21.45	D	0.223	0.876
d_2	21.94	20.04	20.17	21.14	20.50	20.76	V	0.219	0.714
d_3	21.19	18.88	18.51	20.52	19.36	19.69	DV	0.335	-
mean	22.02	20.15	19.68	21.07	20.25	20.63			
Season II									
d_1	21.52	20.98	20.29	21.83	19.67	20.86	D	0.457	-
d_2	21.76	21.14	20.73	20.82	19.58	20.81	V	1.042	3.397
d_3	21.58	20.58	19.54	20.72	19.38	20.36	DV	1.727	-
mean	21.62	20.90	20.19	21.12	19.54	20.68			
Season III									
d_1	20.78	20.71	20.07	20.56	19.69	20.36	D	0.701	-
d_2	21.74	20.24	19.76	20.13	19.05	20.19	V	0.784	2.558
d_3	21.10	20.14	20.19	20.42	18.98	20.17	DV	1.648	-
mean	14.28	13.46	13.32	13.52	12.68	13.45			

varieties and their interactions. Among the high yielding varieties v_1 and v_4 were on par with local variety and were hundred per cent free from gall midge incidence. v_2 followed by v_3 were the susceptible varieties.

Season II

Incidence of gall midge was significantly influenced by dates of transplanting, varieties and their interactions. High yielding varieties v_1, v_4 and local variety were on par and were hundred per cent free from gall midge incidence. v_2 and v_3 were the susceptible varieties.

Season III

Gall midge incidence was significantly influenced by dates of transplanting, varieties and their interactions. When transplanted on d_1, v_2 and v_3 were on par . The rate of disease incidence in v_2 was significantly more than v_3 when transplanted on d_2 and d_3.

4.1.4.2 Incidence of rice bug (Table 68)

Season I

Only varietal difference was seen. All the high yielding varieties registered lower rice bug attack in comparison to local variety.

Season II and III

Rice bug attack was not significant in these seasons

4.1.4.3 Incidence of leaf roller

4.1.4.3.1 Incidence of leaf roller at active tillering stage (Table 69)

Season I

Only varietal difference was seen. The high yielding variety v_4 was completely free from leaf roller incidence. Maximum incidence was observed in local variety. No significant differences in the pest incidence were observed among v_1, v_2 and v_3 .

Season II

Dates of transplanting, varieties and their interactions significantly influenced the leaf roller incidence. The high yielding varieties v_4 was hundred per cent free from leaf roller

Table 66 Incidence of gall midge(silver shoots m^{-2})as influenced by different dates of transplanting and varieties at active tillering stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0(1.00)	1.50(1.58)	0.95(1.40)	0(1.00)	0(1.00)	0.49(1.20)	D	0.011	0.045
d_2	0(1.00)	2.79(1.95)	2.37(1.83)	0(1.00)	0(1.00)	1.03(1.36)	V	0.010	0.031
d_3	0(1.00)	5.15(2.48)	4.62(2.37)	0(1.00)	0(1.00)	1.95(1.57)	DV	0.021	0.064
mean	0(1.00)	3.15(2.04)	2.64(1.91)	0(1.00)	0(1.00)	1.16(1.39)			
Season II									
d_1	0(1.00)	0.88(1.37)	0.62(1.27)	0(1.00)	0(1.00)	0.30(1.13)	D	0.021	0.084
d_2	0(1.00)	1.18(1.48)	0.82(1.35)	0(1.00)	0(1.00)	0.40(1.17)	V	0.023	0.074
d_3	0(1.00)	5.92(2.85)	5.67(2.73)	0(1.00)	0(1.00)	2.32(2.26)	DV	0.030	0.090
mean	0(1.00)	2.66(1.93)	2.37(1.78)	0(1.00)	0(1.00)	0.98(1.52)			
Season III									
d_1	0(1.00)	0.64(1.22)	0.49(0.93)	0(1.00)	0(1.00)	0.23(1.03)	D	0.007	0.028
d_2	0(1.00)	0.87(1.37)	0.69(1.30)	0(1.00)	0(1.00)	0.31(1.13)	V	0.008	0.025
d_3	0(1.00)	5.86(1.29)	4.60(2.37)	0(1.00)	0(1.00)	2.09(1.33)	DV	0.019	0.057
mean	0(1.00)	2.14(1.77)	1.81(1.19)	0(1.00)	0(1.00)	0.88(1.16)			

Figures in parenthesis are transformed values

Table 67 Incidence of gall midge(silver shoots m-2)as influenced by different dates of transplanting and varieties at panicle initiation stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0(1.00)	0.62(1.27)	0.5(1.22)	0(1.00)	0(1.00)	0.22(1.10)	D	0.007	0.029
d_2	0(1.00)	1.95(1.72)	1.70(1.64)	0(1.00)	0(1.00)	0.73(1.27)	V	0.007	0.024
d_3	0(1.00)	2.73(1.93)	2.12(1.77)	0(1.00)	0(1.00)	0.97(1.34)	DV	0.017	0.051
mean	0(1.00)	1.77(1.64)	1.44(1.54)	0(1.00)	0(1.00)	0.64(1.24)			
Season II									
d_1	0(1.00)	0.16(1.08)	0.13(1.06)	0(1.00)	0(1.00)	0.06(1.03)	D	0.023	0.092
d_2	0(1.00)	1.23(1.49)	0.75(1.32)	0(1.00)	0(1.00)	0.40(1.16)	V	0.027	0.089
d_3	0(1.00)	2.50(1.77)	1.71(1.65)	0(1.00)	0(1.00)	0.84(1.28)	DV	0.034	0.102
mean	0(1.00)	1.30(1.45)	0.86(1.34)	0(1.00)	0(1.00)	0.43(1.15)			
Season III									
d_1	0(1.00)	1.67(1.63)	0.88(1.37)	0(1.00)	0(1.00)	0.51(1.20)	D	0.010	0.039
d_2	0(1.00)	1.77(1.66)	1.44(2.56)	0(1.00)	0(1.00)	0.64(1.25)	V	0.018	0.057
d_3	0(1.00)	5.28(2.51)	5.37(2.52)	0(1.00)	0(1.00)	2.13(1.61)	DV	0.023	0.069
mean	0(1.00)	2.91(1.93)	2.56(1.82)	0(1.00)	0(1.00)	1.09(1.35)			

Figures in parenthesis are transformed values

incidence. All the remaining high yielding varieties were on par on d_1 and d_2 while leaf roller incidence in v_5 was significantly lesser than v_2 and v_3 on d_3.

Season III

Leaf roller incidence was significantly influenced by dates of transplanting, varieties and their interactions. On all dates of transplanting the varieties v_4 was hundred per cent free from leaf roller incidence. Among the remaining varieties v_1, v_2 and v_5 were on par and the leaf roller incidence in v_5 was significantly lesser than v_3 for d_1 transplanting. No incidence of leaf roller was observed when transplanted on d_2. On d_3 also v_4 remained free from leaf roller incidence and the incidence in v_2 was significantly lesser than v_1 while all the remaining varieties were on par.

4.1.4.3.2 Incidence of leaf roller at panicle initiation stage (Table 70)

Season I

Dates of transplanting, varieties and their interactions significantly influenced the leaf roller incidence. Leaf roller incidence was absent in v_4. When transplanted on d_1, v_1, v_2, v_3 and v_5 were on par and susceptible to this pest, while on d_2 and d_3, v_5 was found to be more susceptible to leaf roller than v_1, v_2 and v_3 which were on par .

Season II

Leaf roller incidence was significantly influenced by dates of transplanting, varieties and their interactions. Leaf roller incidence was absent in v_4. On d_1 v_5 was on par with v_2 and was more susceptible than v_1 and v_3. While v_1, v_2 and v_5 were on par and v_3 was more resistant than these three varieties on d_2. v_2 was more resistant than v_1, v_3 and v_5 which were on par on d_3.

Season III

Only varietal difference was observed. Leaf roller incidence was absent in v_4. The varieties v_2 and v_3 were on par with v_5 and were more susceptible than v_1.

Table 68 Incidence of rice bug as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.23(1.11)	0.28(1.13)	0.27(1.13)	0.25(1.12)	0.58(1.16)	0.32(1.15)	D	0.005	-
d_2	0.25(1.12)	0.30(1.14)	0.29(1.14)	0.29(1.13)	0.60(1.26)	0.35(1.16)	V	0.011	0.035
d_3	0.29(1.13)	0.33(1.15)	0.30(1.14)	0.31(1.14)	0.59(1.26)	0.36(1.17)	DV	0.007	-
mean	0.26(1.12)	0.30(1.14)	0.29(1.14)	0.28(1.13)	0.59(1.26)	0.34(1.16)			
Season II									
d_1	2.30(1.81)	2.11(1.75)	2.19(1.78)	2.15(1.77)	2.20(1.78)	2.19(1.78)	D	0.076	-
d_2	2.39(1.83)	2.66(1.90)	2.37(1.83)	2.43(1.85)	2.55(1.88)	2.48(1.86)	V	0.020	-
d_3	2.64(1.91)	2.83(1.96)	2.85(1.96)	2.75(1.94)	2.95(1.99)	2.80(1.95)	DV	0.036	-
mean	2.44(1.85)	2.53(1.87)	2.47(1.86)	2.44(1.85)	2.57(1.88)	2.49(1.86)			
Season III									
d_1	6.75(2.78)	7.5(2.91)	7.75(2.95)	7.17(2.86)	7.25(2.87)	7.28(2.88)	D	0.128	-
d_2	7.00(2.83)	7.08(2.84)	7.33(2.88)	7.75(2.96)	7.25(2.85)	7.28(2.88)	V	0.091	-
d_3	7.58(2.93)	7.83(2.97)	7.92(2.98)	7.92(2.98)	7.00(2.82)	7.65(2.94)	DV	0.243	-
mean	7.11(2.85)	7.47(2.91)	7.67(2.94)	7.61(2.93)	7.17(2.85)	7.40(2.90)			

Figures in parenthesis are transformed values

Table 69 Incidence of leaf roller(damaged leaves hill^{-1})as influenced by different dates of transplanting and varieties at active tillering stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.23(1.11)	0.28(1.13)	0.27(1.13)	0(1.00)	0.58(1.26)	0.27(1.12)	D	0.004	-
d_2	0.25(1.12)	0.30(1.14)	0.29(1.14)	0(1.00)	0.60(1.26)	0.24(1.13)	V	0.010	0.032
d_3	0.29(1.13)	0.33(1.15)	0.30(1.14)	0(1.00)	0.59(1.26)	0.24(1.14)	DV	0.006	-
mean	0.25(1.12)	0.30(1.14)	0.29(1.13)	0(1.00)	0.59(1.26)	0.27(1.13)			
Season II									
d_1	0.60(1.26)	0.52(1.23)	0.57(1.25)	0(1.00)	0.57(1.25)	0.45(1.20)	D	0.003	0.011
d_2	0.90(1.38)	0.79(1.34)	0.84(1.36)	0(1.00)	0.82(1.35)	0.67(1.28)	V	0.013	0.041
d_3	0.32(1.15)	0.35(1.16)	0.39(1.18)	0(1.00)	0.23(1.11	0.26(1.12)	DV	0.016	0.047
mean	0.61(1.26)	0.55(1.24)	0.60(1.26)	0(1.00)	0.54(1.24)	0.46(1.20)			
Season III									
d_1	0.78(1.34)	0.79(1.34)	0.84(1.36)	0(1.00)	0.75(1.32)	0.63(1.27)	D	0.003	0.012
d_2	0.35 (1.16)	0.59(1.26)	0.60 (1.26)	0(1.00)	0.82 (1.35)	0.47(1.21)	V	0.009	0.029
d_3	0.60(1.26)	0.52(1.23	0.57(1.25)	0(1.00)	0.57(1.25)	0.45(1.20)	DV	0.010	0.030
mean	0.46(1.20)	0.44(1.19)	0.47(1.20)	0(1.00)	0.44(1.19)	0.36(1.16)			

Figures in parenthesis are transformed values

4.1.4.3.3 Incidence of leaf roller at heading stage (Table 71)

Season I

Leaf roller incidence was significantly influenced by dates of transplanting, varieties and their interactions. Making transplanting late resulted in higher incidence of leaf roller. Leaf roller incidence was absent in v_4. Transplanting in d_1 resulted in higher leaf roller incidence in v_3 while all varieties were on par. No significant difference in leaf roller attack was observed among v_1, v_2, v_3 and v_5 on d_1 while incidence in v_3 was significantly less than v_1 on d_2. On d_3 transplanting v_2, v_1 and v_5 were on par and highest incidence was seen in v_2.

Season II

Varieties and its interaction with dates of transplanting significantly influenced leaf roller incidence. Leaf roller incidence was absent in v_4. Both at d_1 and d_2, v_2 was the most susceptible one. On d_1 transplanting, v_3 and v_1 were on par and had more attack than v_5 while no significant difference among v_1, v_2 and v_5 was observed on d_2. On d_3, among v_1, v_2 and v_3, v_1 was more susceptible and v_3 and v_5 were on par and v_2 recorded fewer incidences than v_1, v_3 and v_5.

Season III

Leaf roller incidence was significantly influenced by varieties and its interaction with dates of transplanting. Leaf roller incidence was absent in v_4. On d_1, v_3, v_1 and v_5 were on par and v_3 and v_1 were found to have more leaf roller incidence than v_2. On d_2, v_1 was most susceptible followed by v_3. v_2 and v_5 were on par. On d_3, v_1 and v_3 were on par and had more incidence than v_2 and v_5.

4.1.4.4 Incidence of sheath rot (Table72)

Season I

Dates of transplanting and varieties significantly influenced the sheath rot incidence. Transplanting on d_1 resulted in lesser incidence of sheath rot. Sheath rot incidence was significantly less in local variety compared to high yielding varieties. No significant

Table 70 Incidence of leaf roller(damaged leaves hill^{-1})as influenced by different dates of transplanting and varieties at panicle initiation stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.25(1.50)	1.29(1.51)	1.22(1.49)	0(1.00)	1.39(1.52)	1.01(1.40)	D	0.004	0.017
d_2	1.41(1.55)	1.41(1.55)	1.47(1.57)	0(1.00)	2.38(1.84)	1.33(1.50)	V	0.013	0.045
d_3	2.58(1.89)	2.59(1.89)	2.46(1.86)	0(1.00)	3.02(2.00)	2.13(1.73)	DV	0.031	0.092
mean	1.75(1.65)	1.76(1.65)	1.72(1.64)	0(1.00)	2.23(1.79)	1.49(1.55)			
Season II									
d_1	3.07(2.02)	3.02(2.00)	2.84(1.96)	0(1.00)	2.84(1.96)	2.39(1.79)	D	0.019	0.074
d_2	3.05(2.01)	3.07(2.02)	2.42(1.85)	0(1.00)	3.44(2.11)	2.40(1.80)	V	0.029	0.093
d_3	3.43(2.11)	3.41(2.10)	3.02(2.00)	0(1.00)	3.05(2.01)	2.58(1.84)	DV	0.031	0.092
mean	3.18(2.04)	2.26(1.75)	2.76(1.97)	0(1.00)	3.11(2.03)	2.28(1.76)			
Season III									
d_1	2.78(1.89)	3.43(2.11)	3.44(2.11)	0(1.00)	3.64(2.15)	2.66(1.85)	D	0.014	-
d_2	2.78(1.89)	3.50(2.12)	3.45(2.11)	0(1.00)	3.72(2.17)	2.69(1.86)	V	0.014	0.045
d_3	2.90(1.92)	3.72(2.17)	3.89(2.21)	0(1.00)	3.58(2.14)	2.82(1.87)	DV	0.037	-
mean	2.82(1.90)	3.55(2.13)	3.59(2.14)	0(1.00)	3.65(2.16)	3.31(2.08)			

Figures in parenthesis are transformed values

Table 71 Incidence of leaf roller (damaged leaves hill^{-1}) as influenced by different dates of transplanting and varieties at heading stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	2.67(1.92)	2.67(1.92)	3.29(2.08)	0(1.00)	2.79(1.95)	2.27(1.77)	D	0.021	0.084
d_2	2.69(1.92)	2.67(1.92)	3.79(2.19)	0(1.00)	3.00(1.99)	2.38(1.79)	V	0.014	0.045
d_3	3.51(2.03)	3.47(2.01)	3.37(2.09)	0(1.00)	3.35(2.09)	2.74(1.91)	DV	0.052	0.155
mean	2.96(1.96)	2.86(1.97)	3.48(2.11)	0(1.00)	3.05(2.01)	2.5(1.82)			
Season II									
d_1	3.69(2.16)	4.57(2.36)	3.71(2.17)	0(1.00)	3.25(2.06)	3.04(1.95)	D	0.018	0.071
d_2	3.63(2.15)	4.71(2.39)	3.97(2.23)	0(1.00)	3.68(2.16)	3.20(1.99)	V	0.020	0.064
d_3	4.56(2.36)	2.36(1.83)	3.86(2.20)	0(1.00)	3.74(2.18)	2.90(1.91)	DV	0.031	0.093
mean	3.96(2.23)	3.88(2.190	3.85(2.20)	0(1.00)	3.56(2.13)	3.05(1.95)			
Season III									
d_1	3.94(2.22)	3.18(2.05)	3.97(2.23)	0(1.00)	3.58(2.14)	2.93(1.93)	D	0.024	0.094
d_2	4.56(2.36)	3.36(2.09)	3.93(2.22)	0(1.00)	3.34(2.08)	3.04(1.95)	V	0.022	0.072
d_3	4.56(2.36)	2.69(1.92)	4.15(2.27)	0(1.00)	2.84(1.96)	2.85(1.90)	DV	0.042	0.127
mean	4.35(2.31)	3.08(2.02)	4.02(2.24)	0(1.00)	3.25(2.06)	2.94(1.93)			

Figures in parenthesis are transformed values

difference was seen among v_4, v_2 and v_1. But they were more resistant to rot incidence than v_3.

Season II and III

Neither dates of transplanting nor varieties did influence sheath rot incidence in these seasons.

4.1.4.5 Incidence of sheath blight

4.1.4.5.1 Incidence of sheath blight at active tillering stage (Table 73)

Season I

Only varietal difference was seen. v_1, v_4 and v_5 were hundred per cent free from incidence of sheath blight. Sheath blight incidence of v_2 and v_3 were on par

Season II

Varieties and its interactions with dates of transplanting were significant. v_1, v_4 and v_5 were hundred per cent free from incidence of sheath blight while v_2 and v_3 were on par and was affected by sheath blight incidence on all dates of transplanting.

Season III

Sheath blight incidence was significantly influenced by dates of transplanting, varieties and their interactions. Earlier transplanting resulted in lesser disease incidence. Sheath blight incidence was absent in v_1, v_4 and v_5, while v_2 and v_3 were on par and was affected by sheath blight incidence on all dates of transplanting except with a difference for v_3 having a less incidence than v_2 on d_2.

4.1.4.5.2 Incidence of sheath blight at panicle initiation stage (Table 74)

Season I

Sheath blight incidence was significantly influenced by dates of transplanting, varieties and their interactions. Earlier transplanting resulted in lesser disease incidence.

Table 72 Incidence of sheath rot (% of affected tillers) as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.24(1.50)	1.30(1.52)	1.33(1.53)	1.27(1.51)	1.20(1.48)	1.27(1.50)	D	0.006	0.025
d_2	1.33(1.53)	1.30(1.54)9	1.63(1.62)	1.27(1.51)	1.13(1.46)	1.35(1.53)	V	0.008	0.026
d_3	1.44(1.56)	1.29(1.51)	1.57(1.36)	1.32(1.52)	1.20(1.50)	1.38(1.54)	DV	0.020	
mean	1.34(1.53)	1.30(1.52)2	1.51(1.50)	1.29(1.51)	1.18(1.48)	1.33(1.52)			
Season II									
d_1	3.32(2.08)	3.30(2.07)	3.73(2.02)	3.04(2.01)	2.90(1.97)	3.26(2.02)	D	0.025	-
d_2	3.23(2.06)	3.10(2.03)5	3.49(2.12)	3.14(2.03)	3.13(2.03)	3.23(2.06)	V	0.027	-
d_3	3.30(2.07)	3.20(2.06)6	3.48(2.11)	3.19(2.05)	3.29(2.07)	3.30(2.07)	DV	0.041	-
mean	3.28(2.07)	3.24(2.05)	3.57(2.08)	3.12(2.03)	3.11(2.02)	3.26(2.05)			
Season III									
d_1	2.56(1.89)	2.72(1.93)	2.53(1.88)	3.04(2.01)	2.47(1.86)	2.66(1.91)	D	0.012	-
d_2	2.66(1.91)	2.76(1.94)	2.9(1.97)	2.68(1.92)	2.75(1.94)	2.75(1.94)	V	0.026	-
d_3	2.82(1.95)	2.87(1.97)	2.97(1.99)	2.58(1.89)	2.65(1.91)	2.78(1.94)	DV	0.037	-
mean	2.68(1.92)	2.78(1.95)	2.8(1.95)	2.77(1.94)	2.62(1.90)	2.73(1.93)			

Figures in parenthesis are transformed values

Table 73 Incidence of sheath blight(% of affected tillers) as influenced by different dates of transplanting and varieties at transplanting stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0(1.00)	0.97(1.40)	0.89(1.37)	0(1.00)	0(1.00)	0.37(1.16)	D	0.010	-
d_2	0(1.00)	0.95(1.40)	1.01(1.42)	0(1.00)	0(1.00)	0.39(1.16)	V	0.011	0.037
d_3	0(1.00)	1.08(1.44)	1.03(1.43)	0(1.00)	0(1.00)	0.42(1.17)	DV	0.022	-
mean	0(1.00)	1.00(1.41)	0.98(1.41)	0(1.00)	0(1.00)	0.39(1.16)			
Season II									
d_1	0(1.00)	0.81(1.35)	0.90(1.38)	0(1.00)	0(1.00)	0.18(1.15)	D	0.007	0.026
d_2	0(1.00)	0.66(1.29)	0.66(1.29)	0(1.00)	0(1.00)	0.13(1.12)	V	0.005	0.018
d_3	0(1.00)	0.83(1.35)	0.82(1.35)	0(1.00)	0(1.00)	0.16(1.14)	DV	0.014	0.043
mean	0(1.00)	0.77(1.33)	0.79(1.34)	0(1.00)	0(1.00)	0.16(1.13)			
Season III									
d_1	0(1.00)	0.49(1.22)	0.54(1.24)	0(1.00)	0(1.00)	0.21(1.09)	D	0.004	0.014
d_2	0(1.00)	0.64(1.28)	0.58(1.25)	0(1.00)	0(1.00)	0.24(1.11)	V	0.006	0.018
d_3	0(1.00)	0.77(1.33)	0.77(1.33)	0(1.00)	0(1.00)	0.31(1.130	DV	0.007	0.021
mean	0(1.00)	0.63(1.28)	0.63(1.28)	0(1.00)	0(1.00)	0.25(1.11)			

Figures in parenthesis are transformed values

Sheath blight incidence was absent in v_1, v_4 and v_5 while the disease incidence was significantly higher in v_2 than v_3 on all dates of transplanting.

Season II

Varieties and its interaction with dates of transplanting significantly influenced sheath blight incidence. Sheath blight incidence was absent in v_1, v_4 and v_5 while v_2 and v_3 were on par and was affected by sheath blight incidence on all dates of transplanting except with a difference for v_3 having a less incidence than v_2 on d_3.

Season III

Sheath blight incidence was significantly influenced by dates of transplanting, varieties and their interactions. Earlier transplanting resulted in lesser disease incidence. Sheath blight incidence was absent in v_1, v_4 and v_5. On d_1 transplanting disease incidence was significantly higher in v_2 than v_3. The disease incidence of, v_2 and v_3 were on par on d_3 and higher in v_3 than v_2 on d_2.

4.2.4.5.3 Incidence of sheath blight at heading stage (Table 75)

Season I

Sheath blight incidence was significantly influenced by dates of transplanting, varieties and their interactions. Earlier transplanting resulted in lesser disease incidence. Sheath blight incidence was absent in v_1, v_4 and v_5 while v_2 and v_3 were on par and were affected with this disease and in general the disease incidence was higher in v_2 than v_3.

Season II

Dates of transplanting and varieties significantly influenced the sheath blight incidence. Late transplanting resulted in higher disease incidence. On all dates of transplanting v_1, v_4 and v_5 were hundred per cent free from sheath blight incidence while v_3 was having a lesser incidence than v_2 on d_3 transplanting.

Season III

Varieties and its interaction with date of transplanting significantly influenced the

Table 74 Incidence of sheath blight (% of affected tillers) as influenced by different dates of transplanting and varieties at panicle initiation stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0(1.00)	1.07(1.44)	0.97(1.41)	0(1.00)	0(1.00)	0.41(1.17)	D	0.002	0.006
d_2	0(1.00)	1.25(1.50)	0.96(1.40)	0(1.00)	0(1.00)	0.44(1.18)	V	0.002	0.008
d_3	0(1.00)	1.35(1.53)	1.23(1.49)	0(1.00)	0(1.00)	0.52(1.21)	DV	0.007	0.021
mean	0(1.00)	1.22(1.49)	1.05(1.43)	0(1.00)	0(1.00)	0.46(1.19)			
Season II									
d_1	0(1.00)	1.14(1.46)	1.11(1.45)	0(1.00)	0(1.00)	0.45(1.18)	D	0.012	0.046
d_2	0(1.00)	1.57(1.60)	1.21(1.45)	0(1.00)	0(1.00)	0.56(1.21)	V	0.010	0.032
d_3	0(1.00)	1.75(1.66)	1.29(1.51)	0(1.00)	0(1.00)	0.61(1.23)	DV	0.018	0.018
mean	0(1.00)	1.49(1.58)	1.20(1.47)	0(1.00)	0(1.00)	0.54(1.21)			
Season III									
d_1	0(1.00)	0.58(1.260	0.63(1.280	0(1.00)	0(1.00)	0.24(1.11)	D	0.005	0.020
d_2	0(1.00)	0.63(1.28)	0.70(1.30)	0(1.00)	0(1.00)	0.27(1.12)	V	0.002	0.006
d_3	0(1.00)	0.98(1.41)	0.88(1.37)	0(1.00)	0(1.00)	0.37(1.16)	DV	0.007	0.021
mean	0(1.00)	0.73(1.32)	0.74(1.32)	0(1.00)	0(1.00)	0.29(1.13)			

Figures in parenthesis are transformed values

Table 75 Incidence of sheath blight (% of affected tillers) as influenced by different dates of transplanting and varieties at heading stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0(1.00)	1.43(1.56)	1.33(1.53)	0(1.00)	0(1.00)	0.55(1.22)	D	0.005	0.019
d_2	0(1.00)	1.68(1.64)	1.52(1.59)	0(1.00)	0(1.00)	0.64(1.25)	V	0.007	0.024
d_3	0(1.00)	1.8(1.67)	1.75(1.66)	0(1.00)	0(1.00)	0.71(1.27)	DV	0.013	0.041
mean	0(1.00)	1.64(1.62)	1.53(1.59)	0(1.00)	0(1.00)	0.63(1.24)			
Season II									
d_1	0(1.00)	2.23(1.74)	2.23(1.74)	0(1.00)	0(1.00)	0.45(1.31)	D	0.002	0.009
d_2	0(1.00)	2.27(1.76)	2.25(1.75)	0(1.00)	0(1.00)	0.45(1.32)	V	0.007	0.024
d_3	0(1.00)	2.36(1.76)	2.33(1.71)	0(1.00)	0(1.00)	0.47(1.32)	DV	0.008	-
mean	0(1.00)	2.28(1.76)	2.27(1.74)	0(1.00)	0(1.00)	0.46(1.31)			
Season III									
d_1	0(1.00)	1.11(1.45)	0.96(1.40)	0(1.00)	0(1.00)	0.41(1.17)	D	0.041	-
d_2	0(1.00)	1.17(1.47)	1.00(1.41)	0(1.00)	0(1.00)	0.43(1.18)	V	0.008	0.026
d_3	0(1.00)	1.23(1.49)	0.99(1.41)	0(1.00)	0(1.00)	0.44(1.18)	DV	0.017	0.050
mean	0(1.00)	1.16(1.47)	0.98(1.41)	0(1.00)	0(1.00)	0.43(1.18)			

Figures in parenthesis are transformed values

sheath blight incidence. The varieties v_1, v_4 and v_5 were hundred per cent free from sheath blight incidence while v_3 was having a lesser incidence than v_2 on all dates of transplanting.

4.2.4.5.4 Incidence of sheath blight at beginning of grain filling stage (Table 76)

Season I

Sheath blight incidence was significantly influenced by dates of transplanting, varieties and their interactions. Sheath blight incidence was hundred per cent free for v_1, v_4 and v_5 on all dates of transplanting. The disease incidence in v_3 was significantly less than v_2 on d_1 and d_2. Late transplanting resulted in higher disease incidence.

Season II

Incidence of sheath blight was significantly influenced by dates of transplanting, varieties and their interactions. Sheath blight incidence was hundred per cent free for v_1, v_4 and v_5 while v_2 had high incidence than v_3 on all dates of transplanting except in d_1 where v_2 had lesser incidence than v_3

Season III

Incidence of sheath blight was significantly influenced by dates of transplanting, varieties and their interactions. Sheath blight incidence was hundred per cent free for v_1, v_4 and v_5 while v_3 was more affected than v_2 on d_1 and d_3 and vice versa in d_2.

4.1.5 Soil characters

4.1.5.1 Organic carbon content of soil (Table 77a, 77b, 77c and 77d)

Seasons I, II and III

Organic carbon content of soil was not significantly influenced by either different dates of transplanting or varieties at all stages of observation in these seasons.

4.1.5.2 pH of soil (Table 78a, 78b, 78c and 77d)

Seasons I, II and III

Neither different dates of transplanting nor varieties influenced the pH of soil at different stages of observation in these seasons.

Table 76 Incidence of sheath blight (% of affected tillers) as influenced by different dates of and varieties at beginning of grain filling stage in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0(1.00)	1.73(1.65)	1.62(1.61)	0(1.00)	0(1.00)	0.67(1.25)	D	0.003	0.013
d_2	0(1.00)	1.75(1.66)	1.64(1.62)	0(1.00)	0(1.00)	0.68(1.26)	V	0.003	0.011
d_3	0(1.00)	1.95(1.72)	2.01(1.74)	0(1.00)	0(1.00)	0.79(1.29)	DV	0.008	0.023
mean	0(1.00)	1.81(1.68)	1.76(1.66)	0(1.00)	0(1.00)	0.71(1.27)			
Season II									
d_1	0(1.00)	4.13(2.26)	4.80(2.41)	0(1.00)	0(1.00)	1.79(1.53)	D	0.006	0.024
d_2	0(1.00)	4.69(2.39)	4.46(2.34)	0(1.00)	0(1.00)	1.83(1.54)	V	0.004	0.014
d_3	0(1.00)	5.34(2.52)	4.94(2.44)	0(1.00)	0(1.00)	2.06(1.59)	DV	0.010	0.030
mean	0(1.00)	4.72(2.39)	4.73(2.39)	0(1.00)	0(1.00)	1.89(1.56)			
Season III									
d_1	0(1.00)	1.49(1.58)	1.65(1.63)	0(1.00)	0(1.00)	0.63(1.24)	D	0.003	0.010
d_2	0(1.00)	1.39(1.55)	1.36(1.53)	0(1.00)	0(1.00)	0.55(1.22)	V	0.010	0.033
d_3	0(1.00)	1.39(1.55)	1.73(1.65)	0(1.00)	0(1.00)	0.62(1.24)	DV	0.006	0.018
mean	0(1.00)	1.42(1.56)	1.58(1.61)	0(1.00)	0(1.00)	0.60(1.23)			

Figures in parenthesis are transformed values

Table77 a Organic carbon content of initial soil as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.130	1.150	1.150	1.120	1.137	1.137	D	0.0043	-
d_2	1.133	1.113	1.113	1.103	1.107	1.114	V	0.0047	-
d_3	1.127	1.120	1.130	1.120	1.123	1.124	DV	0.0100	-
mean	1.130	1.128	1.131	1.114	1.122	1.125			
Season II									
d_1	1.120	1.117	1.120	1.120	1.127	1.121	D	0.0054	-
d_2	1.133	1.140	1.123	1.123	1.110	1.126	V	0.0085	-
d_3	1.123	1.113	1.130	1.110	1.117	1.119	DV	0.0173	-
mean	1.126	1.123	1.124	1.118	1.118	1.122			
Season III									
d_1	1.123	1.127	1.130	1.120	1.120	1.124	D	0.0014	-
d_2	1.127	1.133	1.120	1.123	1.123	1.125	V	0.0046	-
d_3	1.113	1.103	1.120	1.107	1.117	1.112	DV	0.0074	-
mean	1.121	1.121	1.123	1.117	1.120	1.120			

Table 77 b Organic carbon content (%) of soil as influenced by different Dates of transplanting and varieties at 30 DAS in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.123	1.120	1.127	1.123	1.120	1.123	D	0.0084	-
d_2	1.100	1.130	1.103	1.107	1.110	1.110	V	0.0075	-
d_3	1.103	1.097	1.120	1.090	1.100	1.102	DV	0.0170	-
mean	1.109	1.116	1.117	1.107	1.110	1.112			
Season II									
d_1	1.110	1.117	1.113	1.097	1.107	1.109	D	0.0041	-
d_2	1.117	1.090	1.100	1.093	1.123	1.105	V	0.0070	-
d_3	1.100	1.093	1.123	1.080	1.097	1.099	DV	0.0125	-
mean	1.109	1.100	1.112	1.090	1.109	1.104			
Season III									
d_1	1.077	1.117	1.120	1.097	1.097	1.101	D	0.0025	-
d_2	1.117	1.117	1.097	1.103	1.127	1.112	V	0.0033	-
d_3	1.090	1.087	1.113	1.097	1.110	1.099	DV	0.0037	-
mean	1.094	1.107	1.110	1.099	1.111	1.104			

Table 77 c C Organic carbon content (%) of soil as influenced by different dates of transplanting and varieties at 60 DAS in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.110	1.103	1.130	1.097	1.100	1.108	D	.0.103	-
d_2	1.090	1.127	1.090	1.093	1.093	1.099	V	0.0074	-
d_3	1.097	1.080	1.073	1.077	1.090	1.083	DV	0.0160	-
mean	1.099	1.103	1.098	1.089	1.094	1.097			
Season II									
d_1	1.063	1.103	1.120	1.087	1.083	1.091	D	0.0051	-
d_2	1.107	1.073	1.080	1.077	1.087	1.085	V	0.0068	-
d_3	1.080	1.073	1.110	1.060	1.087	1.082	DV	0.0095	-
mean	1.083	1.083	1.103	1.074	1.086	1.086			
Season III									
d_1	1.060	1.097	1.107	1.083	1.077	1.085	D	0.0027	-
d_2	1.097	1.097	1.073	1.087	1.107	1.092	V	0.0030	-
d_3	1.073	1.077	1.093	1.070	1.093	1.081	DV	0.0031	-
mean	1.077	1.090	1.091	1.080	1.092	1.086			

Table 78 b pH of soil as influenced by different dates of transplanting and varieties at 30 days after transplanting in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	5.80	5.79	5.82	5.80	5.78	5.80	D	0.014	-
d_2	5.78	5.80	5.81	5.80	5.82	5.80	V	0.009	-
d_3	5.80	5.81	5.83	5.82	5.80	5.81	DV	0.030	-
mean	5.79	5.80	5.82	5.81	5.80	5.80			
Season II									
d_1	5.81	5.82	5.78	5.78	5.78	5.80	D	0.011	-
d_2	5.79	5.79	5.79	5.78	5.80	5.79	V	0.013	-
d_3	5.80	5.80	5.78	5.79	5.79	5.79	DV	0.017	-
mean	5.80	5.81	5.78	5.78	5.79	5.79			
Season III									
d_1	5.81	5.82	5.81	5.81	5.80	5.81	D	0.012	-
d_2	5.80	5.78	5.79	5.79	5.78	5.79	V	0.013	-
d_3	5.79	5.83	5.79	5.79	5.80	5.80	DV	0.022	-
mean	5.80	5.81	5.80	5.80	5.79	5.80			

Table 78 c pH of soil as influenced by different dates of transplanting and varieties at 60 days after transplanting in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	5.89	5.89	5.87	5.89	5.90	5.89	D	0.0163	-
d_2	5.91	5.88	5.87	5.90	5.87	5.89	V	0.0156	-
d_3	5.85	5.89	5.87	5.87	5.84	5.86	DV	0.0218	-
mean	5.88	5.89	5.87	5.89	5.87	5.88			
Season II									
d_1	5.91	5.91	5.88	5.91	5.88	5.90	D	0.0112	-
d_2	5.89	5.85	5.89	5.87	5.90	5.88	V	0.0118	-
d_3	5.88	5.90	5.90	5.89	5.89	5.89	DV	0.0193	-
mean	5.90	5.89	5.89	5.89	5.89	5.89			
Season III									
d_1	5.86	5.89	5.87	5.90	5.90	5.89	D	0.0090	-
d_2	5.88	5.90	5.91	5.91	5.88	5.89	V	0.0154	-
d_3	5.91	5.88	5.90	5.89	5.89	5.89	DV	0.0207	-
mean	5.88	5.89	5.89	5.90	5.89	5.89			

4.1.5.3 CEC of soil (Table 79a, 79b ,79c and 79d)

Seasons. I, II and III

Neither different dates of transplanting nor varieties influenced the CEC of soil at different stages of observation in these seasons.

EXPERIMENT AT PATTAMBI

4.2.1 Growth characters

4.2.1.1 Plant height (Table80)

Season I

When observation on plant height was taken at 30 DAT it was revealed that the high yielding varieties did not show any significant difference among themselves but local variety was significantly taller than other varieties on all dates of transplanting.

Observation at 60 DAT revealed that local variety was significantly taller than other varieties on all dates of transplanting and transplanting on d_1 resulted in taller plants for v_1 than v_3 and v_2. No significant difference among high yielding varieties was observed when transplanted on d_2, while v_2 plants were taller than v_1 and v_4 on d_3.

At harvest also local variety was significantly taller than other varieties and among d_1 transplanted plants v_3 had more height than v_1 and v_2. On d_2, v_2 was the dwarf one and v_1, v_3 and v_4 were on par, while on d_3 plant height of v_2 was significantly less than that of v_1 and the remaining varieties were on par.

Season II

Local variety was the tallest variety on all dates of transplanting. There was no significant difference among high yielding varieties on d_1 and d_2 transplanted plants at 30 DAT, while on d_3 v_1 was taller than v_2 and v_3.

When observation was taken on 60 DAT, local variety was tallest on all dates of transplanting. Transplanting on d_1 resulted in taller plants for v_1 and v_4 than v_2 and v_3, which were on par. On d_2, v_1 was on par with v_4 and was taller than v_2 and v_3 while v_4 was on par with v_3. But no significant difference among varieties was noticed in d_3.

Table 78 d pH of soil as influenced by different dates of transplanting and varieties at harvest in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	5.72	5.73	5.67	5.67	5.67	5.69	D	0.014	-
d_2	5.70	5.72	5.69	5.72	5.67	5.70	V	0.014	-
d_3	5.66	5.68	5.72	5.68	5.67	5.68	DV	0.020	-
mean	5.69	5.71	5.70	5.69	5.67	5.69			
Season II									
d_1	5.68	5.70	5.69	5.68	5.68	5.69	D	0.003	-
d_2	5.68	5.68	5.67	5.67	5.71	5.68	V	0.004	-
d_3	5.68	5.68	5.67	5.67	5.68	5.68	DV	0.004	-
mean	5.68	5.69	5.68	5.67	5.69	5.68			
Season III									
d_1	5.71	5.70	5.67	5.71	5.70	5.70	D	0.003	-
d_2	5.71	5.71	5.69	5.70	5.67	5.69	V	0.006	-
d_3	5.68	5.67	5.67	5.67	5.68	5.67	DV	0.087	-
mean	5.70	5.69	5.68	5.69	5.68	5.69			

Table 79 a CEC (C mol kg^{-1}) of initial soil as influenced by different dates of transplanting and varieties in different seasons at Vellayani

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	14.61	14.45	14.49	14.61	14.67	14.57	D	0.015	-
d_2	14.51	14.45	14.31	14.49	14.58	14.47	V	0.025	-
d_3	14.47	14.55	14.41	14.45	14.60	14.50	DV	0.035	-
mean	14.53	14.48	14.40	14.52	14.62	14.51			
Season II									
d_1	14.03	13.89	13.93	14.01	14.06	13.98	D	0.007	-
d_2	13.98	13.97	13.78	13.88	14.42	14.01	V	0.010	-
d_3	13.89	13.94	13.93	14.00	14.01	13.95	DV	0.022	-
mean	13.97	13.93	13.88	13.96	14.16	13.98			
Season III									
d_1	13.87	13.39	13.91	13.85	13.87	13.78	D	0.016	-
d_2	13.83	13.49	14.19	14.26	14.04	13.96	V	0.000	-
d_3	14.11	13.50	14.11	14.11	13.56	13.88	DV	0.000	-
mean	13.94	13.46	14.07	14.07	13.82	13.87			

Table 79 b **CEC(C mol kg^{-1}) of soil as influenced by different dates of transplanting and varieties at 30 days after transplanting in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	14.35	14.19	14.22	14.34	14.40	14.30	D	0.015	-
d_2	14.23	14.18	14.04	14.22	14.32	14.20	V	0.025	-
d_3	14.21	14.28	14.14	14.19	14.34	14.23	DV	0.034	-
mean	14.26	14.22	14.13	14.25	14.35	14.24			
Season II									
d_1	13.77	13.62	13.67	13.74	13.80	13.72	D	0.007	-
d_2	13.72	13.70	13.52	13.61	14.16	13.74	V	0.010	-
d_3	13.63	13.69	13.66	13.74	13.75	13.69	DV	0.022	-
mean	13.71	13.67	13.62	13.70	13.90	13.72			
Season III									
d_1	13.60	13.14	13.65	13.59	13.62	13.52	D	0.016	-
d_2	13.58	13.24	13.94	13.90	13.79	13.69	V	0.011	-
d_3	13.86	13.25	13.85	13.86	13.31	13.63	DV	0.012	-
mean	13.68	13.21	13.82	13.78	13.57	13.61			

Table 79 c **CEC(C mol kg^{-1}) of soil as influenced by different dates of transplanting and varieties at 60 days after transplanting in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	14.00	13.83	13.86	13.97	14.04	13.94	D	0.014	-
d_2	13.90	13.89	13.75	13.85	14.00	13.88	V	0.024	-
d_3	13.85	13.93	13.87	13.93	14.02	13.92	DV	0.034	-
mean	13.92	13.89	13.83	13.91	14.02	13.91			
Season II									
d_1	13.58	13.41	13.44	13.53	13.61	13.51	D	0.010	-
d_2	13.51	13.50	13.32	13.42	13.64	13.48	V	0.021	-
d_3	13.43	13.48	13.45	13.54	13.54	13.49	DV	0.023	-
mean	13.50	13.46	13.41	13.50	13.60	13.49			
Season III									
d_1	13.42	12.94	13.47	13.41	13.43	13.33	D	0.016	-
d_2	13.38	13.05	13.75	13.71	13.65	13.51	V	0.021	-
d_3	13.66	13.05	13.65	13.65	13.09	13.42	DV	0.031	-
mean	13.49	13.01	13.62	13.59	13.39	13.42			

When plant height was taken at harvest, local variety was the tallest on all dates of transplanting. Transplanting on d_1 revealed that v_1 and v_4 were on par and v_1 was taller than v_2 and v_3, which were on par. On d_2 plant height of v_3 was on par with v_1 but significantly higher than v_2 and v_4. On d_3 again v_1, v_2 and v_4 were on par and v_3 was taller than v_2 and v_4.

Season III

Highest plant height was registered by local variety and all high yielding varieties were on par at 30 DAT on all dates of transplanting.

At 60 DAT on all dates of transplanting local variety was the tallest and among d_1 transplanted plants v_1 was taller than v_3. All high yielding varieties were on par on d_2. On d_3, v_1 was taller than the remaining high yielding varieties.

At harvest also on all dates of transplanting local variety was the tallest. On d_1 transplanting v_3 and v_4 were on par and taller than v_1 and v_2. v_2 was having significantly lower height than v_3 and v_4 on d_2 and no varietal difference was observed on d_3.

4.2.1.2 Total dry matter production (TDMP)

4.2.1.2.1 Total dry matter production at transplanting stage (Table 81)

Season I

TDMP was significantly influenced by dates of transplanting and its interactions with varieties. When transplanted on d_1, TDMP was significantly higher for v_1 and all the remaining varieties were on par. But no varietal wise difference was seen on d_2 and d_3.

Season II

Only dates of transplanting resulted significant difference in TMDP. Transplanting on d_1 resulted in higher TDMP and it was on par with d_2 but higher than that of d_3.

Season III

Neither main effects nor interactions was significant in this season.

Table 79 d **CEC(C mol kg^{-1}) of soil as influenced by different dates of transplanting and varieties at harvest in different seasons at Vellayani**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	13.80	13.66	13.71	13.81	13.88	13.77	D	0.024	-
d_2	13.67	13.76	13.59	13.60	13.80	13.68	V	0.033	-
d_3	13.64	13.75	13.72	13.75	13.77	13.73	DV	0.032	-
mean	13.70	13.73	13.67	13.72	13.82	13.73			
Season II									
d_1	13.42	13.31	13.32	13.39	13.47	13.38	D	0.021	-
d_2	13.33	13.36	13.18	13.01	13.48	13.27	V	0.023	-
d_3	13.22	13.37	13.35	13.42	13.34	13.34	DV	0.311	-
mean	13.32	13.35	13.28	13.27	13.43	13.33			
Season III									
d_1	13.22	12.72	13.31	13.23	13.24	13.15	D	0.021	-
d_2	13.20	12.89	13.55	13.54	13.48	13.33	V	0.031	-
d_3	13.50	12.87	13.51	13.28	12.90	13.21	DV	0.032	-
mean	13.31	12.83	13.45	13.35	13.21	13.23			

Table 80 **Plant height (cm) as influenced by different dates of transplanting and varieties in different seasons at Pattambi**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	73.86	71.22	70.42	72.37	104.69	78.51	D	0.295	1.157
d_2	72.36	70.75	72.56	72.11	104.64	75.40	V	0.252	0.823
d_3	68.86	67.92	67.94	68.64	95.94	72.55	DV	0.661	1.982
mean	71.69	69.96	70.31	71.04	101.76	75.49			
Season II									
d_1	76.64	74.11	73.33	75.67	104.61	80.87	D	0.283	1.112
d_2	72.83	69.50	70.92	70.89	98.00	75.40	V	0.379	1.235
d_3	71.69	65.33	65.72	67.00	102.67	72.55	DV	0.790	2.368
mean	73.72	69.65	69.99	71.19	101.76	76.27			
Season III									
d_1	66.94	65.81	63.78	67.11	94.92	71.71	D	0.425	1.668
d_2	65.00	64.89	65.56	67.33	97.78	72.11	V	0.421	1.373
d_3	64.75	63.19	63.72	65.14	96.67	70.69	DV	0.535	1.605
mean	65.56	64.63	64.35	66.53	96.46	71.51			

Table 80 a Interaction effect of dates of transplanting and varieties on plant height (cm) at different growth stages during 1 st season at Pattambi

Varieties	dates of transplanting								
	d_1			d_2			d_3		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
v_1	51.33	79.67	87.33	47.72	74.67	84.33	46.67	71.67	84.33
v_2	50.50	75.33	87.67	47.42	74.00	79.00	43.31	77.00	80.33
v_3	48.81	75.67	92.00	47.19	74.33	85.69	43.39	74.67	83.00
v_4	50.00	77.33	90.33	47.00	75.33	84.64	46.17	71.67	82.00
v_5	74.87	119.67	136.67	66.00	113.00	131.00	65.67	99.33	119.00
Effect			SE				CD		
DVP			1.247				3.526		

Table 80 b Interaction effect of dates of transplanting and varieties on plant height (cm) at different growth stages during II nd season at Pattambi

Varieties	Dates of transplanting								
	d_1			d_2			d_3		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
v_1	48.33	79.33	85.14	47.00	75.67	84.50	43.00	73.00	81.00
v_2	48.33	75.17	78.72	46.67	71.33	82.97	39.00	71.33	77.75
v_3	46.33	75.00	80.42	44.00	71.00	87.33	39.17	72.67	83.33
v_4	46.33	79.17	83.33	45.00	76.67	82.92	39.67	72.42	79.42
v_5	70.33	107.67	136.33	67.33	109.08	118.00	69.00	108.33	131.00
Effect			SE				CD		
DVP			1.247				3.528		

Table 80 c Interaction effect of dates of transplanting and varieties on plant height (cm) at different growth stages during 3 rd season at Pattambi

Varieties	Dates of transplanting								
	d_1			d_2			d_3		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
v_1	38.33	72.67	78.83	38.42	72.67	78.00	35.67	67.33	79.25
v_2	41.00	70.00	79.25	39.75	71.33	75.67	34.60	63.00	78.60
v_3	40.75	68.00	83..17	38.17	71.08	81.00	35.45	59.00	82.33
v_4	40.58	69.67	83.17	37.67	83.00	83.33	35.00	62.00	81.67
v_5	60.42	102.67	114.58	58.42	106.67	114.33	55.45	91.33	122.83
Effect			SE				CD		
DVP			1.177				3.328		

4.2.1.2.2 Total dry matter production at active tillering stage (Table 82)

Season I

Only varietal difference was seen. TDMP of v_1 was on par with v_5 but significantly higher than that of remaining high yielding varieties. The least TDMP was recorded by v_3, which was on par with v_2.

Season II.

Only varietal difference was noticed. Maximum TDMP was shown by v_5, but significantly higher than that of remaining varieties. Among high yielding varieties, v_1 had higher TDMP than the remaining high yielding varieties, which were on par.

Season III

The main effect of dates of transplanting and varieties were significant. Transplanting on d_2 gave a higher value than d_2 and on par with d_1. Among varieties local variety produced more TDMP and among high yielding varieties, v_1 produced more TDMP than the remaining varieties and least TDMP was produced by v_3, which was on par with v_2.

4.2.1.2.3 Total dry matter production at panicle initiation stage (Table 83)

Season I

TDMP was significantly influenced by dates of transplanting, varieties and their interactions. Maximum TDMP was shown by v_5 followed by v_1 and minimum by v_3 on all dates of transplanting. But v_3 was on par with v_4 on d_2. While TDMP of v_4 was higher than that of v_2 on d_1 and on par with v_2 on d_2 and had a lower value than v_2 on d_3.

Season II

Dates of transplanting, varieties and their interactions significantly influenced the TDMP. Maximum TDMP was registered by v_5 followed by v_1, and minimum by v_3 on all dates of transplanting and on d_3, v_3 was on par with and v_4 and v_2.

Table 81 **Total dry matter production(g hill^{-1}) as influenced by different dates of transplanting and varieties at transplanting stage in different seasons at Pattambi**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	2.17	1.88	1.91	1.86	1.81	1.93	D	0.009	0.034
d_2	1.90	1.84	1.86	1.93	1.99	1.90	V	0.035	-
d_3	1.89	1.91	1.91	1.84	1.86	1.88	DV	0.052	0.155
mean	1.98	1.88	1.89	1.88	1.89	1.90			
Season II									
d_1	1.91	1.93	2.01	1.97	1.98	1.96	D	0.013	0.052
d_2	1.95	2.07	1.92	1.86	1.82	1.92	V	0.019	-
d_3	1.88	1.89	1.94	1.88	1.85	1.89	DV	0.048	-
mean	1.92	1.96	1.96	1.90	1.88	1.92			
Season III									
d_1	1.93	1.91	1.83	1.79	1.86	1.86	D	0.014	-
d_2	1.88	1.86	1.95	1.94	1.94	1.91	V	0.018	-
d_3	1.99	1.91	1.90	1.88	1.87	1.91	DV	0.035	-
mean	1.93	1.89	1.89	1.87	1.89	1.90			

Table.82 **Total dry matter production(g hill^{-1}) as influenced by different dates of transplanting and varieties at active tillering stage in different seasons at Pattambi**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	3.30	2.91	2.90	3.18	3.54	3.17	D	0.035	-
d_2	3.39	2.80	2.78	2.94	3.43	3.07	V	0.052	0.171
d_3	3.16	2.82	2.66	3.13	3.39	3.03	DV	0.069	-
mean	3.28	2.84	2.78	3.08	3.45	3.09			
Season II									
d_1	3.33	2.85	2.83	3.14	3.71	3.17	D	0.072	-
d_2	3.17	2.78	2.68	2.90	3.54	3.01	V	0.049	0.159
d_3	2.97	2.68	2.77	2.59	3.11	2.82	DV	0.013	-
mean	3.15	2.77	2.76	2.88	3.45	3.00			
Season III									
d_1	3.27	3.01	2.74	2.88	3.33	3.05	D	0.054	0.213
d_2	3.04	2.48	2.65	2.91	3.26	2.87	V	0.037	0.120
d_3	2.69	2.34	2.38	2.67	3.00	2.62	DV	0.086	-
mean	3.00	2.61	2.59	2.82	3.20	2.84			

Season III

Varieties and its interactions with dates of transplanting were significant. High TDMP was registered by v_5 on all dates of transplanting. On d_1, v_1 and v_4 were on par and had higher TDMP than v_2 and v_3. On d_2, v_1 had significantly higher TDMP than v_4 and v_2 but on par with v_3. On d_3, v_1 and v_4 was on par and had higher TDMP than v_2 and v_3, which was also on par

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4.2.1.2.4 Total dry matter production at heading stage (Table 84)

Season I

Varieties and its interactions with dates of transplanting significantly influenced the TDMP. Maximum TDMP was registered by v_5 and minimum by v_3 on all dates of transplanting. On d_1 and d_2, v_1 and v_4 were on par but v_1 had higher TDMP than the remaining high yielding varieties on d_3. On d_1, v_2 had higher TDMP than v_3, but on par with v_4 and v_3 on d_2 and d_3.

Season II

Varieties and its interactions with dates of transplanting significantly influenced the TDMP. On all dates of transplanting maximum TDMP was registered by v_5. Among high yielding varieties, v_1 recorded maximum and v_3 registered minimum TDMP. But v_1 was on par with v_4 on d_2 while v_4 was on par with v_2 on d_1.

Season III

TDMP was significantly influenced by dates of transplanting, varieties and their interactions. Maximum TDMP was registered by v_5 and minimum by v_3 on all dates of transplanting. On d_1 and d_2 v_1, v_2 and v_4 were on par. On d_2, v_3 was on par with v_2 and v_4. v_1 and v_2 were on par and significantly higher than v_3 on d_3.

Table 83 Total dry matter production(g hill^{-1}) as influenced by different dates of transplanting and varieties at panicle initiation stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	6.57	5.82	5.40	6.11	7.72	6.32	D	0.011	0.043
d_2	6.32	5.64	5.39	5.55	7.45	6.07	V	0.057	0.185
d_3	5.91	5.66	4.84	5.47	6.83	5.74	DV	0.055	0.164
mean	6.27	5.71	5.21	5.71	7.33	6.05			
Season II									
d_1	6.42	5.65	5.33	6.05	7.64	6.22	D	0.040	0.157
d_2	5.95	5.34	4.91	5.35	6.83	5.68	V	0.094	0.305
d_3	6.17	4.90	5.07	5.13	6.61	5.57	DV	0.105	0.315
mean	6.18	5.30	5.10	5.51	7.03	5.82			
Season III									
d_1	5.78	5.20	4.69	5.67	6.29	5.52	D	0.048	-
d_2	5.50	5.00	5.22	5.10	6.37	5.44	V	0.084	0.273
d_3	5.60	4.85	4.51	5.29	6.34	5.32	DV	0.120	0.361
mean	3.70	3.28	3.24	3.46	4.23	3.58			

Table 84 Total dry matter production(g hill^{-1}) as influenced by different dates of transplanting and varieties at heading stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	8.55	7.52	7.09	8.22	9.71	8.22	D	0.060	-
d_2	7.97	7.58	7.29	7.87	9.24	7.99	V	0.106	0.347
d_3	8.14	7.58	7.34	7.77	8.95	7.96	DV	0.117	0.351
mean	8.22	7.56	7.24	7.95	9.30	8.05			
Season II									
d_1	8.21	7.66	6.68	7.44	8.91	7.78	D	0.087	-
d_2	7.94	7.54	6.94	7.86	8.78	7.81	V	0.061	0.200
d_3	8.03	7.09	6.72	7.69	8.80	7.66	DV	0.078	0.235
mean	8.06	7.43	6.78	7.66	8.83	7.75			
Season III									
d_1	7.26	7.07	6.39	7.00	8.46	7.24	D	0.041	0.162
d_2	7.35	7.10	6.89	7.21	8.32	7.38	V	0.095	0.309
d_3	7.73	7.57	6.99	7.35	8.28	7.58	DV	0.112	0.335
mean	7.45	7.25	6.76	7.19	8.36	7.40			

4.2.1.2.5 Total dry matter production at beginning of grain filling stage (Table 85)

Season I

Varieties and its interactions with dates of transplanting significantly influenced the TDMP. v_5 recorded the maximum TDMP and v_3 recorded the minimum TDMP on all dates of transplanting. But v_3 was on par with v_2 on d_1 and d_3. Among high yielding varieties, v_1 had higher TDMP than the remaining high yielding varieties on d_1 but v_1 was on par with v_4 and v_2 on d_2. v_4 was also on par with v_2 on d_2 and d_3 but had a high TDMP than v_2 on d_1.

Season II

Dates of transplanting, varieties and their interactions significantly influenced the TDMP. On all transplanting dates, v_5 had maximum TDMP. Among high yielding varieties, v_1 produced maximum TDMP and v_3 produced the minimum TDMP on d_1 and d_2. But v_3 was on par with v_4 on d_3. On d_2, v_1 and v_4 were also on par while v_4 was on par with v_2 on d_1.

Season III

Only varietal difference was seen. Maximum TDMP was registered by v_5 and minimum by v_3. Kanchana(v_1), Jyothi (v_2) and Kairali (v_4) were on par.

4.2.1.2.6 Total dry matter production at harvest (Table 86)

Season I.

TDMP was significantly influenced by dates of transplanting, varieties and their interactions. Early transplanting resulted in higher TDMP and d_3 registered the lowest TDMP. When transplanted on d_1, v_1 produced maximum TDMP followed by v_4 and theses were significantly higher than the remaining varieties. v_1 was on par with v_4 on d_2 transplanting and these were significantly higher than the remaining varieties except v_2. On d_3 transplanting also v_1 produced maximum TDMP and it was significantly higher than the remaining varieties except v_4.

Season II

Only varietal difference was seen. Higher TDMP was produced by v_1 and it was on par with v_4 and was significantly higher than that of remaining high yielding varieties. The least TDMP was recorded by v_3, which was on par with v_5 and v_2.

Season III

Varieties and its interactions with dates of transplanting significantly influenced the TDMP. v_1 produced higher TDMP and was on par with v_4 and v_5 on d_1 and it was on par with v_4 on d_2 and d_3. The lowest TDMP was registered by v_3 on d_1 and it was on par with v_2 and v_5. The lowest TDMP was produced by v_5 for the remaining dates of transplanting and it was on par with v_3 on d_2 and v_2 and v_3 on d_3.

4.2.1.3 Dry matter production of leaf

4.2.1.3.1 Dry matter production of leaf at transplanting stage (Table 87)

Season I

Only varietal difference was observed. Lowest DMP of leaf was registered by v_5, which was on par with v_3. All high yielding varieties did not differ in their DMP of leaf.

Season II

Varietal difference was observed. Maximum DMP of leaf was shown by v_1, which was on par with v_4. The varieties v_3 and v_5 were on par and had a significantly less DMP of leaf than v_1 but v_4 had high DMP of leaf than v_5.

Season III

Neither dates of transplanting nor varieties significantly influenced dry matter production of leaf.

Table 85 Total dry matter production(g hill^{-1}) as influenced by different dates of transplanting and varieties at beginning of grain filling stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	8.62	7.65	7.52	8.29	9.79	8.37	D	0.080	-
d_2	8.05	7.89	6.84	7.94	9.29	8.00	V	0.089	0.289
d_3	8.20	7.61	7.37	7.83	9.17	8.04	DV	0.083	0.247
mean	8.29	7.71	7.24	8.02	9.41	8.14			
Season II									
d_1	8.23	7.68	7.08	7.60	9.02	7.92	D	0.087	0.341
d_2	7.97	7.61	6.99	7.88	8.97	7.88	V	0.067	0.218
d_3	7.96	7.17	6.73	6.73	8.83	7.48	DV	0.087	0.260
mean	8.05	7.49	6.93	7.40	8.94	7.76			
Season III									
d_1	7.40	7.14	6.43	7.02	8.41	7.28	D	0.102	-
d_2	7.32	7.20	6.92	7.27	8.51	7.44	V	0.079	0.257
d_3	7.91	7.58	7.13	7.57	8.62	7.76	DV	0.140	-
mean	7.54	7.31	6.82	7.29	8.51	7.50			

Table 86 Total dry matter production(g hill^{-1}) as influenced by different dates of transplanting and varieties at harvest in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	30.82	25.61	24.39	28.43	23.52	26.55	D	0.136	0.533
d_2	29.05	25.13	23.21	26.95	23.80	25.63	V	0.567	1.852
d_3	26.25	23.87	23.25	24.94	22.33	24.13	DV	0.759	-
mean	28.71	24.87	23.62	26.77	23.22	25.44			
Season II									
d_1	24.05	20.87	22.92	24.16	21.04	22.61	D	0.425	1.667
d_2	23.62	21.81	19.63	21.53	19.22	21.16	V	0.620	2.025
d_3	21.93	20.31	18.91	21.07	20.28	20.50	DV	0.912	2.268
mean	23.20	21.00	20.49	22.25	20.18	21.42			
Season III									
d_1	20.27	19.16	19.01	20.83	17.98	19.45	D	0.222	-
d_2	21.30	19.65	17.89	20.24	17.54	19.32	V	0.379	1.237
d_3	20.15	18.14	17.79	19.27	19.18	18.91	DV	0.483	1.443
mean	20.57	18.98	18.23	20.12	18.23	19.23			

4.2.1.3.2 Dry matter production of leaf at active tillering stage (Table 88)

Season I

Main effect of varieties and its interactions with dates of transplanting were significant. On d_1, v_1 produced maximum DMP of leaf and v_5 recorded lowest DMP of leaf, which was on par with v_4. On d_2, v_4 recorded highest DMP of leaf followed by v_1, which was significantly higher than v_3 and v_2 and on d_3, v_1 was on par with v_4 and significantly higher than v_3 and v_5.

Season II

No difference in DMP of leaf was observed either with respect to varieties or with different dates of transplanting.

Season III

Dates of transplanting and varieties produced differential response on DMP of leaf. Maximum DMP of leaf was recorded from plants transplanted on d_1. No significant difference was observed with transplanting on d_2 and d_3. Among varieties, the least DMP of leaf was produced by v_2 and v_5 and the highest by v_1 and v_4. The DMP of leaf of v_3 was on par with v_4.

4.2.1.3.3 Dry matter production of leaf at panicle initiation stage (Table 89)

Season I

DMP of leaf was significantly influenced by dates of transplanting, varieties and their interactions. Transplanting on d_1 resulted in high leaf DMP for v_4 and v_1, which were on par followed by v_3 and the minimum DMP of leaf was registered by v_2 and v_5, which were also on par. But transplanting on d_2 resulted in least DMP of leaf in v_4, which was on par with v_5, and highest by v_1 followed by v_3. On d_3, v_1 and v_2 were on par had high DMP of leaf when transplanted followed by v_4, which was on par with v_3 but had higher DMP of leaf than v_5.

Season II

Dates of transplanting, varieties and their interactions significantly influenced the DMP of leaf. Here also v_1 and v_4 produced maximum DMP of leaf when transplanted

Table 87 **Dry matter production of leaf (g hill^{-1}) as influenced by different dates of tranplanting and varieties at transplanting stage in different seasons at Pattambi**

Dates of transplanting	Varieties							
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.0270	0.0270	0.0253	0.0267	0.0237	0.0259	D	0.00018	-
d_2	0.0277	0.0263	0.0260	0.0277	0.0243	0.0264	V	0.00067	0.00219
d_3	0.0277	0.0263	0.0267	0.0280	0.0240	0.0265	DV	0.00018	-
mean	0.0274	0.0266	0.0260	0.0274	0.0240	0.0263			
Season II									
d_1	0.0280	0.0267	0.0250	0.0270	0.0237	0.0261	D	0.00024	-
d_2	0.0267	0.0263	0.0253	0.0273	0.0240	0.0259	V	0.00081	0.00264
d_3	0.0280	0.0267	0.0250	0.0277	0.0237	0.0262	DV	0.00032	-
mean	0.0276	0.0266	0.0251	0.0273	0.0238	0.0261			
Season III									
d_1	0.0273	0.0267	0.0250	0.0277	0.0243	0.0262	D	0.00026	-
d_2	0.0273	0.0263	0.0253	0.0273	0.0233	0.0259	V	0.00065	-
d_3	0.0273	0.0267	0.0233	0.0253	0.0273	0.0260	DV	0.00055	-
mean	0.0273	0.0266	0.0246	0.0268	0.0250	0.0260			

Table 88 **Dry matter production of leaf (g hill^{-1}) as influenced by different dates of transplanting and varieties at active tillering stage in different seasons at Pattambi**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.100	0.950	0.960	0.877	0.807	0.777	D	0.0241	-
d_2	1.113	0.923	0.953	1.143	1.013	0.827	V	0.0310	0.1010
d_3	1.017	0.900	0.827	0.983	0.820	0.745	DV	0.0366	0.1097
mean	1.077	0.924	0.913	1.001	0.880	0.783			
Season II									
d_1	1.287	1.083	1.033	0.920	0.783	1.021	D	0.074	-
d_2	1.000	0.903	0.873	0.943	0.957	0.935	V	0.084	-
d_3	1.370	0.860	0.660	0.860	0.937	0.937	DV	0.114	-
mean	1.219	0.949	0.856	0.908	0.892	0.965			
Season III									
d_1	1.230	0.987	1.000	1.173	0.997	1.077	D	0.0351	0.1380
d_2	0.973	0.793	0.970	0.920	0.863	0.904	V	0.0201	0.0657
d_3	0.973	0.773	0.980	0.910	0.637	0.855	DV	0.0526	-
mean	1.059	0.851	0.983	1.001	0.832	0.945			

on d_1, followed by v_2 and v_3 which were on par and the least DMP of leaf by v_5. When transplanted on d_2 maximum DMP of leaf was observed in v_1 followed by v_3 and minimum by v_5, which was on par with v_4 and v_2. When transplanted on d_3 v_1 produced more DMP in leaf , followed by v_2, which was on par with v_5 and v_4 but had a higher DMP than v_3.

Season III

Only varietal wise difference was observed with v_1 having the highest and v_5 the lowest DMP of leaf. The DMP of v_4 and v_2 were on par but v_4 had a higher DMP value than v_3.

4.2.1.3.4 Dry matter production of leaf at heading stage (Table 90)

Season I

Dates of transplanting, varieties and their interactions significantly influenced the DMP of leaf. The DMP of leaf of v_1 was significantly higher than that of v_4 but was on par with v_2, v_5 and v_3 when transplanted on d_1 and DMP of leaf of v_4 and v_1 were significantly higher than v_3, but on par with v_2 and v_5 when transplanted on d_2. High yielding varieties v_1, v_2 and v_4 and the v_3 were on par in DMP of leaf and had a value significantly higher than that of v_5 when transplanted on d_3.

Season II

DMP of leaf was significantly influenced by dates of transplanting, varieties and their interactions. On all dates of transplanting less leaf DMP of leaf was shown by v_5. Maximum DMP of leaf was registered by v_1 and v_4, which were on par followed by v_2 and v_3 which were also on par and significantly higher than that of v_5 when transplanted on d_1. When transplanted on d_2 DMP of leaf was the highest for v_1 and lowest for v_5. v_3, v_2 and v_4 were on par, but had a significantly low DMP of leaf than v_1 and high DMP of leaf than v_5. When transplanted on d_3, v_1 was on par with v_2, v_4 and v_3 and produced more DMP of leaf than v_5.

Season III

Only dates of transplanting resulted a significant difference in DMP of leaf with

Table 89 Dry matter production of leaf (g $hill^{-1}$) as influenced by different dates of transplanting and varieties at panicle initiation stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	2.233	1.853	1.970	2.237	1.750	2.009	D	0.0100	0.0390
d_2	2.187	1.753	1.873	1.633	1.727	1.835	V	0.0291	0.0949
d_3	1.887	1.870	1.617	1.683	1.430	1.697	DV	0.0378	0.1132
mean	2.102	1.826	1.820	1.851	1.636	1.847			
Season II									
d_1	2.017	1.853	1.803	1.993	1.600	1.853	D	0.0151	0.0594
d_2	1.877	1.497	1.653	1.520	1.440	1.597	V	0.0342	0.1120
d_3	2.043	1.643	1.480	1.527	1.570	1.653	DV	0.0405	0.1210
mean	1.979	1.664	1.646	1.680	1.537	1.701			
Season III									
d_1	1.827	1.657	1.500	1.710	1.313	1.601	D	0.0194	-
d_2	1.823	1.430	1.390	1.730	1.360	1.547	V	0.0316	0.1030
d_3	1.687	1.547	1.620	1.487	1.390	1.546	DV	0.0720	-
mean	1.779	1.544	1.503	1.642	1.354	1.565			

Table 90 Dry matter production of leaf (g $hill^{-1}$) as influenced by different dates of transplanting and varieties at heading stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	3.087	2.867	2.873	2.717	2.883	2.885	D	0.0382	-
d_2	2.960	2.863	2.633	2.983	2.827	2.853	V	0.0501	0.1630
d_3	2.953	2.877	2.727	2.913	2.023	2.699	DV	0.0963	0.2890
mean	3.000	2.869	2.744	2.871	2.578	2.812			
Season II									
d_1	3.107	2.663	2.610	3.027	2.310	2.743	D	0.0246	0.0967
d_2	2.877	2.593	2.653	2.580	2.273	2.595	V	0.0292	0.0952
d_3	2.700	2.637	2.570	2.617	2.330	2.571	DV	0.0613	0.1840
mean	2.894	2.631	2.611	2.741	2.304	2.636			
Season III									
d_1	2.713	2.670	2.500	2.597	2.410	2.578	D	0.0190	0.0744
d_2	2.707	2.493	2.597	2.573	2.270	2.528	V	0.0680	-
d_3	2.603	2.443	2.207	2.413	2.290	2.391	DV	0.0857	-
mean	2.674	2.536	2.434	2.528	2.323	2.499			

least value observed for d_3 transplanting and highest for d_1 transplanting, which was on par with d_2.

4.2.1.3.5 Dry matter production of leaf at beginning of grain filling stage (Table91)

Season I

Varieties and its interactions with dates of transplanting significantly influenced DMP of leaf. v_1 gave the maximum DMP of leaf when transplanted on d_1, which was significantly higher than that of the remaining varieties and the lowest DMP of leaf was produced by v_5, which was on par with v_2 and v_3. Transplanting on d_2 resulted in high DMP of leaf in v_2 and v_1, which was on par, followed by v_4 and v_3, which were also on par. However, DMP of leaf of v_5 was significantly lesser than the remaining varieties. Transplanting on d_3 produced high leaf DMP in v_2, v_1 and v_4, which were on par and significantly higher than that of v_3 and v_5, v_5 having the least DMP of leaf.

Season II

DMP of leaf was significantly influenced by dates of transplanting and varieties. Early transplanting resulted in higher DMP of leaf. Among varieties maximum DMP of leaf was shown by v_1, which was on par with v_3 and v_2, but significantly higher than v_4 and v_5. DMP of leaf of v_3 and v_2 were also significantly higher than that of v_5.

Season III

The main effect of dates of transplanting, varieties and their interactions were significant. The lowest leaf DMP was shown by v_5, which was on par with v_2, and v_5 on d_1. When transplanted on d_2 and d_3, v_5, v_4 and v_2 were on par and had lower DMP than v_1 and v_3.

4.2.1.3.6 Dry matter production of leaf at harvest (Table 92)

Season I

Dates of transplanting, varieties and their interactions were significant in this season. v_2 and v_4 and v_1 were on par and recorded higher value of leaf DMP than v_3 and

Table 91 Dry matter production of leaf (g hill^{-1}) as influenced by different dates of transplanting and varieties at beginning of grain filling stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	2.82	2.68	2.65	2.76	2.63	2.71	D	0.014	0.042
d_2	2.80	2.87	2.67	2.67	2.49	2.70	V	0.010	0.091
d_3	2.73	2.74	2.51	2.66	2.39	2.61	DV	0.033	0.116
mean	2.78	2.76	2.61	2.70	2.50	2.67			
Season II									
d_1	2.68	2.35	2.43	2.32	2.07	2.37	D	0.023	0.091
d_2	2.41	2.32	2.29	2.18	2.03	2.25	V	0.057	0.186
d_3	2.37	2.35	2.39	2.11	1.95	2.23	DV	0.069	-
mean	2.48	2.34	2.37	2.20	2.02	2.28			
Season III									
d_1	2.88	2.54	2.56	2.78	2.49	2.65	D	0.038	0.150
d_2	2.43	2.31	2.61	2.33	2.11	2.36	V	0.066	0.214
d_3	2.60	2.25	2.41	2.34	2.03	2.33	DV	0.070	0.209
mean	2.64	2.37	2.53	2.48	2.21	2.44			

Table 92 Dry matter production of leaf (g hill^{-1}) as influenced by different dates of transplanting and varieties at harvest in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.63	1.68	1.30	1.53	1.12	1.45	D	0.052	0.204
d_2	1.51	1.75	1.33	1.66	1.18	1.49	V	0.066	0.217
d_3	1.42	1.02	1.06	1.87	0.80	1.23	DV	0.066	0.199
mean	1.52	1.48	1.23	1.69	1.03	1.39			
Season II									
d_1	1.87	1.69	1.74	2.35	1.45	1.82	D	0.064	-
d_2	2.18	1.76	1.16	1.48	1.35	1.59	V	0.058	0.190
d_3	1.69	1.82	1.36	1.78	1.31	1.59	DV	0.165	-
mean	1.91	1.76	1.42	1.87	1.37	1.67			
Season III									
d_1	2.87	1.78	1.95	1.78	1.30	1.94	D	0.008	0.031
d_2	2.35	1.69	1.74	1.87	1.45	1.82	V	0.113	0.367
d_3	2.35	1.69	1.74	1.87	1.45	1.82	DV	0.092	0.275
mean	2.53	1.72	1.81	1.84	1.40	1.86			

v_5, which were also on par on d_1. DMP of leaf of v_2 was significantly higher than that of v_1 but on par with v_4 on d_2. Here v_3 and v_5 also were on par and v_5 produced significantly low DMP of leaf in comparison with other high yielding varieties. Transplanting on d_3 also resulted in high DMP of leaf for v_4 followed by v_1 and was significantly higher than that of v_3 and v_2, which were on par.

Season II

Only varietal difference was seen. The varieties v_1, v_4 and v_2 were on par and recorded high DMP of leaf than v_3 and v_5, which were also on par.

Season III

DMP of leaf was significantly influenced by dates of transplanting, varieties and their interactions. Maximum DMP of leaf was shown by v_4 on all dates of transplanting and minimum by v_5, which was on par with v_2 on d_2 and d_3. No significant difference among v_1, v_2 and v_3 was also seen.

4.2.1.4 Dry matter production of stem

4.2.1.4.1 Dry matter production of stem at transplanting stage (Table93)

Season I, II and III

DMP of stem was not significantly different with different dates of transplanting or varieties.

4.2.1.4.2 Dry matter production of stem at active tillering stage (Table 94)

Season I

Dates of transplanting, varieties and their interactions significantly influenced the DMP of stem. Local variety had high DMP of stem on all dates of transplanting. When transplanted on d_1, among high yielding varieties DMP of stem of v_4 was significantly higher than the remaining high yielding varieties, v_1 and v_2 were on par but had higher

DMP of stem than v_3. Transplanting on d_2 produced a higher DMP of stem for v_1 in comparison with remaining high yielding varieties, of which v_3 also had a higher DMP of stem than v_4. DMP of stem of v_1, and v_4 were on par but significantly higher than v_2 and v_3, which was also on par when transplanted on d_3.

Season II

Dates of transplanting, varieties and their interactions significantly influenced the DMP of stem. Maximum DMP of stem was recorded by v_5 on all dates of transplanting. DMP of stem of v_1 was significantly higher than that of v_4, v_2 and v_3, which were on par, when transplanted on d_1, but v_1 and v_4 were on par, when transplanted on d_2 and had a higher DMP of stem than v_3 and v_2, with v_2 having the lowest DMP of stem. No significant difference in DMP of stem among high yielding varieties was observed for d_3 transplanting.

Season III

Varieties and its interaction with dates of transplanting significantly influenced the DMP of stem. Here again maximum DMP of stem was produced by v_5 on all dates of transplanting. DMP of stem of v_1 was significantly higher than v_3 and v_2 but on par with v_4 when transplanted on d_1, while DMP of stem of v_1 and v_2 were on par but significantly higher than that of v_4 and v_3, which were also par, when transplanted on d_2 and no significant difference among high yielding varieties was seen on d_3.

4.2.1.4.3 Dry matter production of stem at panicle initiation stage (Table 95)

Season I

Dates of transplanting and varieties significantly influenced the DMP of stem. Transplanting on d_1 and d_2 resulted in high DMP of stem. Maximum DMP of stem was produced by v_5 and among high yielding varieties, maximum DMP of stem was produced by v_1 and minimum by v_3. DMP of stem of v_2 was significantly higher than that of v_4.

Season II

Dates of transplanting and varieties significantly influenced the DMP of stem. Transplanting on d_1 resulted in maximum and d_3 transplanting resulted in minimum DMP

Table 93 Dry matter production of stem (g hill $^{-1}$) as influenced by different dates of transplanting and varieties at transplanting stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.0460	0.0443	0.0443	0.0437	0.0430	0.0443	D	0.00063	-
d_2	0.0417	0.0430	0.0410	0.0427	0.0427	0.0422	V	0.00064	-
d_3	0.0417	0.0417	0.0417	0.0413	0.0420	0.0417	DV	0.00087	-
mean	0.0431	0.0430	0.0423	0.0426	0.0426	0.0427			
Season II									
d_1	0.0420	0.0413	0.0417	0.0437	0.0410	0.0419	D	0.00084	-
d_2	0.0417	0.0420	0.0420	0.0430	0.0417	0.0421	V	0.00050	-
d_3	0.0437	0.0450	0.0453	0.0440	0.0427	0.0441	DV	0.00326	-
mean	0.0424	0.0428	0.0430	0.0436	0.0418	0.0427			
Season III									
d_1	0.0440	0.0440	0.0423	0.0417	0.0423	0.0429	D	0.00049	-
d_2	0.0427	0.0440	0.0423	0.0457	0.0423	0.0434	V	0.00056	-
d_3	0.0430	0.0417	0.0423	0.0423	0.0457	0.0430	DV	0.00084	-
mean	0.0432	0.0432	0.0423	0.0432	0.0434	0.0431			

Table 94 Dry matter production of stem (g hill $^{-1}$) as influenced by different dates of transplanting and varieties at active tillering stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.557	1.483	1.380	1.693	1.957	1.614	D	0.0218	0.0857
d_2	1.553	1.327	1.387	1.277	1.827	1.474	V	0.0194	0.0634
d_3	1.533	1.440	1.343	1.553	1.880	1.550	DV	0.0336	0.1010
mean	1.548	1.417	1.370	1.508	1.888	1.546			
Season II									
d_1	1.630	1.283	1.250	1.350	1.970	1.497	D	0.0123	0.0481
d_2	1.453	1.170	1.297	1.410	1.900	1.446	V	0.0159	0.0519
d_3	1.250	1.233	1.293	1.273	1.807	1.371	DV	0.0356	0.1070
mean	1.444	1.229	1.280	1.344	1.892	1.438			
Season III									
d_1	1.597	1.220	1.347	1.427	1.850	1.488	D	0.0457	-
d_2	1.477	1.440	1.193	1.223	1.860	1.439	V	0.0395	0.1290
d_3	1.220	1.127	1.293	1.253	1.623	1.303	DV	0.0711	0.2130
mean	1.431	1.262	1.278	1.301	1.778	1.410			

of stem. High yielding varieties produced less DMP of stem than local variety and v_1 had higher DMP of stem than v_2 and v_3. DMP of stem of v_4 also significantly higher than v_3.

Season III

Varieties and its interactions with dates of transplanting significantly influenced the DMP of stem. On all dates of transplanting v_5 recorded highest and v_3 recorded lowest DMP of stem. When transplanted on d_1, v_1, v_2 and v_4 were on par and had higher DMP of stem than v_3. Transplanting on d_2 and d_3 recorded higher DMP of stem for v_1 and it was on par with v_2 and significantly higher than v_4.

4.2.1.4.4 Dry matter production of stem at heading stage (Table 96)

Season I

Varieties and its interaction with dates of transplanting significantly influenced the DMP of stem. Local variety produced maximum dry matter on all dates of transplanting. DMP of stem of v_1 was significantly higher than v_3 and v_2 when transplanted on d_1, and the lowest DMP of stem was for v_2. When transplanted on d_2, v_4 produced more DMP of stem than remaining high yielding varieties of which v_1 and v_2 were on par. When transplanted on d_3, v_1 produced highest and v_3 recorded the lowest DMP of stem and v_2 and v_4 were on par.

Season II

Dates of transplanting and varieties significantly influenced the DMP of stem. No significant difference on DMP of stem when transplanted on d_1 and d_2. But transplanting on d_3 resulted in a significant reduction in DMP of stem. High yielding varieties had less DMP of stem than local variety with v_1 having a higher value than v_2 and v_3, which were on par. DMP of stem of v_4 was also significantly higher than that of v_3.

Season III

Varieties and its interactions with dates of transplanting were significant. High DMP of stem was registered by v_5 and lowest by v_3 on all dates of transplanting. DMP of

Table 95 Dry matter production of stem (g hill^{-1}) as influenced by different dates of transplanting and varieties at panicle initiation stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	2.95	2.69	2.32	2.56	4.42	2.99	D	0.018	0.069
d_2	2.88	2.63	2.30	2.66	4.37	2.97	V	0.019	0.062
d_3	2.82	2.61	2.29	2.53	4.05	2.86	DV	0.056	-
mean	2.88	2.65	2.31	2.58	4.28	2.94			
Season II									
d_1	3.01	2.63	2.34	2.74	4.46	3.04	D	0.035	0.135
d_2	2.86	2.62	2.24	2.63	4.09	2.89	V	0.078	0.254
d_3	2.59	2.24	2.34	2.38	3.93	2.70	DV	0.084	-
mean	2.82	2.50	2.31	2.58	4.16	2.87			
Season III									
d_1	2.58	2.55	2.07	2.50	3.72	2.68	D	0.033	-
d_2	2.50	2.41	2.20	2.32	3.72	2.63	V	0.062	0.202
d_3	2.49	2.35	2.09	2.32	3.84	2.62	DV	0.047	0.140
mean	1.66	1.59	1.43	1.55	2.52	1.75			

Table 96 Dry matter production of stem (g hill^{-1}) as influenced by different dates of transplanting and varieties at heading stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	3.68	2.81	3.42	3.50	5.28	3.74	D	0.078	0.308
d_2	3.17	3.11	2.71	3.46	4.61	3.41	V	0.075	0.245
d_3	3.46	3.07	2.78	3.07	4.66	3.41	DV	0.082	0.248
mean	3.44	2.99	2.97	3.34	4.85	3.52			
Season II									
d_1	3.55	3.34	2.99	3.39	4.79	3.61	D	0.065	0.225
d_2	3.60	3.26	2.88	3.47	4.72	3.59	V	0.057	0.186
d_3	3.11	2.71	2.70	2.99	4.52	3.20	DV	0.062	-
mean	3.42	3.10	2.86	3.28	4.68	3.47			
Season III									
d_1	3.20	2.99	2.85	3.10	4.24	3.28	D	0.017	-
d_2	3.04	2.93	2.80	3.00	4.33	3.22	V	0.041	0.133
d_3	3.06	3.06	2.56	2.96	4.41	3.21	DV	0.047	0.142
mean	3.10	2.99	2.73	3.02	4.33	3.24			

stem of v_1 was significantly higher than v_3 on d_1. DMP of stem of v_1, v_2 and v_4 were on par, when transplanted on d_2 and d_3.

4.2.1.4.5 Dry matter production of stem at beginning of grain filling stage (Table 97)

Season I

Dates of transplanting ,varieties and their interactions significantly influenced the DMP of stem. Early transplanting registered higher DMP of stem. On all dates of transplanting v_5 registered maximum DMP of stem, with v_2 registering lowest DMP of stem in d_1 and v_3 registering lowest DMP of stem in d_2 and d_3.

Season II

Dates of transplanting ,varieties and their interactions significantly influenced the DMP of stem. On all dates of transplanting v_5 registered maximum DMP of stem with v_3 registered lowest DMP of stem in d_1 and d_2 and v_2 in d_3, which was on par with v_3 and v_4.

Season III

Only varietal difference in DMP of stem was observed, with highest DMP of stem by v_5 and lowest by v_3, which was on par with v_2 and v_4.

4.2.1.4.6 Dry matter production of stem at harvest (Table 98)

Season I

Dates of transplanting ,varieties and their interactions significantly influenced the DMP of stem. All high yielding varieties had low DMP of stem than local variety. DMP of stem of v_1, v_4 and v_2 were on par, but v_1 produced significantly higher DMP of stem than v_3 when transplanted on d_1. Transplanting on d_2 gave more or less similar DMP of stem for v_1 and v_2, but higher than that of v_3 and v_4, which were also on par. However, transplanting on d_3 gave more or less similar values for v_1 and v_3 but higher than that of v_2 and v_4, which were on par.

Season II

Only varietal difference was seen in this season with local variety having higher DMP of stem than high yielding varieties, which were on par.

Season III

Dates of transplanting ,varieties and their interactions significantly influenced the DMP of stem. High yielding varieties had low DMP of stem than local variety. The DMP of stem of v_1 was significantly higher than that of v_2, v_3 and v_4 when transplanted on d_1 and d_2, but v_1 was on par with v_3 when transplanted on d_3. DMP of stem of v_3 was significantly low on d_1 but on par with v_4 on d_2. On all dates of transplanting v_2 and v_4 were on par and on d_3 these were on par with v_3 and significantly inferior to v_1.

4.2.1.5 Tiller number (Table 99 and 99a)

Season I

Varietal difference was significant and consistent over different periods of observation. Kanchana produced maximum tillers and it was on par with v_2 and local variety produced the lowest tiller number. At 30 DAS, on all dates of transplanting all the high yielding varieties were on par and produced maximum tillers $hill^{-1}$ and lowest tiller count was registered by local variety. When observation was taken at 60 DAS tiller production of v_1 was significantly higher than that of v_3 and v_5 for d_1 transplanting. No significant difference was observed in tiller production among v_1 and v_4 when transplanted on d_2 but local variety had lower tiller production and it was on par with v_4 and v_2 for d_3 transplanting. When observation was taken at harvest, v_1 was significantly superior to all other varieties except v_4 for d_1 and d_2 transplanting. For d_3 transplanting all high yielding varieties were on par and local variety produced lowest number of tillers.

Season II

Only varietal difference was observed. Tiller number was significantly lower for v_5 on all dates of transplanting. v_1 produced maximum tillers and it was on par with v_4 and local variety produced the lowest tiller number and it was on par with v_3.

Table 97 Dry matter production of stem (g hill^{-1}) as influenced by different dates of transplanting and varieties at beginning of grain filling stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	3.80	3.17	3.39	3.77	5.43	3.91	D	0.074	0.292
d_2	3.39	3.21	2.62	3.52	4.88	3.52	V	0.654	0.213
d_3	3.59	3.22	2.98	3.25	4.82	3.57	DV	0.072	0.217
mean	3.60	3.20	3.00	3.51	5.04	3.67			
Season II									
d_1	3.75	3.57	3.18	3.53	4.89	3.78	D	0.074	0.289
d_2	3.81	3.47	3.02	3.86	4.85	3.80	V	0.056	0.184
d_3	3.72	2.80	2.95	2.87	4.69	3.40	DV	0.073	0.219
mean	3.76	3.28	3.05	3.42	4.81	3.66			
Season III									
d_1	3.18	3.24	2.86	3.03	4.33	3.33	D	0.081	-
d_2	3.05	3.16	2.68	3.01	4.22	3.23	V	0.101	0.330
d_3	3.12	3.08	2.93	3.11	4.12	3.27	DV	0.089	-
mean	2.06	2.08	1.87	2.04	2.78	2.17			

Table 98 Dry matter production of stem (g hill^{-1}) as influenced by different dates of transplanting and varieties at harvest in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	5.21	5.05	4.92	5.10	5.74	5.20	D	0.098	0.385
d_2	4.89	4.69	4.46	4.45	5.34	4.76	V	0.150	0.490
d_3	4.94	4.13	4.80	4.02	5.59	4.69	DV	0.211	0.633
mean	5.01	4.62	4.72	4.52	5.56	4.89			
Season II									
d_1	4.98	4.88	4.84	5.01	5.86	5.11	D	0.040	-
d_2	4.95	4.87	4.82	4.77	5.43	4.97	V	0.118	0.385
d_3	4.85	4.58	4.46	4.72	5.61	4.84	DV	0.181	-
mean	4.93	4.78	4.71	4.83	5.63	4.98			
Season III									
d_1	5.16	4.82	4.97	4.78	5.79	5.11	D	0.059	0.232
d_2	4.93	4.67	4.40	4.61	5.57	4.84	V	0.079	0.257
d_3	4.87	4.61	4.24	4.59	5.51	4.76	DV	0.110	0.330
mean	4.99	4.70	4.54	4.66	5.63	4.90			

Table 99 Tiller number as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	9.00	8.19	8.17	8.67	7.61	8.33	D	0.098	-
d_2	8.64	7.98	7.89	8.62	7.14	8.05	V	0.150	0.490
d_3	8.31	8.19	8.11	7.90	7.14	7.93	DV	0.211	-
mean	8.65	8.12	8.06	8.40	7.30	8.10			
Season II									
d_1	7.78	7.19	6.94	7.67	6.78	7.27	D	0.040	-
d_2	7.72	7.36	6.94	7.58	6.75	7.27	V	0.118	0.385
d_3	7.64	7.31	7.06	7.36	6.69	7.21	DV	0.181	-
mean	7.71	7.29	6.98	7.54	6.74	7.25			
Season III									
d_1	7.22	6.58	6.81	7.11	6.56	6.86	D	0.059	-
d_2	7.31	7.06	6.53	7.01	6.31	6.84	V	0.079	0.257
d_3	7.06	6.64	6.96	6.92	6.58	6.83	DV	0.110	0.330
mean	7.20	6.76	6.77	7.01	6.48	6.84			

Table 99.a Interaction effect of dates of transplanting and varieties on tiller number at different growth stages during Ist season at Pattambi

Varieties	dates of transplanting								
	d_1			d_2			d_3		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
v_1	8.33	8.92	8.58	9.17	9.25	8.58	8.92	8.17	7.83
v_2	8.01	8.42	7.58	8.92	8.08	7.58	8.75	8.00	7.83
v_3	8.58	7.83	7.25	8.83	8.17	7.50	8.33	8.13	7.67
v_4	8.78	9.00	8.17	8.58	9.08	8.33	8.17	7.92	7.44
v_5	7.17	7.33	6.92	7.08	8.17	7.58	7.25	7.42	6.75
Effect			SE			CD			
DVP			0.236			0.667			

Season III

Main effect of varieties and its interactions with dates of transplanting was significant. For d_1 transplanting v_1 produced more number of tillers and it was on par with v_4 on d_1, with v_2 and v_4 on d_2 and with v_3 and v_4 on d_3. Local variety registered lowest tiller number and it was on par with v_2 on d_1 and d_3 and with v_3 on d_2. The tiller number was not significant among v_3 and v_2 but significantly lower than v_1 which was on par with v_4.

4.2.1.6 Leaf area index (LAI)

4.2.1.6.1 Leaf area index at transplanting stage (Table 100)

Season I

Only varietal difference was seen. All the high yielding varieties were not significantly different in their LAI, but less than that of local variety.

Season II

Varieties and its interactions with dates of transplanting significantly influenced the LAI. The local variety had recorded highest LAI on dates of transplanting. LAI of v_1, v_2 and v_3 was on par but higher than that of v_4 on d_1 while LAI of v_2, v_3 and v_4 were on par and significantly higher than v_1 on d_2 and v_2, v_3 and v_4 were on par but LAI of v_2 alone was significantly higher than v_1 on d_3.

Season III

Early transplanting resulted in high LAI values. Maximum LAI was for v_5 and no significant difference among high yielding varieties were also observed.

4.2.1.6.2 Leaf area index at active tillering stage (Table 101)

Season I

Varieties and its interaction with dates of transplanting influenced LAI. Though local variety gave maximum LAI on all dates of transplanting and it was on par with v_2

on d_1. v_1 and v_4 were on par and had a higher LAI than v_3 on d_1 while on d_2 LAI of v_4 was significantly higher than that of v_1, v_2 and v_3 and the lowest LAI was shown by v_3, which was on par with v_2. v_3 and v_2 were on par and had higher LAI than v_1 and v_4 on d_3 with v_4 having the lowest value.

Season II

Only varietal difference was observed. No significant difference among high yielding varieties was seen, but having a significantly low LAI than v_5.

Season III.

Only varietal difference was observed. No significant difference among high yielding varieties was seen, but having a significantly low LAI than v_5.

4.2.1.6.3 Leaf area index at panicle initiation stage (Table 102)

Season I

LAI was not significantly different between d_2 and d_1. But d_3 was having a lowest LAI. All the high yielding varieties had low LAI than v_5, but among the high yielding varieties, v_1, v_4 and v_2 were on par and recorded higher LAI higher than that of v_3.

Season II

Earlier transplanting resulted in significantly higher LAI, but d_3 was having the lowest LAI. All the high yielding varieties had low LAI than v_5, but among the high yielding varieties v_1, v_4 and v_2 were on par and had higher LAI than that of v_3.

Season III

Dates of transplanting and varieties significantly influenced the LAI. Earlier transplanting was found to have better LAI. However, no significant difference was seen between transplanting on d_1 and d_2. LAI of plants transplanted on d_1 was significantly higher than that of d_3. Maximum LAI was registered by v_5. Among high yielding varieties, v_1 and v_4 were on par and had highest LAI than v_2 and the lowest was recorded by v_3.

Table 100 **Leaf area index of rice as influenced by different dates of transplanting and varieties at transplanting stage in different seasons at Pattambi**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.307	0.363	0.330	0.313	0.540	0.371	D	0.0052	-
d_2	0.303	0.340	0.303	0.317	0.617	0.376	V	0.0173	0.0566
d_3	0.307	0.330	0.330	0.323	0.603	0.379	DV	0.0145	-
mean	0.306	0.344	0.321	0.318	0.587	0.375			
Season II									
d_1	0.337	0.310	0.320	0.267	0.560	0.359	D	0.0058	-
d_2	0.260	0.303	0.293	0.303	0.573	0.347	V	0.0091	0.0296
d_3	0.283	0.313	0.303	0.290	0.583	0.355	DV	0.0095	0.0284
mean	0.293	0.309	0.306	0.287	0.572	0.353			
Season III									
d_1	0.277	0.307	0.313	0.297	0.597	0.358	D	0.0034	0.0130
d_2	0.293	0.273	0.283	0.273	0.587	0.342	V	0.0132	0.0430
d_3	0.283	0.283	0.273	0.283	0.573	0.339	DV	0.0080	-
mean	0.284	0.288	0.290	0.284	0.586	0.346			

Table 101 **Leaf area index of rice as influenced by different dates of transplanting and varieties at active tillering stage in different seasons at Pattambi**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.353	1.513	1.197	1.360	1.617	1.408	D	0.0405	-
d_2	1.280	1.167	1.123	1.360	1.747	1.335	V	0.0415	0.1350
d_3	1.233	1.390	1.420	1.013	1.630	1.337	DV	0.0499	0.1500
mean	1.289	1.357	1.247	1.244	1.664	1.360			
Season II									
d_1	1.360	1.407	1.210	1.330	1.620	1.385	D	0.0384	-
d_2	1.277	1.290	1.263	1.333	1.770	1.387	V	0.0429	0.1400
d_3	1.343	1.250	1.267	1.317	1.633	1.362	DV	0.0559	-
mean	1.327	1.316	1.247	1.327	1.674	1.378			
Season III									
d_1	1.280	1.237	1.260	1.267	1.597	1.328	D	0.0177	-
d_2	1.317	1.243	1.283	1.273	1.620	1.347	V	0.0211	0.0690
d_3	1.267	1.260	1.203	1.233	1.530	1.299	DV	0.0267	-
mean	1.288	1.247	1.249	1.258	1.582	1.325			

4.2.1.6.4 Leaf area index at heading stage (Table 103)

Season I

LAI was significantly influenced by dates of transplanting and varieties. Transplanting on d_1 and d_2 were on par but LAI of plants in d_1 were significantly higher than that of d_3. Maximum LAI was seen for v_5. Among high yielding varieties, v_1 had the maximum LAI and v_3 the minimum and v_2 and v_4 were on par.

Season II

Dates of transplanting and varieties significantly influenced the LAI. Transplanting on d_1 gave maximum LAI and no significant difference was observed between d_2 and d_3. Local variety recorded maximum LAI. Among high yielding varieties, v_3 had the lowest LAI, v_1 and v_4 were on par but LAI of v_1 was significantly higher than that of v_2.

Season III

LAI was significantly influenced by dates of transplanting and varieties. Earlier transplanting resulted in better LAI. Local variety recorded maximum LAI. LAI of v_1, v_4 and v_2 were on par, but v_1 and v_4 were significantly higher than that of v_3.

4.2.1.6.5 Leaf area index at beginning of grain filling stage (Table 104)

Season I

Dates of transplanting and varieties significantly influenced the LAI. Earlier transplanting resulted in higher LAI. Lowest LAI was registered by d_3 transplanting. Maximum LAI was registered by v_5. Among high yielding varieties, v_1 had the maximum LAI and v_3 the minimum and v_2 and v_4 were on par.

Season II

LAI was significantly influenced by dates of transplanting and varieties. Earlier transplanting resulted in higher LAI. Lowest LAI was registered by d_3. Maximum LAI was registered by v_5. Among high yielding varieties, v_1 had the maximum LAI and it was on par with v_4. The minimum LAI was registered by v_3.

Season III

Dates of transplanting and varieties significantly influenced the LAI. Earlier transplanting resulted in higher LAI. Lowest LAI was registered by d_3. Maximum LAI

Table 102 **Leaf area index of rice as influenced by different dates of transplanting and varieties at panicle initiation stage in different seasons at Pattambi**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	4.27	4.15	3.87	4.23	4.40	4.18	D	0.015	0.057
d_2	4.33	4.13	3.87	4.30	4.46	4.22	V	0.033	0.106
d_3	4.10	3.93	3.77	3.98	4.42	4.04	DV	0.066	
mean	4.23	4.07	3.84	4.17	4.42	4.15			
Season II									
d_1	4.17	4.12	3.93	4.16	4.69	4.21	D	0.018	0.069
d_2	3.91	3.87	3.72	3.91	4.57	3.99	V	0.019	0.063
d_3	3.88	3.80	3.61	3.83	4.37	3.90	DV	0.041	
mean	3.99	3.93	3.75	3.97	4.54	4.04			
Season III									
d_1	3.88	3.74	3.72	3.80	4.25	3.88	D	0.021	0.083
d_2	3.75	3.68	3.63	3.76	4.20	3.80	V	0.020	0.065
d_3	3.71	3.62	3.48	3.68	4.08	3.72	DV	0.041	
mean	3.78	3.68	3.61	3.75	4.18	3.80			

Table 103 **Leaf area index of rice as influenced by different dates of transplanting and varieties at heading stage in different seasons at Pattambi**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	4.82	4.70	4.65	4.75	4.85	4.75	D	0.014	0.053
d_2	4.77	4.72	4.51	4.70	4.82	4.70	V	0.014	0.044
d_3	4.68	4.63	4.53	4.67	4.79	4.66	DV	0.042	-
mean	4.76	4.68	4.56	4.71	4.82	4.71			
Season II									
d_1	4.75	4.69	4.57	4.61	4.88	4.70	D	0.028	0.112
d_2	4.60	4.47	4.35	4.59	4.75	4.55	V	0.023	0.074
d_3	4.50	4.45	4.37	4.46	4.74	4.51	DV	0.046	-
mean	4.62	4.54	4.43	4.56	4.79	4.59			
Season III									
d_1	4.40	4.35	4.30	4.38	4.83	4.45	D	0.019	0.074
d_2	4.29	4.22	4.19	4.26	4.84	4.36	V	0.020	0.065
d_3	4.19	4.15	4.08	4.18	4.55	4.23	DV	0.046	-
mean	4.29	4.24	4.19	4.28	4.74	4.35			

was registered by v_5. Among high yielding varieties, v_1 had the maximum LAI and it was on par with v_4 which was on par with v_2. The minimum LAI was registered by v_3.

4.2.1.6.6 Leaf area index at harvest (Table 105)

Season I

LAI was significantly influenced by dates of transplanting and varieties. Earlier transplanting resulted in higher LAI. Lowest LAI was registered by d_3. Maximum LAI was registered by v_1 and it was on par with all varieties except local variety.

Season II

Dates of transplanting and varieties significantly influenced the LAI. Transplanting on d_1 resulted in higher LAI than transplanting on d_3. Among high yielding varieties v_3, v_4 and v_1 registered higher LAI and higher than v_2. Local variety recorded lowest LAI and was on par with v_2.

Season III

Dates of transplanting, varieties and their interactions significantly influenced the LAI. When transplanted on d_1, LAI of v_2, v_3 and v_4 were on par but v_2 and v_3 had high LAI than v_1 and v_5, which were also on par. v_4 was on par with v_1 but had higher LAI than v_5. When transplanted on d_2, maximum LAI was shown by v_4 and v_1, which were on par, and v_4 registered a significant higher LAI than v_2, v_3 and v_5 while LAI of v_1 was only significantly higher than that of v_2 and v_5. On d_3 transplanting no significant difference among varieties were observed.

4.2.1.7 CGR (Crop growth rate)

4.2.1.7.1 Crop growth rate between active tillering to panicle initiation stage (Table105a)

Season I

Dates of transplanting and varieties and their interactions significantly influenced the CGR. On all dates of transplanting v_5 registered maximum CGR and among high yielding varieties v_1 had higher CGR than other varieties

Season II

CGR was significantly influenced by dates of transplanting and varieties. Transplanting on d_1 registered maximum CGR. Local variety registered maximum CGR than other varieties and among high yielding varieties v_1 registered maximum and v_3 registered minimum CGR.

Season III

CGR was significantly influenced by dates of transplanting and varieties. Transplanting on d_1 registered maximum CGR and it was on par with d_2. Local variety registered maximum CGR than other varieties and among high yielding varieties v_1 registered maximum and it was on par with v_4.

4.2.1.7.2 Crop growth rate between panicle initiation stage to harvest (Table 105 b)

Season I

Both dates of transplanting and varieties were significant. No significant difference in CGR was seen among plants transplanted on d_1 and d_2. Local variety registered minimum CGR, while high yielding variety v_1 registered maximum CGR and was on par with v_4.

Season II

Varieties significantly influenced CGR. All high yielding varieties produced higher CGR than local variety and the varieties v_1, v_2 and v_4 were on par.

Season III

Varieties significantly influenced CGR. All high yielding varieties produced higher CGR than local variety and the varieties v_1, v_2 and v_4 were on par.

4.2.1.8 Relative growth rate (RGR)

4.2.1.8.1 Relative growth rate between active tillering to panicle initiation stage

(Table105c)

Season I

Dates of transplanting and varieties significantly influenced the RGR. Transplanting on d_1 registered maximum and d_3 registered minimum RGR. Local variety registered maximum RGR and among high yielding varieties v_1 had higher RGR than other varieties.

Table 104 Leaf area index as influenced by different dates of transplanting and at beginning of grain filling stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	4.33	4.13	3.87	4.30	4.46	4.22	D	0.015	0.057
d_2	4.27	4.15	3.87	4.23	4.40	4.18	V	0.033	0.106
d_3	4.10	3.93	3.77	3.98	4.42	4.04	DV	0.066	-
mean	4.23	4.07	3.84	4.17	4.43	4.15			
Season II									
d_1	4.18	4.12	3.93	4.16	4.69	4.22	D	0.018	0.069
d_2	3.94	3.87	3.72	3.91	4.57	4.00	V	0.019	0.063
d_3	3.93	3.80	3.61	3.83	4.37	3.91	DV	0.041	-
mean	4.02	3.93	3.75	3.97	4.54	4.04			
Season III									
d_1	3.88	3.74	3.72	3.80	4.25	3.88	D	0.021	0.083
d_2	3.75	3.68	3.63	3.76	4.20	3.80	V	0.020	0.065
d_3	3.71	3.62	3.48	3.68	4.08	3.71	DV	0.041	-
mean	3.78	3.68	3.61	3.75	4.18	3.80			

Table.105 Leaf area index of rice as influenced by different dates of transplanting and varieties at harvest in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.353	1.231	0.897	1.297	1.167	1.189	D	0.0246	0.0097
d_2	1.143	1.080	0.940	0.973	0.970	1.021	V	0.0461	0.1426
d_3	1.087	0.993	1.407	0.937	0.907	1.066	DV	0.0937	-
mean	1.194	1.101	1.081	1.069	1.014	1.092			
Season II									
d_1	1.120	1.013	1.140	1.107	0.917	1.059	D	0.0129	0.0505
d_2	1.003	1.020	1.170	1.047	0.910	1.030	V	0.0220	0.0719
d_3	0.993	0.840	1.050	1.147	0.873	0.981	DV	0.0459	-
mean	1.039	0.958	1.120	1.100	0.900	1.023			
Season III									
d_1	1.007	1.130	1.163	1.103	0.927	1.066	D	0.1230	0.0625
d_2	0.967	0.837	0.870	1.057	0.833	0.913	V	0.1470	0.0453
d_3	0.837	0.763	0.820	0.850	0.770	0.808	DV	0.2640	0.1120
mean	0.937	0.910	0.951	1.003	0.843	0.929			

Table105 a CGR (g m^{-2} day^{-1}) between transplanting to panicle initiation stage as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	9.834	8.792	7.794	9.477	15.839	10.347	D	0.0330	0.1297
d_2	9.871	8.494	7.884	8.070	14.642	9.792	V	0.1642	0.5351
d_3	8.993	8.382	6.536	8.107	13.329	9.069	DV	0.2162	0.6481
mean	9.566	8.556	7.405	8.551	14.603	9.736			
Season II									
d_1	10.139	8.397	7.564	9.313	15.526	10.188	D	0.0750	0.2947
d_2	9.023	7.623	6.477	7.564	12.998	8.737	V	0.2001	0.6520
d_3	9.425	6.328	7.042	7.296	12.828	8.584	DV	0.2767	-
mean	9.529	7.449	7.028	8.057	13.784	9.169			
Season III									
d_1	8.591	7.348	6.387	8.673	11.863	8.572	D	0.1182	0.4644
d_2	8.092	7.020	7.303	7.042	11.872	8.266	V	0.1779	0.5797
d_3	8.062	6.566	5.829	7.608	11.971	8.007	DV	0.3227	-
mean	8.248	6.978	6.506	7.774	11.902	8.282			

Table105 b CGR (g m^{-2} day^{-1}) between panicle initiation to harvest as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	24.090	18.657	17.679	21.739	15.163	19.466	D	0.1893	0.7438
d_2	22.231	18.280	16.258	20.619	15.913	18.660	V	0.7677	2.5016
d_3	19.319	16.733	16.968	18.263	14.766	17.210	DV	0.9253	2.7736
mean	21.880	17.890	16.968	20.207	15.281	18.445			
Season II									
d_1	16.018	13.086	13.687	16.603	11.353	14.149	D	0.2937	-
d_2	16.071	14.605	11.970	14.248	11.152	13.609	V	0.5107	1.6642
d_3	13.740	13.314	13.078	13.971	10.491	12.919	DV	0.7272	-
mean	15.276	13.668	12.912	14.941	10.999	13.559			
Season III									
d_1	12.205	11.555	11.990	13.013	9.072	11.567	D	0.2676	-
d_2	13.793	12.396	9.984	12.997	8.439	11.522	V	0.4415	1.4387
d_3	12.270	10.731	10.723	11.584	10.459	11.153	DV	0.5686	-
mean	12.756	11.561	10.899	12.531	9.323	11.414			

Season II

Dates of transplanting and varieties significantly influenced the RGR. Transplanting on d_1 registered maximum RGR. Local variety registered maximum RGR than other varieties and among high yielding varieties v_1 registered maximum RGR than other varieties.

Season III

RGR was significantly influenced by dates of transplanting and varieties. Transplanting on d_1 registered maximum RGR. Higher RGR was registered by v_5 and minimum by v_3.

4.2.1.8.2 Relative growth rate between panicle initiation stage and harvest.

(Table105d)

Seasons I, II and III

Varieties significantly influenced the RGR. Local variety registered minimum RGR. All high yielding varieties were on par.

4.2.1.9 Leaf number hill^{-1}

4.2.1.9.1 Leaf number at transplanting stage (Table 106)

Season I

Only varietal wise difference was seen. Lowest leaf number was observed in local variety. Among high yielding varieties, maximum LAI was seen in v_3 and the remaining varieties did not differ significantly.

Season II

Varieties and its interaction with dates of transplanting significantly influenced leaf number. Transplanting on d_1 and d_2 gave the same response having more leaf numbers in v_3 and lowest

Table105 c RGR (g g $^{-1}$day^{-1}) between transplanting to panicle initiationstage as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.0371	0.0377	0.0346	0.0396	0.0580	0.0414	D	0.0002	0.0008
d_2	0.0401	0.0374	0.0355	0.0351	0.0529	0.0402	V	0.0008	0.0026
d_3	0.0381	0.0363	0.0309	0.0363	0.0521	0.0387	DV	0.0011	-
mean	0.0384	0.0371	0.0337	0.0370	0.0543	0.0401			
Season II									
d_1	0.0409	0.0365	0.0337	0.0389	0.0568	0.0414	D	0.0001	0.0004
d_2	0.0378	0.0340	0.0297	0.0334	0.0495	0.0369	V	0.0004	0.0013
d_3	0.0384	0.0288	0.0324	0.0338	0.0516	0.0370	DV	0.0011	-
mean	0.0390	0.0331	0.0319	0.0354	0.0526	0.0384			
Season III									
d_1	0.0366	0.0334	0.0314	0.0385	0.0487	0.0377	D	0.0004	0.0016
d_2	0.0358	0.0330	0.0328	0.0321	0.0476	0.0363	V	0.0006	0.0020
d_3	0.0345	0.0310	0.0288	0.0344	0.0488	0.0355	DV	0.0012	-
mean	0.0356	0.0325	0.0310	0.0350	0.0484	0.0365			

Table105 d RGR (g g $^{-1}$day^{-1})between panicle initiation to harvest as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.0262	0.0246	0.0250	0.0259	0.0195	0.0243	D	0.0001	-
d_2	0.0257	0.0248	0.0240	0.0266	0.0205	0.0243	V	0.0006	0.0020
d_3	0.0249	0.0237	0.0260	0.0252	0.0208	0.0241	DV	0.0007	-
mean	0.0256	0.0244	0.0250	0.0259	0.0203	0.0242			
Season II									
d_1	0.0215	0.0209	0.0222	0.0227	0.0167	0.0208	D	0.0004	-
d_2	0.0226	0.0229	0.0217	0.0226	0.0178	0.0215	V	0.0008	0.0026
d_3	0.0204	0.0229	0.0222	0.0229	0.0176	0.0212	DV	0.0011	-
mean	0.0215	0.0222	0.0220	0.0227	0.0173	0.0212			
Season III									
d_1	0.0199	0.0206	0.0223	0.0208	0.0173	0.0202	D	0.0003	-
d_2	0.0219	0.0218	0.0191	0.0222	0.0165	0.0203	V	0.0006	0.0020
d_3	0.0203	0.0207	0.0216	0.0205	0.0187	0.0203	DV	0.0007	-
mean	0.0207	0.0211	0.0210	0.0211	0.0175	0.0203			

in v_5, while v_1, v_2 and v_4 were on par. But on d_3, maximum leaf number was shown by v_3 and minimum by local variety, which was on par with v_4. Here v_1 and v_2 were on par and had more leaf number than v_4.

Season III

Only varietal difference was observed. Jyothi produced minimum leaf number, while other varieties were on par .

4.2.1.9.2 Leaf number at active tillering stage (Table 107)

Season I

Dates of transplanting did not influence leaf number, only varietal wise difference was seen. Number of leaves in local variety was significantly less than high yielding varieties, which were on par.

Season II

Dates of transplanting, varieties and their interactions were not significantly influenced the leaf number in this stage. .

Season III

Dates of transplanting did not influence leaf number, only varietal wise difference was seen. Number of leaves in local variety was significantly less than high yielding varieties, which were on par.

4.2.1.9.3 Leaf number at panicle initiation stage (Table 108)

Season I

Dates of transplanting and varieties significantly influenced the leaf production. Maximum leaf was produced when transplanted on d_1 and no significant difference was

Table 106 Leaf number of rice as influenced by different dates of transplanting and varieties at transplanting stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	8.00	8.00	8.33	7.67	6.00	7.60	D	0.039	-
d_2	8.00	8.00	8.33	7.67	6.00	7.60	V	0.141	0.458
d_3	7.67	7.67	8.67	7.67	6.00	7.53	DV	0.232	-
mean	7.89	7.89	8.44	7.67	6.00	7.58			
Season II									
d_1	8.00	7.67	9.33	8.00	6.00	7.80	D	0.112	-
d_2	8.00	8.00	10.00	7.67	6.00	7.93	V	0.197	0.643
d_3	7.67	7.67	9.00	6.67	6.67	7.53	DV	0.242	0.724
mean	7.89	7.78	9.44	7.44	6.22	7.76			
Season III									
d_1	7.67	6.00	7.67	7.00	7.00	7.07	D	0.061	-
d_2	8.00	6.00	8.00	7.00	7.00	7.20	V	0.270	0.880
d_3	8.00	6.00	8.00	7.67	7.17	7.37	DV	0.308	
mean	7.89	6.00	7.89	7.22	7.06	7.21			

Table 107 Leaf number of rice as influenced by different dates of transplanting and varieties at active tillering stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	24.00	22.50	23.50	23.67	21.83	23.10	D	0.660	-
d_2	21.33	23.33	22.83	23.33	21.33	22.43	V	0.519	1.694
d_3	24.17	24.83	24.50	25.33	20.00	23.77	DV	1.346	-
mean	23.17	23.56	23.61	24.11	21.06	23.10			
Season II									
d_1	24.33	21.83	24.50	22.35	19.17	22.44	D	0.466	-
d_2	18.83	19.17	20.42	26.83	22.33	21.52	V	0.919	-
d_3	24.17	23.58	24.72	22.42	20.17	23.01	DV	1.199	-
mean	22.44	21.53	23.21	23.87	20.56	22.32			
Season III									
d_1	24.00	26.50	24.17	21.17	19.67	23.10	D	0.403	-
d_2	26.33	26.83	24.33	26.17	21.33	25.00	V	0.917	2.991
d_3	26.43	24.00	24.83	25.83	22.00	24.62	DV	1.160	-
mean	25.59	25.78	24.44	24.39	21.00	24.24			

noticed between d_2 and d_3. Maximum number of leaves were produced by local variety and it was on par with v_4 and v_3. Local variety produced minimum number of leaves and it was on par with v_2 and v_3.

Season II

Dates of transplanting and varieties significantly influenced the leaf production. Transplanting on d_3 gave minimum leaf number and d_1 and d_2 were on par. All the high yielding varieties were on par and had more leaves than local variety.

Season III

Dates of transplanting and varieties significantly influenced the leaf production. With respect to leaf production v_2 and v_3 were on par and they produced more number of leaves than v_1 and local variety.

4.2.1.9.4 **Leaf number at heading stage** (Table 109)

Season I

Only dates of transplanting influenced the leaf production. Early transplanting resulted in better leaf production. The lowest leaf production was recorded by d_3.

Season II

Only varietal difference was seen. Local variety produced minimum number of leaves. Among high yielding varieties v_1, v_3 and v_4 were on par and had higher leaf production that v_2.

Season III

Dates of transplanting, varieties and their interactions were significant with respect to leaf production . When transplanted on d_1, all the high yielding varieties did not show any significant difference in the leaf production but v_3 was on par with v_5, which recorded lowest production. But transplanting on d_2 gave higher leaf production for v_5 and v_3. v_1, v_4 and v_2 were on par. On d_3, v_1 and v_2 were on par and produced lesser number of leaves than v_3, v_4 and v_5, which were also on par.

Table 108 Leaf number of rice as influenced by different dates of transplanting and varieties at panicle initiation stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	40.43	37.75	39.20	38.80	36.00	31.24	D	0.357	1.282
d_2	36.00	33.67	35.00	35.67	34.00	28.07	V	0.670	2.184
d_3	37.67	33.67	35.00	39.17	34.33	29.10	DV	1.580	-
mean	38.03	35.03	36.40	37.88	34.78	29.47			
Season II									
d_1	38.38	38.79	38.67	37.33	34.17	37.47	D	0.628	2.464
d_2	34.00	38.50	35.33	38.83	33.00	35.93	V	0.795	2.592
d_3	37.67	35.50	33.17	30.33	27.33	32.80	DV	1.830	-
mean	36.68	37.60	35.72	35.50	31.50	35.40			
Season III									
d_1	35.00	43.67	43.67	37.67	35.67	39.13	D	1.230	4.831
d_2	32.67	32.67	33.33	33.33	27.17	31.83	V	0.872	2.844
d_3	27.67	32.67	30.33	30.67	33.83	31.03	DV	2.080	-
mean	31.78	36.33	35.78	33.89	32.22	34.00			

Table 109 Leaf number of rice as influenced by different dates of transplanting and varieties at heading stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	39.67	36.79	34.50	37.33	35.96	36.85	D	0.603	2.367
d_2	26.07	39.50	30.75	31.00	32.29	31.92	V	1.646	-
d_3	24.12	26.68	23.35	26.80	23.17	24.82	DV	2.507	-
mean	29.95	34.33	29.53	31.71	30.47	31.20			
Season II									
d_1	33.17	29.83	37.33	36.00	23.00	31.87	D	1.536	-
d_2	26.00	24.67	24.83	29.83	21.83	25.43	V	1.038	3.385
d_3	25.00	25.17	30.50	27.00	23.67	26.27	DV	2.164	-
mean	28.06	26.56	30.89	30.94	22.83	27.86			
Season III									
d_1	33.75	35.42	31.75	33.50	27.96	32.48	D	0.255	1.002
d_2	30.25	30.25	35.50	35.50	26.33	31.57	V	0.839	2.735
d_3	33.33	38.67	38.67	41.00	30.42	28.68	DV	1.693	5.076
mean	32.44	32.03	35.31	33.61	34.04	30.91			

4.2.1.9.4 Leaf number at beginning of grain filling stage (Table 110)

Season I

Only dates of transplanting significantly influenced leaf production. Transplanting on d_1 resulted in higher leaf production and lowest leaf production was observed for d_3.

Season II

Dates of transplanting and varieties significantly influenced the leaf production. Transplanting on d_1 resulted in higher leaf production but no significant difference was observed between d_2 and d_3. All the high yielding varieties produced more number of leaves than the local variety and no significant difference were seen among high yielding varieties.

Season III

Dates of transplanting and varieties did not significantly influence leaf number at this stage.

4.2.1.9.5 Leaf number at harvest (Table 111)

Season I

Leaf production was significantly influenced by dates of transplanting and varieties. Plants transplanted on d_1 gave more leaf number and it was on par with d_2. The lowest leaf production was recorded by d_3. Local variety had the least leaf production. Among high yielding varieties, maximum leaf was produced by v_1. Leaf production of v_4 was on par with v_2 and significantly higher than v_3

Season II

Dates of transplanting and varieties significantly influenced the leaf production. Transplanting on d_1 resulted in higher leaf production. No significant difference was observed between d_2 and d_3. Lowest leaf production was seen in v_5, which was on par with v_3. Highest leaf production was in v_1 and it was on par with v_4 and v_2 but higher than that of v_3.

Table 110 Leaf number of rice as influenced by different dates of transplanting and varieties at beginning of grain filling stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	35.33	32.67	35.50	37.33	31.33	34.43	D	0.367	1.442
d_2	33.00	32.00	29.67	35.00	30.00	31.93	V	1.274	-
d_3	30.00	29.00	30.00	28.33	25.67	28.60	DV	1.784	-
mean	32.78	31.22	31.72	33.56	29.00	31.66			
Season II									
d_1	33.67	33.00	33.83	35.33	26.67	32.50	D	0.963	3.780
d_2	28.00	25.33	24.67	25.00	22.67	25.13	V	0.896	2.922
d_3	27.42	23.67	23.77	26.33	24.00	25.04	DV	1.099	-
mean	29.69	27.33	27.42	28.89	24.44	27.56			-
Season III									
d_1	26.92	29.13	26.17	25.75	24.33	26.46	D	1.003	-
d_2	29.75	30.17	28.97	30.50	28.11	29.50	V	0.959	-
d_3	30.00	25.67	31.58	31.08	26.67	29.00	DV	1.820	-
mean	28.89	28.32	28.91	29.11	26.37	28.32			

Table 111 Leaf number of rice as influenced by different dates of transplanting and varieties at harvest in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	17.17	15.17	15.00	16.67	15.17	15.83	D	0.075	0.292
d_2	17.17	15.17	14.50	16.33	13.83	15.40	V	0.275	0.898
d_3	15.67	15.67	15.33	14.92	13.50	15.02	DV	0.577	-
mean	16.67	15.33	14.94	15.97	14.17	15.42			
Season II									
d_1	13.67	12.83	12.17	13.67	12.00	12.87	D	0.038	0.151
d_2	13.50	13.00	12.17	13.17	11.50	12.67	V	0.290	0.947
d_3	13.50	12.67	12.17	12.83	11.50	12.53	DV	0.482	-
mean	13.56	12.83	12.17	13.22	11.67	12.69			
Season III									
d_1	13.67	11.67	12.50	13.17	12.17	12.63	D	0.212	-
d_2	13.83	14.17	12.83	13.67	12.00	13.30	V	0.323	-
d_3	13.17	12.50	13.00	13.50	11.83	12.80	DV	0.320	-
mean	13.56	12.78	12.78	13.44	12.00	12.91			

Season III

Neither dates of transplanting nor varieties influenced the leaf number at this stage.

4.2.2. Yield attributes and yield

4.2.2.1 Maximum LAI (Table 112)

Season I

Dates of transplanting and varieties significantly influenced the LAI. Earlier transplanting resulted in high LAI. LAI was maximum for v_5 and minimum for v_3. Among high yielding varieties, v_1 had the highest LAI and v_2 and v_4 were not significantly different.

Season II

LAI was significantly influenced by dates of transplanting and varieties. Transplanting on d_3 resulted in a significant reduction in LAI, but those transplanted on d_1 recorded the maximum LAI. LAI was maximum for v_5 and minimum for v_3. Kanchana and v_4 were on par. Among high yielding varieties, v_1 had the highest LAI.

Season III

Dates of transplanting and varieties significantly influenced the LAI.. Early transplanting resulted in high LAI. Among varieties v_5 had the maximum LAI. Among high yielding varieties, v_1, v_4 and v_2 were on par but v_1 and v_4 recorded a high LAI than v_3.

4.2.2.2 Days to 50 per cent flowering (Table 113)

Season I

Dates of transplanting and varieties significantly influenced days to 50 per cent flowering. Transplanting on d_3 took more number of days and d_3 took less number of days to 50 per cent flowering. Among high yielding varieties, v_1, v_2 and v_4 were on par and v_3 took less number of days to 50 per cent flowering. However, v_5 remains the one having taken least number of days to 50 per cent flowering.

Season II

Varieties and its interactions with dates of transplanting were significant. Whatever be the date of transplanting, least number of days for 50 per cent flowering was taken by v_5. Among high yielding varieties, when transplanted on d_1, no significant difference was seen but on d_2, v_3 took less number of days to 50 per cent flowering than v_4, v_1 and v_2 which were on par while on d_3, v_3 and v_4 were on par and took less number of days than v_1 and v_2 which was also on par.

Season III

Only varietal difference was seen. Here also v_5 took least number of days to 50 per cent flowering. Among high yielding varieties, v_3 recorded the least number of days to 50 per cent flowering, which was significantly less than v_1, v_2 and v_4 which was on par.

4.2.2.3 Days to physiological maturity (Table 114)

Season I

Dates of transplanting and varieties significantly influenced the days to physiological maturity. Transplanting on d_1 resulted in more number of days to physiological maturity and it was on par with d_2 and lesser days was taken by d_3 transplanting to reach physiological maturity. High yielding varieties took more days to physiological maturity than local variety. v_1, v_2 and v_4 were on par and v_3 took less number of days than v_1, v_2 and v_4.

Season II

Only varietal difference was observed. High yielding varieties took more number of days to physiological maturity than local variety. Kanchana was on par with v_2. v_4 took significantly more number of days than v_3 to reach physiological maturity.

Season III

Only varieties significantly influenced the days to physiological maturity. All the high yielding varieties were on par and took more days for physiological maturity than local variety.

Table 112 **Maximum leaf area index as influenced by different dates of transplanting and varieties in different seasons at Pattambi**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	4.89	4.79	4.73	4.83	4.93	4.83	D	0.012	0.047
d_2	4.85	4.80	4.57	4.79	4.91	4.78	V	0.013	0.041
d_3	4.76	4.71	4.61	4.73	4.81	4.73	DV	0.042	-
mean	4.83	4.77	4.64	4.78	4.88	4.78			
Season II									
d_1	4.82	4.74	4.65	4.70	4.92	4.77	D	0.031	0.122
d_2	4.70	4.56	4.46	4.73	4.85	4.66	V	0.026	0.084
d_3	4.61	4.55	4.48	4.57	4.82	4.61	DV	0.055	-
mean	3.10	3.03	2.98	3.10	3.23	3.09			
Season III									
d_1	4.51	4.45	4.41	4.54	4.92	4.57	D	0.022	0.087
d_2	4.39	4.34	4.30	4.35	4.89	4.45	V	0.020	0.065
d_3	4.29	4.28	4.20	4.26	4.61	4.33	DV	0.055	-
mean	4.39	4.36	4.30	4.39	4.81	4.45			

Table 113 **Days to 50 per cent flowering as influenced by different dates of transplanting and varieties in different seasons at Pattambi**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	79.33	79.00	77.33	79.33	67.33	76.47	D	0.180	0.708
d_2	77.33	77.00	74.00	76.33	67.67	74.47	V	0.431	1.401
d_3	76.33	76.00	72.00	76.33	66.00	73.33	DV	0.496	-
mean	77.67	77.33	74.44	77.33	67.00	74.76			
Season II									
d_1	74.67	73.67	73.00	74.00	66.33	72.33	D	0.616	-
d_2	77.00	76.33	72.00	77.00	65.67	73.60	V	0.429	1.401
d_3	78.33	77.67	74.00	73.33	65.33	73.73	DV	0.600	1.798
mean	76.67	75.89	73.00	74.78	65.78	73.22			
Season III									
d_1	72.00	72.00	70.00	72.00	62.00	69.60	D	0.464	-
d_2	72.67	73.33	68.67	72.33	60.67	69.53	V	0.460	1.499
d_3	70.33	69.67	68.33	70.33	60.00	67.73	DV	0.782	-
mean	71.67	71.67	69.00	71.56	60.89	68.96			

4.2.2.4 Number of panicles hill $^{-1}$ (Table 115)

Season I

Dates of transplanting and varieties were significant with respect to the production of panicles hill^{-1}. Transplanting on d_1 resulted in higher production of panicles hill $^{-1}$ and it was on par with d_2. Lower production of panicles hill $^{-1}$ was obtained when transplanted on d_3.

Season II

Only varieties significantly influenced panicle number. More number of panicles hill $^{-1}$ was produced by v_1 and it was on par with v_4. Lowest panicles hill $^{-1}$ was produced by local variety and it was on par with high yielding varieties v_3 and v_2.

Season III

Dates of transplanting, varieties and their interactions were not significant with respect to the production of panicles hill^{-1}.

4.2.2.5 Number of filled grains panicle^{-1} (Table 116)

Season I

Dates of transplanting and varieties were significant. Earlier transplanting resulted in more filled grains panicle^{-1}. No significant difference was seen between d_2 and d_3. Filled grain panicle $^{-1}$ was significantly low in v_5. Among high yielding varieties, v_1 and v_4 were on par and had more filled grain panicle^{-1} than v_2 and v_3, which were also on par.

Season II

Filled grains panicle^{-1} was significantly influenced by dates of transplanting and varieties. Earlier transplanting resulted in more filled grain panicle^{-1} and the lowest filled grain panicle^{-1} was recorded by v_5. Among high yielding varieties, v_1 and v_4 were on par but number of filled grains panicle^{-1} in v_1 was significantly higher than that of v_3 and v_2, which were on par with v_4.

Season III

Main effect of dates of transplanting and its interaction with varieties were significant. When transplanted on d_1, v_1 was significantly superior to other varieties, which were on par. All varieties were on par for d_2 and d_3 transplanting.

Table.114 Days to physiological maturity as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	104.33	104.00	102.33	104.00	92.33	101.40	D	0.660	2.041
d_2	102.33	102.00	99.00	101.33	92.67	99.47	V	0.519	1.694
d_3	101.33	101.00	97.00	101.33	91.00	98.33	DV	1.346	-
mean	102.67	102.33	99.44	102.22	92.00	99.73			
Season II									
d_1	99.67	98.67	97.00	99.00	91.33	97.13	D	0.466	-
d_2	102.00	101.33	97.00	102.00	90.67	98.60	V	1.199	3.594
d_3	103.33	102.67	99.00	98.33	90.33	98.73	DV	0.919	-
mean	101.67	100.89	97.67	99.78	90.78	98.16			
Season III									
d_1	97.00	97.00	95.00	97.00	87.00	94.60	D	0.403	-
d_2	97.00	98.33	93.33	96.67	85.67	94.20	V	0.917	2.991
d_3	95.33	94.67	93.00	95.67	84.33	92.60	DV	1.160	-
mean	96.44	96.67	93.78	96.44	85.67	93.80			

Table115 Number of panicles hill $^{-1}$ as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	8.01	7.17	7.15	7.77	6.85	7.39	D	0.054	0.213
d_2	8.19	7.17	6.75	7.56	6.42	7.22	V	0.122	0.399
d_3	7.58	7.33	7.25	7.22	6.44	7.17	DV	0.284	-
mean	7.93	7.22	7.05	7.52	6.57	7.26			
Season II									
d_1	6.66	5.75	5.83	6.61	5.72	6.12	D	0.055	-
d_2	6.58	6.28	5.92	6.31	5.53	6.12	V	0.172	0.564
d_3	6.44	5.97	5.83	6.25	5.53	6.00	DV	0.279	-
mean	6.56	6.00	5.86	6.39	5.59	6.08			
Season III									
d_1	6.33	6.08	6.33	6.50	5.75	6.20	D	0.008	-
d_2	6.42	6.22	5.83	6.31	5.33	6.02	V	0.182	-
d_3	6.25	5.73	5.69	6.25	5.56	5.90	DV	0.191	-
mean	6.33	6.01	5.95	6.35	5.55	6.04			

4.2.2.6 Thousand grain weight (Table 117)

Season I

Only varietal influence was seen. Maximum thousand grain weight was registered by v_1 and it was on par with v_4 and v_2 and significantly higher than v_5 and v_3.

Season II

Only varietal difference was seen. Thousand grain weight of v_1, v_4 and v_2 were on par and significantly higher than that of v_5 and v_3. Least grain weight was given by v_3.

Season III

Dates of transplanting, varieties and their interactions were significant with respect to thousand grain weight. On all dates of transplanting, thousand grain weight of v_3 was significantly low. Thousand grain weight of v_1 and v_4 were on par and significantly higher than that of v_5 and v_2, which were also on par on d_1. On d_2, v_2 and v_1 were on par and had higher grain weight than v_4 and v_3. On d_3, v_4 was on par with v_1 and v_2 and significantly higher than v_5, which was on par with v_1 and v_2.

4.2.2.7 Grain chaff ratio (Table 118)

Season I

Grain chaff ratio was significantly influenced by dates of transplanting and varieties. Earlier transplanting resulted in higher grain chaff ratio and d_3 registered lowest grain chaff ratio. Grain chaff ratio was significantly higher in v_1 and it was on par with v_4 and the lowest grain chaff ratio was registered by v_5, which was on par with v_3 and v_2.

Season II

Higher grain chaff ratio was registered by d_1 followed by d_2 and lowest by d_3. All high yielding varieties were on par and had higher grain chaff ratio than local variety.

Season III

Grain chaff ratio was significantly influenced by dates of transplanting and varieties and their interactions. Transplanting on d_1 resulted in maximum grain chaff ratio for v_3 and minimum for v_4 and otherhigh yielding varieties were on par. On d_2 maximum grain chaff ratio was for

Table116 Number of filled grains panicle^{-1} as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties							
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	94.33	88.00	91.33	93.67	85.00	90.47	D	0.610	2.394
d_2	94.00	86.00	85.00	92.00	82.00	87.80	V	0.684	2.231
d_3	90.00	87.00	84.00	89.00	80.00	86.00	DV	1.109	-
mean	92.78	87.00	86.78	91.56	82.33	88.09			
Season II									
d_1	88.00	84.00	87.00	88.00	78.00	85.00	D	0.667	2.618
d_2	84.00	80.00	78.00	82.00	77.00	80.20	V	0.895	2.920
d_3	78.00	75.00	76.00	74.00	71.00	74.80	DV	1.572	
mean	83.33	79.67	80.33	81.33	75.33	80.00			
Season III									
d_1	77.00	69.67	72.00	72.67	72.67	72.80	D	0.893	3.505
d_2	72.33	70.33	69.33	68.33	68.33	69.73	V	0.958	-
d_3	67.33	68.33	67.33	68.67	68.67	68.07	DV	1.343	4.028
mean	72.22	69.44	69.55	69.89	69.89	70.20			

Table 117 Thousand grain weight(g) as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	28.00	26.63	26.43	27.50	26.20	26.95	D	0.134	-
d_2	27.53	27.20	26.00	26.20	26.83	26.75	V	0.258	0.840
d_3	26.97	26.63	26.03	26.80	26.37	26.56	DV	0.314	-
mean	27.50	26.82	26.16	26.83	26.47	26.76			
Season II									
d_1	26.53	25.83	24.97	26.83	25.47	25.93	D	0.040	-
d_2	26.70	26.57	24.40	25.90	25.70	25.85	V	0.133	0.433
d_3	26.50	26.20	24.63	26.50	25.67	25.90	DV	0.243	-
mean	26.58	26.20	24.67	26.41	25.61	25.89			
Season III									
d_1	26.83	25.53	24.73	26.70	25.97	25.95	D	0.089	0.349
d_2	26.43	26.67	24.17	25.67	25.87	25.76	V	0.180	0.588
d_3	26.20	25.64	24.27	26.21	25.50	25.50	DV	0.237	0.711
mean	26.49	25.95	24.39	26.19	25.78	25.76			

v_1 and minimum for v_5 and all other varieties were on par. All high yielding varieties were on par and significantly superior to local variety on d_3 transplanting.

4.2.2.8 Grain yield (Table 119)

Grain yield was significantly influenced by dates of transplanting, varieties and their interactions. Later transplanting resulted in lowering the grain production. On all dates of transplanting lowest grain yield was given by v_5. When transplanted on d_1 highest grain yield was obtained from v_1 and it was on par with v_4 and v_2 and significantly superior to v_3. But transplanting on d_2 resulted in high grain yield for v_1 and v_4 which were on par. On d_3 among high yielding varieties maximum grain yield was recorded by v_1 and minimum by v_3. v_4 and v_2 were on par.

Season II

Grain yield was significantly influenced by dates of transplanting and varieties. Transplanting on d_1 registered maximum grain yield and was on par with d_2 and lowest grain yield was registered by d_3. The highest grain yield was obtained from v_1 followed by v_4. v_2 and v_3 were on par and lowest grain yield was obtained from local variety.

Season III

Dates of transplanting and varieties significantly influenced grain yield. Earlier transplanting resulted in higher grain yield. Grain yield of d_1 and d_2 transplanting were on par. Local variety produced lowest grain yield and among high yielding varieties v_1 and v_4 were on par and significantly superior than v_3 and v_2 and yield of v_3 was higher than that of v_2.

4.2.2.9 Straw yield (Table 120)

Season I

Straw yield was significantly influenced by dates of transplanting varieties and their interactions. Transplanting on d_1 and d_2 resulted in higher straw yield for v_5, but it was on par with v_3 and v_1 on d_3. Straw yield of high yielding varieties were not significantly different on d_1 but v_1 had higher straw yield than v_2 on d_2 and v_3 and v_1 produced more straw than v_4 on d_3.

Table118 Grain chaff ratio of rice as influenced by different dates of transplanting and varieties at transplanting stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	3.81	3.48	3.61	3.70	3.50	3.62	D	0.029	0.090
d_2	3.75	3.50	3.44	3.65	3.45	3.56	V	0.030	0.097
d_3	3.54	3.39	3.33	3.50	3.22	3.40	DV	0.062	-
mean	3.70	3.46	3.46	3.62	3.39	3.52			
Season II									
d_1	3.48	3.48	3.53	3.48	3.19	3.43	D	0.003	0.129
d_2	3.32	3.32	3.30	3.22	3.15	3.26	V	0.003	0.121
d_3	3.27	3.17	3.18	3.09	2.95	3.13	DV	0.005	-
mean	3.36	3.32	3.34	3.26	3.10	3.27			
Season III									
d_1	3.21	2.96	3.02	3.00	2.57	2.95	D	0.005	0.215
d_2	3.15	2.82	2.97	2.93	2.58	2.89	V	0.006	0.149
d_3	2.76	2.81	2.83	2.84	2.41	2.73	DV	0.007	0.179
mean	3.04	2.86	2.94	2.92	2.52	2.86			

Table 119 Grain yield (kg ha^{-1}) as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	4787	4598	4460	4648	3503	4399	D	16.4	64.5
d_2	4737	4437	4346	4667	3389	4315	V	26.2	85.3
d_3	4373	3887	3657	3967	3328	3842	DV	64.8	194.4
mean	4632	4307	4155	4427	3407	4186			
Season II									
d_1	4158	3913	3637	3979	3107	3759	D	34.5	158.3
d_2	4032	3746	3656	3893	3179	3701	V	40.3	131.5
d_3	3945	3621	3579	3832	2993	3594	DV	87.5	
mean	4045	3760	3624	3902	3093	3685			
Season III									
d_1	3530	3232	3462	3424	2747	3279	D	12.9	50.5
d_2	3446	3128	3199	3381	2583	3148	V	24.0	78.4
d_3	3335	3032	3107	3352	2671	3099	DV	48.1	-
mean	3437	3131	3256	3386	2667	3175			

Season II

Only varietal difference was observed. Highest straw yield was registered by local variety and among high yielding varieties, maximum straw yield was for v_4 which was on par with v_1 and v_2 and significantly higher than v_3.

Season III

Only varietal difference was seen. High yielding varieties had less straw yield than local variety. However, all the high yielding varieties did not differ in their straw yield.

4.2.2.10 Harvest index (Table 121)

Season I

Varieties and its interactions with dates of transplanting significantly influenced the HI. No significant difference in HI was observed among high yielding varieties when transplanted on d_1 and d_2 but their HI were significantly higher than that of local variety. When transplanted on d_3, v_4 and v_1 were on par and had high HI than the remaining varieties and v_3 had the lowest HI than high yielding varieties. However, the least HI was recorded by v_5 on all dates of transplanting.

Season II

Only varietal wise difference was seen. But the difference was observed only between high yielding varieties and local variety. Lowest HI was registered by local variety.

Season III

HI was significantly influenced by dates of transplanting , varieties and their interactions. Earlier transplanting resulted in high HI value but no significant difference in HI when transplanted on d_2 and d_3. On all the dates of transplanting lowest HI was recorded by v_5. Transplanting on d_1 resulted in no significant difference in HI among v_1, v_3 and v_4. But HI of v_1, v_3 was significantly higher than that of v_2. Transplanting on d_2 resulted in high HI values for v_4 and v_1, which were on par and significantly higher than

Table 120 Straw yield (kg ha^{-1}) as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	5327	5167	5067	5233	5973	5353	D	67.9	266.4
d_2	5254	4961	5013	5116	5824	5234	V	58.9	192.0
d_3	4776	4520	4790	4247	5045	4676	DV	94.5	283.4
mean	5119	4883	4957	4865	5614	5088			
Season II									
d_1	4658	4510	4430	4765	5182	4709	D	38.6	-
d_2	4627	4520	4452	4553	4890	4608	V	66.0	215.2
d_3	4503	4433	4323	4675	4707	4528	DV	256.7	-
mean	4596	4488	4402	4664	4926	4615			
Season III									
d_1	4307	4140	4263	4261	4772	4349	D	24.6	-
d_2	4213	4150	4240	4363	4867	4367	V	51.3	167.4
d_3	4213	4190	4127	4204	4733	4293	DV	59.9	-
mean	4244	4160	4210	4276	4791	4336			

Table 121 Harvest index of rice as influenced by different dates of transplanting and varieties at transplanting stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.467	0.470	0.470	0.470	0.367	0.449	D	0.003	-
d_2	0.477	0.470	0.467	0.480	0.370	0.453	V	0.004	0.0131
d_3	0.480	0.460	0.433	0.483	0.397	0.451	DV	0.005	0.0159
mean	0.474	0.467	0.457	0.478	0.378	0.451			
Season II									
d_1	0.473	0.463	0.450	0.453	0.373	0.443	D	0.003	-
d_2	0.467	0.450	0.453	0.463	0.393	0.445	V	0.006	0.0187
d_3	0.467	0.450	0.453	0.450	0.390	0.442	DV	0.008	-
mean	0.469	0.454	0.452	0.456	0.386	0.443			
Season III									
d_1	0.450	0.437	0.450	0.447	0.363	0.429	D	0.002	0.0066
d_2	0.440	0.427	0.427	0.447	0.363	0.421	V	0.004	0.0114
d_3	0.450	0.423	0.430	0.433	0.347	0.417	DV	0.004	0.0118
mean	0.447	0.429	0.436	0.442	0.358	0.422			

that of v_2 and v_3, which were also on par. HI of v_1 was significantly higher when transplanted on d_3 and the remaining high yielding varieties were not significantly different in their HI.

4.2.3 Nutrient uptake

4.2.3.1 Nitrogen uptake

4.2.3.1.1 Nitrogen uptake at transplanting stage (Table 122)

Season I

Dates of transplanting, varieties and their interactions were significant with respect to nitrogen uptake. On all dates of transplanting maximum uptake was registered by local variety and it was on par with v_2 on d_3 transplanting. Among high yielding varieties, v_2 and v_3 were on par on d_1 transplanting and significantly lower than v_4. On d_2 transplanting v_1 and v_4 were on par and significantly higher than v_2 and v_3 which were on par and recorded lowest nitrogen uptake. All high yielding varieties were on par on d_3 transplanting.

Season II

The main effect of dates of transplanting, varieties and their interactions were significant. On all dates of transplanting maximum uptake was registered by local variety. No significant difference in nitrogen uptake was observed among high yielding varieties for d_1 and d_3 transplanting. For d_2 transplanting, v_3 registered lowest nitrogen uptake and it was on par with v_1 and v_2.

Season III

Varietal difference was observed. Here also maximum uptake was registered by v_5. v_4 and v_1 were on par but nitrogen uptake of v_4 was significantly higher than that of v_2 and v_3.

4.2.3.1.2 Nitrogen uptake at active tillering stage (Table 123)

Season I

Nitrogen uptake was significantly influenced by dates of transplanting and varieties. Early transplanting resulted in higher uptake values. Higher nitrogen uptake was recorded by local variety. Among high yielding varieties, maximum uptake was shown by v_1 and a minimum by v_3. v_4 and v_1 were on par.

Season II

Nitrogen uptake was significantly influenced by varietal differences and dates of transplanting. Early transplanting resulted in higher uptake value. No significant difference among high yielding varieties were seen with respect to nitrogen uptake but their nitrogen uptake was significantly lower than that of local variety.

Season III

Only varietal difference in nitrogen uptake was seen. Maximum nitrogen uptake was registered by local variety. Among high yielding varieties maximum uptake was registered by v_4 and it was on par with v_1. Uptake of nitrogen by v_3 was not significantly different from v_1 and v_2

4.2.3.1.3 Nitrogen uptake at panicle initiation stage (Table 124)

Season I

Dates of transplanting, varieties and their interactions significantly influenced nitrogen uptake. On all dates of transplanting local variety registered maximum nitrogen uptake. When transplanted on d_1 among high yielding varieties, v_1 and v_4 were on par and v_1 had a higher uptake value than v_2 and v_3. When transplanted on d_2, among high yielding varieties v_1 gave maximum nitrogen uptake and all other varieties were on par and registered lower uptake. Transplanting on d_3 resulted in no significant difference among high yielding varieties with respect to nitrogen uptake.

Table122 Nitrogen uptake (kg ha^{-1}) at transplanting stage as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.376	1.303	1.216	1.487	1.691	1.414	D	0.0141	0.0553
d_2	1.452	1.317	1.238	1.445	1.609	1.412	V	0.0274	0.0894
d_3	1.125	1.180	1.132	1.166	1.266	1.174	DV	0.0579	0.1736
mean	1.317	1.267	1.195	1.366	1.522	1.334			
Season II									
d_1	1.226	1.129	1.134	1.152	1.483	1.225	D	0.0226	0.0887
d_2	1.124	1.110	1.046	1.182	1.350	1.162	V	0.0226	0.0736
d_3	1.068	1.007	1.042	1.137	1.412	1.133	DV	0.0447	0.1340
mean	1.139	1.082	1.074	1.157	1.415	1.173			
Season III									
d_1	1.094	1.086	0.970	1.152	1.358	1.132	D	0.0191	-
d_2	1.089	1.047	1.026	1.182	1.248	1.118	V	0.0251	0.0819
d_3	1.076	1.060	1.029	1.155	1.307	1.126	DV	0.0411	-
mean	1.086	1.064	1.009	1.163	1.304	1.125			

Table 123 Nitrogen uptake (kg ha^{-1}) at active tillering stage as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	31.03	26.97	25.10	29.50	33.93	29.31	D	0.423	1.661
d_2	29.30	27.30	26.20	28.30	32.97	28.81	V	0.333	1.085
d_3	23.07	23.87	22.90	24.40	28.67	24.58	DV	0.920	-
mean	27.80	26.04	24.73	27.40	31.86	27.57			
Season II									
d_1	24.67	23.63	24.57	23.27	31.33	25.49	D	0.231	0.908
d_2	23.53	23.67	23.23	24.90	30.07	25.08	V	0.363	1.182
d_3	22.03	21.57	21.37	22.20	28.57	23.15	DV	0.709	-
mean	23.41	22.96	23.06	23.46	29.99	24.57			
Season III									
d_1	22.93	21.97	22.13	23.73	26.30	23.41	D	0.263	-
d_2	21.80	21.33	21.77	24.70	27.17	23.35	V	0.448	1.462
d_3	22.37	21.93	20.17	22.03	27.93	22.89	DV	0.637	-
mean	22.37	21.75	21.35	23.49	27.13	23.22			

Season II

Dates of transplanting and varieties significantly influenced nitrogen uptake. Transplanting on d_1 recorded maximum uptake, while d_2 and d_3 were on par and had significantly lower uptake. High yielding varieties registered lower uptake value than local variety, but among them v_1 had a significantly higher value than v_2, v_3 and v_4.

Season III

Dates of transplanting, varieties and their interactions significantly influenced nitrogen uptake. On all dates of transplanting, local variety registered higher uptake values. Among high yielding varieties, v_4, v_1 and v_2 were on par and v_4 had a higher nitrogen uptake value than v_3 on d_1 transplanting. When transplanted on d_2, v_1, v_4 and v_2 were on par and lowest uptake was registered by v_3 and it was on par with v_2. Transplanting on d_3 resulted in higher uptake values for v_1 followed by v_2, v_3 and v_4, which were on par.

4.2.3.1.4 Nitrogen uptake at heading stage (Table 125)

Season I

Varieties and its interaction with dates of transplanting significantly influenced the nitrogen uptake. Transplanting on d_1 gave significantly higher uptake value for v_5 against high yielding varieties and among high yielding varieties, v_1 was on par with v_4 and had higher uptake than v_2 and v_3 which were on par. But transplanting on d_2 resulted in no significant difference in uptake among high yielding varieties, but a significantly lower value than v_5. Transplanting on d_3 resulted in higher uptake value for v_5 which was on par with v_4 and v_2 and significantly higher than v_1 and v_3 which were also on par.

Season II

Nitrogen uptake was significantly influenced by dates of transplanting, varieties and their interactions. Maximum uptake was registered by v_1 when transplanted on d_1 and v_2, v_3, v_4 and v_5 were on par. But when transplanted on d_2, no significant difference was found among any of the varieties. When transplanted on d_3, v_1 was on par with v_3 and v_5 and significantly higher than v_4 and v_2, which also were on par.

Table 124 Nitrogen uptake (kg ha $^{-1}$) at panicle initiation stage as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	44.73	42.12	42.45	43.62	58.52	46.29	D	0.349	1.372
d_2	45.23	41.83	40.90	41.67	57.07	45.34	V	0.589	1.920
d_3	37.50	36.87	36.90	38.07	57.30	41.33	DV	0.751	2.253
mean	42.49	40.27	40.08	41.12	57.63	44.32			
Season II									
d_1	48.97	40.87	42.93	42.57	63.83	47.83	D	0.296	1.162
d_2	40.07	40.93	40.40	41.37	65.53	45.66	V	0.616	2.009
d_3	44.23	38.83	41.80	38.63	57.90	44.28	DV	1.686	-
mean	44.42	40.21	41.71	40.86	62.42	45.92			
Season III									
d_1	39.23	38.57	37.20	40.30	62.70	43.60	D	0.299	1.174
d_2	37.73	35.93	34.53	37.17	62.73	41.62	V	0.594	1.936
d_3	37.53	34.13	33.43	32.97	62.23	40.06	DV	0.798	2.392
mean	38.17	36.21	35.06	36.81	62.56	41.76			

Table 125 Nitrogen uptake (kg ha $^{-1}$) at heading stage as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	60.10	55.53	54.83	58.70	64.43	58.72	D	0.988	-
d_2	57.60	58.27	57.33	57.37	62.90	58.69	V	0.794	2.588
d_3	55.40	54.99	52.07	55.80	59.10	55.46	DV	1.275	3.823
mean	57.70	56.26	54.74	57.29	62.14	57.62			
Season II									
d_1	59.07	55.27	57.03	56.33	64.47	58.43	D	0.683	2.682
d_2	55.10	53.43	55.23	55.53	56.70	55.20	V	0.785	2.559
d_3	55.20	52.90	55.87	53.07	58.40	55.09	DV	1.305	3.923
mean	56.46	53.87	56.04	54.98	59.86	56.24			
Season III									
d_1	53.90	53.20	55.63	56.23	57.30	55.25	D	0.461	-
d_2	55.50	52.43	55.53	52.63	50.73	53.37	V	0.937	-
d_3	51.53	52.80	53.30	55.10	54.07	53.36	DV	1.019	-
mean	35.68	35.08	36.28	35.91	34.93	35.58			

Season III

Neither dates of transplanting nor varieties registered significant influence on nitrogen uptake at this stage in this season.

4.2.3.1.5 Nitrogen uptake at beginning of grain filling stage (Table 126)

Season I

Varieties and its interaction with dates of transplanting significantly influenced nitrogen uptake. v_5 and v_1 were on par and recorded significantly more nitrogen uptake than the remaining varieties, which were on par when transplanted on d_1. But when transplanted on d_2 all the high yielding varieties were on par and recorded a significantly reduced nitrogen uptake than v_5. No significant difference in nitrogen uptake was seen among varieties when transplanted on d_3.

Season II

Only dates of transplanting influenced nitrogen uptake. Transplanting on d_1 resulted in higher nitrogen uptake than d_2 and d_3 which were on par.

Season III

Neither dates of transplanting nor varieties significantly influenced nitrogen uptake.

4.2.3.1.6 Nitrogen uptake by straw (Table 127)

Season I

Dates of transplanting and varieties significantly influenced nitrogen uptake. Transplanting on d_1 resulted in higher nitrogen uptake by straw and d_2 and d_3 were on par and recorded lower uptake. The varieties v_1 registered higher uptake of nitrogen by straw than v_3 and was on par with all other varieties.

Season II

Nitrogen uptake was significantly influenced by dates of transplanting and varieties Transplanting on d_1 resulted in higher uptake value and d_3 transplanting resulted in lower uptake. Maximum uptake was registered by v_1 and it was on par with v_4 and significantly higher than v_3, v_2 and v_5, which were also on par.

Table 126 **Nitrogen uptake(kg ha $^{-1}$) at beginning of grain filling stage as influenced bydifferent dates of transplanting and varieties in different seasons at Pattambi**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	64.77	60.03	60.37	63.07	65.00	62.65	D	0.511	-
d_2	62.13	61.21	58.25	60.43	68.60	62.13	V	1.011	3.296
d_3	62.98	62.60	59.43	62.20	60.20	61.48	DV	1.435	4.304
mean	63.29	61.28	59.35	61.90	64.60	62.09			
Season II									
d_1	61.21	59.27	63.73	60.93	65.83	62.20	D	0.281	1.105
d_2	60.10	60.00	59.27	61.70	60.00	60.21	V	0.442	-
d_3	60.53	59.23	58.41	60.17	57.97	59.26	DV	1.296	-
mean	60.61	59.50	60.47	60.93	61.27	60.56			
Season III									
d_1	57.33	58.93	59.67	59.50	58.60	58.81	D	0.008	-
d_2	59.80	57.83	57.17	59.20	56.57	58.11	V	0.023	-
d_3	56.80	58.50	58.80	56.70	60.77	58.31	DV	0.017	-
mean	57.98	58.42	58.54	58.47	58.64	58.41			

Table 127 **Nitrogen uptake of by straw (kg ha $^{-1}$) as influenced by different dates of transplanting and varieties in different seasons at Pattambi**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	39.26	37.45	37.67	39.43	38.41	38.44	D	0.255	1.001
d_2	37.73	36.72	36.61	37.84	37.36	37.25	V	0.276	0.900
d_3	37.97	36.62	35.20	36.59	35.64	36.40	DV	0.511	-
mean	38.32	36.93	36.49	37.95	37.14	37.37			
Season II									
d_1	38.61	36.92	37.26	38.27	35.80	37.37	D	0.328	1.288
d_2	37.00	35.67	35.51	37.10	36.33	36.32	V	0.287	0.937
d_3	37.27	35.17	35.55	37.21	35.53	36.14	DV	0.304	-
mean	37.66	36.37	36.10	37.04	35.89	36.61			
Season III									
d_1	38.00	36.03	35.47	35.92	36.41	36.37	D	0.174	0.685
d_2	35.89	35.70	35.18	35.92	35.23	35.59	V	0.225	-
d_3	36.16	36.34	35.51	36.18	33.35	35.51	DV	0.523	1.569
mean	36.16	36.02	35.39	36.01	35.53	35.82			

Season III

Dates of transplanting and its interaction with varieties significantly influenced the nitrogen uptake. Transplanting on d_1 resulted in higher uptake value for v_1, which was on par with other varieties except v_3, which recorded lower uptake. No significant difference among varieties was observed for d_2 transplanting. Local variety registered significantly lower nitrogen uptake on d_3 and it was on par with v_3, which was on par with all other varieties.

4.2.3.1.7 **Nitrogen uptake by Grain** (Table 128)

Season I

Dates of transplanting and varieties significantly influenced nitrogen uptake. Transplanting on d_1 resulted in higher nitrogen uptake by grain and d_2 and d_3 were on par and recorded lower uptake. The variety v_1 registered higher uptake of nitrogen by straw than v_3 and v_5 was on par with all other varieties.

Season II

Only varietal difference was observed. Local variety recorded lowest nitrogen uptake by grain. Among high yielding varieties, v_4, v_3 and v_1 were on par and registered significantly higher uptake than v_2.

Season III

Nitrogen uptake was significantly influenced by dates of transplanting and varieties. Transplanting on d_1 resulted in higher nitrogen uptake by grain and d_3 recorded lower uptake. The variety v_1 registered higher uptake of nitrogen by straw than v_5 and was on par with all other varieties.

4.2.3.2 **Phosphorus uptake**

4.2.3.2.1 Phosphorus uptake at transplanting stage (Table 129)

Season I

Phosphorus uptake was significantly influenced by different dates of transplanting and varieties. Late transplanting resulted in significant reduction in phosphorus uptake. But no significant difference was observed between v_1 and v_4. Maximum uptake was shown by v_5, which was on par with v_1 and no significant difference in phosphorus uptake was observed between v_2, v_3 and v_4.

Season II

Phosphorus uptake was significantly influenced by different dates of transplanting and varieties. Phosphorus uptake was lowest when transplanted on d_3 and no significant difference in phosphorus uptake was seen between transplanting on d_1 and d_2. Maximum phosphorus uptake was registered by v_5 which was significantly higher than that of all high yielding varieties. Among high yielding varieties, uptake of v_3 was significantly less than v_1 and on par with other high yielding varieties.

Season III

Only varietal difference was observed. Higher phosphorus uptake was registered by v_5. Among high yielding varieties, uptake of v_1 was significantly higher than that of v_3, which was on par with v_2 and v_4.

4.2.3.2.2 Phosphorus uptake at active tilling stage (Table 130)

Season I

Phosphorus uptake was significantly influenced by different dates of transplanting and varieties. Early transplanting resulted in higher phosphorus uptake. Among varieties maximum uptake was shown by local variety. Among high yielding varieties, uptake of v_1 was significantly higher than that of v_2 and v_3.

Season II

Dates of transplanting, varieties and their interactions were significant. On all

Table 128 Nitrogen uptake of by grain (kg ha^{-1}) as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	49.92	46.59	46.04	48.99	44.63	47.23	D	0.460	1.805
d_2	47.63	46.86	47.25	45.34	45.47	46.51	V	0.409	1.335
d_3	44.77	46.00	45.26	44.92	46.09	45.41	DV	0.985	-
mean	47.44	46.48	46.18	46.42	45.40	46.38			
Season II									
d_1	45.20	44.98	47.51	46.58	45.53	45.96	D	0.245	-
d_2	46.47	45.83	45.71	45.86	44.34	45.64	V	0.127	0.413
d_3	45.66	44.68	44.50	46.01	44.26	45.02	DV	0.832	-
mean	45.78	45.16	45.91	46.15	44.71	45.54			
Season III									
d_1	47.21	44.68	45.74	47.17	43.83	45.73	D	0.310	1.216
d_2	47.62	46.69	44.70	45.13	44.14	45.66	V	0.563	1.838
d_3	43.97	45.16	43.88	43.95	42.08	44.81	DV	0.682	-
mean	31.61	30.46	30.15	30.77	29.32	30.46			

Table 129 Phosphorus uptake (kg ha^{-1}) at transplanting stage as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.594	0.465	0.492	0.526	0.591	0.533	D	0.0070	0.0276
d_2	0.539	0.453	0.452	0.530	0.555	0.506	V	0.0153	0.0500
d_3	0.481	0.452	0.431	0.462	0.523	0.470	DV	0.0299	-
mean	0.538	0.457	0.458	0.506	0.556	0.503			
Season II									
d_1	0.512	0.488	0.444	0.499	0.583	0.505	D	0.0096	0.0378
d_2	0.473	0.459	0.440	0.461	0.517	0.470	V	0.0085	0.0278
d_3	0.448	0.429	0.423	0.419	0.528	0.449	DV	0.0110	-
mean	0.478	0.459	0.436	0.460	0.543	0.475			
Season III									
d_1	0.468	0.434	0.409	0.426	0.514	0.450	D	0.0033	-
d_2	0.461	0.421	0.414	0.435	0.492	0.445	V	0.0087	0.0284
d_3	0.443	0.438	0.413	0.436	0.503	0.447	DV	0.0144	-
mean	0.458	0.431	0.412	0.432	0.503	0.447			

dates of transplanting maximum uptake was recorded by v_5. The uptake of v_1, v_2 and v_4 were on par and significantly higher than that of v_3, when transplanted on d_1. When transplanted on d_2 uptake of v_1 was on par with v_2 but significantly higher than that of v_3 and v_4 and uptake of v_2 was significantly higher than v_4. Transplanting in d_3 resulted in higher phosphorus uptake value for v_1, in comparison with v_2 and v_3.

Season III

Only varietal difference in phosphorus uptake was seen. Maximum uptake was recorded by v_5. Among high yielding varieties, uptake of v_1 was significantly higher than v_2, v_3 and v_4, which were on par.

4.2.3.2.3 **Phosphorus uptake at panicle initiation stage** (Table 131)

Season I

Phosphorus uptake was significantly influenced by different dates of transplanting and varieties. Early transplanting resulted in higher phosphorus uptake. Maximum uptake was registered by v_5 and among high yielding varieties, uptake of v_1, v_2 and v_4 were on par, but v_1 and v_4 reported significantly higher uptake value than v_3.

Season II

Only varietal difference was seen with maximum phosphorus uptake by v_5. Among high yielding varieties, uptake of v_1 was significantly higher than that of v_2, v_3 and v_4, which were on par.

Season III

Only varietal difference was noticed. All the high yielding varieties were on par and had a significantly lower uptake than v_5.

4.2.3.2.4 **Phosphorus uptake at heading stage** (Table 132)

Season I

The main effect of dates of transplanting, varieties and their interactions were

Table 130 Phosphorus uptake (kg ha $^{-1}$) at active tillering stage as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	14.27	11.80	12.20	12.87	15.10	13.25	D	0.166	0.652
d_2	13.30	11.33	11.53	12.93	14.10	12.64	V	0.291	0.950
d_3	12.00	11.43	10.83	11.53	13.73	11.91	DV	0.668	-
mean	13.19	11.52	11.52	12.44	14.31	12.60			
Season II									
d_1	12.60	12.43	11.43	12.37	15.37	12.84	D	0.133	0.523
d_2	11.30	10.93	10.73	10.33	13.67	11.39	V	0.159	0.516
d_3	11.50	11.00	10.87	11.17	13.27	11.56	DV	0.166	0.496
mean	11.80	11.46	11.01	11.29	14.10	11.93			
Season III									
d_1	11.40	10.60	10.70	10.50	13.10	11.26	D	0.084	-
d_2	11.33	10.67	10.40	10.77	12.73	11.18	V	0.142	0.462
d_3	10.93	10.93	10.77	10.97	12.47	11.21	DV	0.304	-
mean	11.22	10.73	10.62	10.74	12.77	11.22			

Table 131 Phosphorus uptake (kg ha $^{-1}$) at panicle initiation stage as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	15.97	14.73	14.70	16.97	19.07	16.29	D	0.172	0.676
d_2	15.40	14.43	13.83	15.00	18.10	15.35	V	0.301	0.983
d_3	13.73	13.33	13.30	13.40	17.33	14.22	DV	0.495	-
mean	15.03	14.17	13.94	15.12	18.17	15.29			
Season II									
d_1	14.92	13.23	13.60	14.50	17.47	14.74	D	0.250	-
d_2	15.40	13.07	12.80	13.47	17.43	14.43	V	0.195	0.635
d_3	12.67	12.73	13.63	13.00	17.40	13.89	DV	0.445	-
mean	14.33	13.01	13.34	13.66	17.43	14.35			
Season III									
d_1	13.17	13.07	12.83	13.10	17.00	13.83	D	0.173	-
d_2	13.06	12.84	12.90	13.10	17.31	13.84	V	0.350	1.048
d_3	12.67	12.70	12.87	13.07	17.10	13.68	DV	0.475	-
mean	12.96	12.87	12.87	13.09	17.14	13.79			

significant. On all dates of transplanting phosphorus uptake by local variety was significantly higher than that of high yielding varieties. Uptake of v_1 and v_4 were on par, but significantly higher than that of v_2 and v_3, which were also on par on d_1. But transplanting on d_2 resulted in no significant difference in phosphorus uptake among high yielding varieties. Transplanting on d_3 showed a higher uptake value for v_1 in comparison with v_5, v_3 and v_4, which were on par with v_2.

Season II and III

Neither the main effects nor their interactions significantly influenced phosphorus uptake at this stage in these seasons.

4.2.3.2.5 Phosphorus uptake at beginning of grain filling stage (Table 133)

Season I

Dates of transplanting, varieties and their interactions significantly influenced the phosphorus uptake. In general there was reduction in phosphorus uptake with late transplanting, d_1 being given the better uptake values. Transplanting on d_1 and d_2 resulted in higher uptake value for v_5. Uptake of v_1 and v_4 were on par and significantly higher than that of v_2 and v_3, which were also on par in plants transplanted on d_1 while no significant difference among high yielding varieties was seen in d_2 transplanting. There was no significant difference in phosphorus uptake among varieties was observed when transplanted on d_3.

Season II and III

Neither dates of transplanting nor varieties significantly influenced phosphorus uptake.

4.2.3.2.6 Phosphorus uptake by straw (Table 134)

Season I

Differential response in phosphorus uptake was seen with different dates of transplanting. On d_1 transplanting maximum phosphorus uptake was registered by v_4

Table 132 Phosphorus uptake (kg ha $^{-1}$) at heading stage as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	18.90	17.20	17.00	19.27	21.17	18.71	D	0.392	1.539
d_2	16.60	16.63	16.90	17.03	19.03	17.24	V	0.307	1.002
d_3	15.43	16.00	15.60	15.73	17.27	16.01	DV	0.483	1.448
mean	16.98	16.61	16.50	17.86	18.64	17.32			
Season II									
d_1	17.53	15.40	15.80	16.70	17.73	16.63	D	0.332	-
d_2	15.40	15.27	14.90	15.80	14.80	15.23	V	0.381	-
d_3	15.83	14.77	15.87	15.20	17.53	15.84	DV	0.497	-
mean	16.26	15.14	15.52	15.90	16.69	15.90			
Season III									
d_1	15.11	14.94	15.17	15.07	15.18	15.09	D	0.174	-
d_2	14.80	14.67	15.03	15.30	15.07	14.97	V	0.201	-
d_3	15.07	15.10	14.90	15.10	15.20	15.07	DV	0.362	-
mean	9.96	9.92	9.98	10.13	10.09	10.02			

Table 133 Phosphorus uptake (kg ha $^{-1}$) at beginning grain filling stage as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	19.53	17.90	17.33	19.63	22.87	19.45	D	0.112	0.441
d_2	17.33	17.33	17.27	18.20	20.57	18.14	V	0.339	1.106
d_3	16.43	17.20	17.10	16.90	17.13	16.95	DV	0.327	0.982
mean	17.77	17.48	17.23	18.24	20.19	18.18			
Season II									
d_1	18.87	16.53	17.07	17.80	19.37	17.93	D	0.363	-
d_2	16.93	16.33	15.90	16.93	15.93	16.41	V	0.426	-
d_3	17.20	15.77	16.90	16.40	18.90	17.03	DV	0.477	-
mean	17.67	16.21	16.62	17.04	18.07	17.12			
Season III									
d_1	16.83	16.10	16.30	15.83	16.30	16.27	D	0.231	-
d_2	15.83	15.63	16.03	16.17	16.13	15.96	V	0.185	-
d_3	16.00	16.13	15.83	16.03	16.07	16.01	DV	0.354	-
mean	16.22	15.96	16.06	16.01	16.17	16.08			

followed by v_1, v_2 and v_5 and v_3. When transplanted on d_2 highest uptake was by v_1 followed by v_3, v_2, v_4 and v_5 and among them v_4 and v_2 were on par. No significant difference in phosphorus uptake was registered among high yielding varieties but recorded a significantly higher value than v_5 when transplanted on d_3.

Season II

Differential response in phosphorus uptake was seen with different dates of transplanting and varieties. Early transplanting resulted in higher phosphorus uptake. All the high yielding varieties showed more phosphorus uptake than local variety. Among the high yielding varieties, v_1 recorded more phosphorus uptake value than v_3 and v_5 and was on par with other varieties.

Season II

Dates of transplanting and varieties significantly influenced phosphorus uptake. Early transplanting resulted in higher phosphorus uptake. All the high yielding varieties showed more phosphorus uptake than local variety. Among the high yielding varieties, v_1 recorded more phosphorus uptake value than v_4, v_2 and v_3 of which v_2 and v_3 were on par.

4.2.3.5.7 Phosphorus uptake by Grain (Table 135)

Season I and II

Dates of transplanting significantly influenced phosphorus uptake. Early transplanting resulted in higher phosphorus uptake by grain.

Season III

Varietal difference and its interaction with dates of transplanting were observed. Transplanting on d_1 resulted in a higher phosphorus uptake for v_1 in comparison with v_2, v_3 and v_4. But no varietal difference was observed when transplanted on d_2 while d_3 transplanting resulted in significant reduction in phosphorus uptake by v_5 against high yielding varieties, which were on par.

Table 134 Phosphorus uptake by straw (kg ha $^{-1}$) as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	10.29	10.07	9.57	10.52	9.71	10.03	D	0.024	0.095
d_2	10.12	9.68	9.81	9.64	9.48	9.74	V	0.031	0.101
d_3	9.38	9.42	9.49	9.45	8.61	9.27	DV	0.037	0.110
mean	9.93	9.72	9.62	9.87	9.27	9.68			
Season II									
d_1	9.67	9.19	9.47	9.83	9.20	9.47	D	0.074	0.290
d_2	9.87	8.84	9.98	9.59	8.61	9.38	V	0.084	0.274
d_3	9.44	8.91	9.10	9.33	8.61	9.08	DV	0.114	-
mean	9.66	8.98	9.52	9.59	8.81	9.31			
Season III									
d_1	9.46	9.29	9.08	9.58	8.87	9.26	D	0.035	0.138
d_2	10.07	9.06	9.01	9.19	8.34	9.13	V	0.020	0.066
d_3	9.30	9.12	9.25	9.19	8.52	9.07	DV	0.053	-
mean	9.61	9.16	9.11	9.32	8.58	9.15			

Table 135 Phosphorus uptake by grain (kg ha -1) as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	22.80	21.16	20.39	21.06	19.94	21.07	D	0.225	0.883
d_2	21.57	20.82	19.93	21.04	20.44	20.76	V	0.221	-
d_3	20.27	20.15	19.95	21.35	19.02	20.15	DV	0.338	-
mean	21.55	20.76	20.09	21.21	20.13	20.76			
Season II									
d_1	22.30	20.45	20.54	20.17	20.95	20.88	D	0.311	1.221
d_2	20.28	19.21	19.29	20.22	18.45	19.49	V	0.226	-
d_3	19.53	19.29	19.04	20.67	18.36	19.38	DV	0.442	-
mean	20.70	19.65	19.63	20.35	19.25	19.92			
Season III									
d_1	20.84	18.89	18.71	17.80	18.10	18.87	D	0.196	-
d_2	18.99	18.88	19.48	20.41	19.20	19.39	V	0.139	0.453
d_3	19.68	18.73	18.16	18.09	16.88	18.31	DV	0.361	1.073
mean	19.84	18.83	18.78	18.77	17.84	18.81			

4.2.3.3 Potassium uptake

4.2.3.3.1 Potassium uptake at transplanting stage (Table 136)

Season I

Potassium uptake was significantly influenced by dates of transplanting and varieties. Plants transplanted on d_3 recorded the lowest potassium uptake than those transplanted on d_2 and d_3, which were on par. All the high yielding varieties registered more or less similar in potassium uptake but significantly lower in comparison with v_5.

Season II

Potassium uptake was significantly influenced by varieties only. Local variety reported maximum potassium uptake. Among high yielding varieties, uptake of v_1 was significantly higher than that of v_3 and v_2.

Season III

Potassium uptake was significantly different with respect to both dates of transplanting and varieties. A significantly higher potassium uptake was shown by plants transplanted on d_1 and no significant difference was noticed between d_2 and d_3. All the high yielding varieties were on par and registered a lower potassium uptake than local variety.

4.2.3.3.2 Potassium uptake at active tillering stage (Table 137)

Season I

Potassium uptake was significantly influenced by dates of transplanting and varieties. Early transplanting resulted in higher potassium uptake. Maximum uptake was shown by local variety. Among high yielding varieties, uptake of v_1 was significantly higher than that of v_3, which was on par with v_2 and v_4.

Season II

Only varietal differencė was seen. Local variety recorded maximum uptake. Among high yielding varieties, maximum uptake was shown by v_1, which was significantly higher than that of remaining high yielding varieties. v_4 also had a better uptake value than v_2.

Table 136 Potassium uptake(kg ha $^{-1}$) at transplanting stage as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.426	1.442	1.319	1.448	1.977	1.522	D	0.0236	0.0926
d_2	1.457	1.362	1.324	1.454	1.775	1.475	V	0.0453	0.1480
d_3	1.242	1.282	1.225	1.251	1.592	1.318	DV	0.0606	-
mean	1.375	1.362	1.289	1.384	1.781	1.438			
Season II									
d_1	1.490	1.151	1.238	1.431	1.805	1.423	D	0.0305	-
d_2	1.386	1.187	1.205	1.210	1.627	1.323	V	0.0293	0.0954
d_3	1.305	1.206	1.293	1.345	1.705	1.371	DV	0.0726	-
mean	1.394	1.181	1.245	1.329	1.712	1.372			
Season III									
d_1	1.395	1.268	1.367	1.388	1.664	1.416	D	0.0301	0.1180
d_2	1.203	1.106	1.006	1.151	1.516	1.196	V	0.0317	0.1030
d_3	1.167	1.150	1.101	1.077	1.464	1.192	DV	0.0531	-
mean	1.255	1.175	1.158	1.205	1.548	1.268			

Table 137 Potassium uptake (kg ha $^{-1}$) at active tillering stage as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	32.17	29.77	27.23	28.70	39.69	31.51	D	0.300	1.178
d_2	29.30	28.23	28.07	28.33	36.27	30.04	V	0.143	1.385
d_3	25.53	25.90	24.80	26.20	36.03	27.69	DV	0.726	-
mean	29.00	27.97	26.70	27.74	37.33	29.75			
Season II									
d_1	29.90	24.03	26.80	28.90	38.13	29.55	D	0.595	-
d_2	29.03	25.23	26.77	25.47	36.17	28.53	V	0.498	1.625
d_3	26.87	25.90	26.53	26.30	34.53	28.03	DV	0.970	-
mean	28.60	25.06	26.70	26.89	36.28	28.70			
Season III									
d_1	28.40	25.63	28.43	26.53	34.20	28.64	D	0.647	2.540
d_2	24.07	22.60	21.33	24.10	33.00	25.02	V	0.428	1.397
d_3	24.87	23.87	23.63	22.07	29.47	24.78	DV	0.845	2.534
mean	25.78	24.03	24.47	24.23	32.22	26.15			

Season III

Potassium uptake was significantly influenced by dates of transplanting, varieties and their interactions. Local variety recorded maximum uptake. Potassium uptake by v_1 was significantly higher than that of v_4 and v_2, which were on par with v_3, when transplanted on d_1. Potassium uptake of v_4 and v_1 recorded high potassium uptake value than v_3, when transplanted on d_2. However potassium uptake of v_1 was significantly higher than v_4, which was on par with v_2 and v_3 when transplanted on d_3.

4.2.3.3.3 Potassium uptake at panicle initiation stage (Table 138)

Season I

Potassium uptake was significantly influenced by dates of transplanting and varieties. Early transplanting resulted in higher potassium uptake with no significant difference between d_1 and d_2. All the high yielding varieties were on par in their potassium uptake, but significantly lesser than that of local variety.

Season II

Potassium uptake was significantly influenced by dates of transplanting and varieties. Transplanting on d_1 resulted in higher potassium uptake value for v_1, against v_2 and v_4. No significant difference among varieties were noticed when transplanted on d_2. Local variety recorded maximum uptake on d_3 transplanting and it was significantly higher than other varieties, which were on par.

Season III

Only varietal wise difference was noticed. Potassium uptake of high yielding varieties was not significantly different, but lesser than that of v_5.

4.2.3.3.4 Potassium uptake at heading stage (Table 139)

Seasons I, II and III

Neither varietal difference nor dates of transplanting or their interactions produced any significant difference in potassium uptake.

Table 138 Potassium uptake (kg ha $^{-1}$) at panicle initiation stage as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	58.67	54.83	55.77	56.37	74.00	59.93	D	0.960	3.768
d_2	54.17	53.30	54.00	56.33	76.03	58.77	V	0.739	2.409
d_3	49.63	49.60	47.80	51.37	69.03	53.49	DV	1.218	-
mean	54.16	52.58	52.52	54.69	73.02	57.39			
Season II									
d_1	53.30	48.33	48.37	50.17	70.30	54.09	D	2.118	-
d_2	50.90	52.17	52.07	53.00	53.70	52.37	V	1.649	5.377
d_3	59.03	45.90	52.60	47.27	54.50	51.86	DV	3.204	9.606
mean	54.41	48.80	51.01	50.14	59.50	52.77			
Season III									
d_1	50.63	45.00	44.07	49.40	67.50	51.32	D	1.090	-
d_2	50.70	49.33	48.77	49.43	65.37	52.72	V	1.654	5.393
d_3	49.33	42.70	47.17	40.83	59.13	47.83	DV	2.104	-
mean	50.22	45.68	46.67	46.56	64.00	50.62			

Table 139 Potassium uptake (kg ha $^{-1}$) at heading stage as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	83.07	79.50	80.40	83.93	87.00	82.78	D	2.397	-
d_2	77.87	77.03	76.83	77.20	84.30	78.65	V	2.244	-
d_3	61.43	75.20	75.97	80.17	75.87	73.73	DV	2.914	-
mean	74.12	77.24	77.73	80.43	82.39	78.38			
Season II									
d_1	78.67	60.13	76.33	65.77	82.73	72.73	D	2.862	-
d_2	77.50	71.87	72.20	76.43	71.10	73.82	V	3.532	-
d_3	62.23	59.40	75.83	73.60	76.23	69.46	DV	5.445	-
mean	72.80	63.80	74.79	71.93	76.69	72.00			
Season III									
d_1	73.20	68.03	74.37	57.83	59.33	66.55	D	2.838	-
d_2	70.80	70.90	73.10	75.67	72.33	72.56	V	3.191	-
d_3	72.87	60.83	69.37	58.47	73.83	67.07	DV	4.542	-
mean	72.29	66.59	72.28	63.99	68.50	68.73			

4.2.3.3.5 Potassium uptake at beginning of grain filling stage (Table 140)

Seasons I, II and III

Neither varietal difference nor dates of transplanting produced any significant difference in potassium uptake.

4.2.3.3.6 Potassium uptake by straw (Table 141)

Seasons I, II and III

Neither the varieties nor the dates of transplanting influenced the potassium uptake.

4.2.3.3.7 Potassium uptake by grain (Table 142)

Seasons I, II and III

Neither the varieties nor the dates of transplanting influenced the potassium uptake

4.2.4 Incidence of pests and diseases

4.2.4.1 Incidence of gall midge

4.2.4.1.1 Gall midge incidence at active tillering stage (Table 143)

Season I

Gall midge incidence was influenced by dates of transplanting, varieties and their interactions. On all dates of transplanting v_2 and v_3 were susceptible to gall midge than the remaining varieties. v_1, v_4 and v_5 were hundred per cent resistant to this pest. However. v_3 was better than v_2 on all dates of transplanting.

Season II

Dates of transplanting, varieties and their interactions significantly influenced gall midge incidence. On all dates of transplanting v_2 and v_3 were susceptible to gall midge and v_3 was better than v_2. The varieties v_1, v_4 and v_5 were hundred per cent resistant to this pest.

Season III

Dates of transplanting, varieties and their interactions were significant. On all dates of transplanting v_2 and v_3 were susceptible to gall midge than the remaining varieties.

Table 140 Potassium uptake (kg ha^{-1})at beginning of grain filling stage as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	89.50	88.87	86.23	90.53	94.50	89.93	D	2.198	-
d_2	83.43	81.87	81.43	82.80	91.23	84.15	V	2.327	-
d_3	67.27	79.83	80.67	86.80	80.50	79.01	DV	2.549	-
mean	80.07	83.52	82.78	86.71	88.74	84.36			
Season II									
d_1	86.03	66.30	81.93	74.03	89.73	79.61	D	2.553	-
d_2	82.67	76.27	75.63	82.77	75.07	78.48	V	3.346	-
d_3	69.30	65.37	80.43	77.57	81.53	74.84	DV	5.183	-
mean	79.33	69.31	79.33	78.12	82.11	77.64			
Season III									
d_1	64.67	71.07	78.80	64.10	78.43	71.41	D	2.358	-
d_2	77.07	73.47	77.27	81.23	73.60	76.53	V	2.533	-
d_3	78.60	67.03	70.80	64.17	76.33	71.39	DV	3.702	-
mean	73.44	70.52	75.62	69.83	76.12	73.11			

Table 141 Potassium uptake by straw (kg ha^{-1}) as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	89.11	84.79	86.53	84.51	84.63	85.91	D	0.908	-
d_2	87.77	85.31	86.50	84.57	84.25	85.68	V	1.279	-
d_3	88.11	78.84	80.48	82.08	81.16	82.13	DV	1.800	-
mean	88.33	82.98	84.50	83.72	83.34	84.58			
Season II									
d_1	86.33	82.31	81.27	82.87	80.55	82.66	D	0.311	-
d_2	86.09	83.92	83.82	87.33	81.35	84.50	V	0.226	-
d_3	87.06	82.90	85.09	88.25	80.10	84.68	DV	0.442	-
mean	86.49	83.05	83.39	86.15	80.67	83.95			
Season III									
d_1	86.97	80.96	81.78	81.25	80.90	82.37	D	0.196	-
d_2	83.10	82.84	81.26	82.25	82.15	82.32	V	0.139	-
d_3	84.39	80.55	80.75	84.36	81.37	82.29	DV	0.361	-
mean	84.82	81.45	81.27	82.62	81.47	82.33			

Table142 Potassium uptake by grain(kg ha^{-1}) as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	22.80	21.16	20.39	21.06	19.94	21.07	D	0.225	-
d_2	21.57	20.82	19.93	21.04	20.44	20.76	V	0.221	-
d_3	20.27	20.29	20.20	21.54	20.02	20.46	DV	0.338	-
mean	21.55	20.76	20.17	21.21	20.13	20.76			
Season II									
d_1	22.30	20.45	20.54	20.17	20.95	20.88	D	0.440	-
d_2	19.53	19.29	19.04	20.67	18.36	19.38	V	1.004	-
d_3	20.28	19.21	19.29	20.22	18.45	19.49	DV	1.664	-
mean	20.70	19.65	19.63	20.35	19.25	19.92			
Season III									
d_1	20.84	18.89	18.71	17.80	18.10	18.87	D	0.656	-
d_2	18.99	18.88	19.48	20.41	18.53	19.26	V	0.729	-
d_3	19.68	18.73	18.16	18.09	16.88	18.31	DV	1.532	-
mean	19.84	18.83	18.78	18.77	17.84	18.81			

Table 143 Incidence of gall midge(silver shoots m^{-2})as influenced by different dates of transplanting and varieties at active tillering stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0(1.00)	2.41(4.01)	2.15(3.93)	0(1.00)	0(1.00)	0.91(2.19)	D	0.005	0.021
d_2	0(1.00)	12.75(3.02	10.72(2.89	0(1.00)	0(1.00)	4.69(1.78)	V	0.022	0.071
d_3	0(1.00)	14.83(2.88	13.42(2.72	0(1.00)	0(1.00)	5.65(1.72)	DV	0.020	0.059
mean	0(1.00)	10.00(3.34	8.76(3.23)	0(1.00)	0(1.00)	3.75(1.91)			
Season II									
d_1	0(1.00)	1.38(1.10)	0.90(1.08)	0(1.00)	0(1.00)	0.46(1.04)	D	0.010	0.040
d_2	0(1.00)	2.58(2.10)	2.15(2.03)	0(1.00)	0(1.00)	0.95(1.43)	V	0.011	0.037
d_3	0(1.00)	3.25(2.05)	2.95(1.82)	0(1.00)	0(1.00)	1.24(1.37)	DV	0.020	0.061
mean	0(1.00)	2.40(1.81)	2.00(1.69)	0(1.00)	0(1.00)	0.88(1.30)			
Season III									
d_1	0(1.00)	0.63(1.24)	0.45(1.25)	0(1.00)	0(1.00)	0.22(1.10)	D	0.007	0.029
d_2	0(1.00)	0.64(1.38)	0.58(1.34)	0(1.00)	0(1.00)	0.24(1.14)	V	0.004	0.013
d_3	0(1.00)	1.05(1.26)	0.87(1.27)	0(1.00)	0(1.00)	0.38(1.11)	DV	0.011	0.034
mean	0(1.00)	0.77(1.29)	0.63(1.29)	0(1.00)	0(1.00)	0.28(1.12)			

Figures in parenthesis are transformed values

v_1, v_4 and v_5 were hundred per cent resistant to this pest. However, v_3 was better than v_2 on all dates of transplanting.

4.2.4.1.2 Gall midge incidence at panicle initiation stage (Table 144)

Season I

Gall midge incidence was influenced by dates of transplanting, varieties and their interactions. On all dates of transplanting v_2 and v_3 were susceptible to gall midge and v_3 was better than v_2. v_1, v_4 and v_5 were hundred per cent resistant to this pest.

Season II

Gall midge incidence was influenced by dates of transplanting, varieties and their interactions. On all dates of transplanting v_2 and v_3 were susceptible to gall midge and v_3 was better than v_2 except in d_1 where, it was on par with v_2. v_1, v_4 and v_5 were hundred per cent resistant to this pest.

Season III

Gall midge incidence was influenced by dates of transplanting, varieties and their interactions. On all dates of transplanting v_2 and v_3 were susceptible to gall midge and v_3 was better than v_2 on d_2. v_1, v_4 and v_5 were hundred per cent resistant to this pest.

4.2.4.2. Incidence of rice bug (Table 145)

Season I

No significant difference in rice bug attack was observed in this season either with different dates of transplanting or with different varieties.

Season II

Dates of transplanting and their interactions with varieties were significant. v_1, v_4 and v_5 were hundred per cent resistant to this pest. When transplanted on d_1 and d_2, v_3 had lower incidence than v_2. No significant difference in rice bug attack was observed between v_2 and v_3 for d_3 transplanting.

Table 144 Incidence of gall midge(silver shoots m^{-2}) as influenced by different dates of transplanting and varieties at panicle initiation stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0(1.00)	2.41(4.01)	2.15(3.93)	0(1.00)	0(1.00)	0.91(2.19)	D	0.005	0.021
d_2	0(1.00)	12.75(3.02	10.72(2.89	0(1.00)	0(1.00)	4.69(1.78)	V	0.022	0.071
d_3	0(1.00)	14.83(2.88	13.42(2.72	0(1.00)	0(1.00)	5.65(1.72)	DV	0.020	0.059
mean	0(1.00)	10.00(3.34	8.76(3.23)	0(1.00)	0(1.00)	3.75(1.91)			
Season II									
d_1	0(1.00)	1.38(1.10)	0.90(1.08)	0(1.00)	0(1.00)	0.46(1.04)	D	0.010	0.040
d_2	0(1.00)	2.58(2.10)	2.15(2.03)	0(1.00)	0(1.00)	0.95(1.43)	V	0.011	0.037
d_3	0(1.00)	3.25(2.05)	2.95(1.82)	0(1.00)	0(1.00)	1.24(1.37)	DV	0.020	0.061
mean	0(1.00)	2.40(1.81)	2.00(1.69)	0(1.00)	0(1.00)	0.88(1.30)			
Season III									
d_1	0(1.00)	0.63(1.24)	0.45(1.25)	0(1.00)	0(1.00)	0.22(1.10)	D	0.007	0.029
d_2	0(1.00)	0.64(1.38)	0.58(1.34)	0(1.00)	0(1.00)	0.24(1.14)	V	0.004	0.013
d_3	0(1.00)	1.05(1.26)	0.87(1.27)	0(1.00)	0(1.00)	0.38(1.11)	DV	0.011	0.034
mean	0(1.00)	0.77(1.29)	0.63(1.29)	0(1.00)	0(1.00)	0.28(1.12)			

Figures in parenthesis are transformed values

Table145 Incidence of rice bug as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	2.33(1.82)	2.41(1.83)	2.47(1.86)	2.34(1.82)	2.31(1.83)	2.37(1.84)	D	0.023	-
d_2	2.41(1.83)	2.54(1.88)	2.48(1.86)	2.64(1.88)	3.00(1.99)	2.61(1.89)	V	0.018	-
d_3	2.42(1.83)	2.53(1.88)	2.55(1.87)	2.42(1.83)	2.98(1.98)	2.58(1.88)	DV	0.038	-
mean	2.39(1.83)	2.49(1.1.6	2.50(1.86)	2.47(1.86)	2.76(1.93)	2.52(1.87)			
Season II									
d_1	3.78(4.84)	3.82(4.89)	3.83(4.90)	3.51(4.49)	3.35(4.29)	3.66(4.68)	D	0.021	0.083
d_2	3.76(4.81)	3.83(4.90)	3.87(4.96)	3.57(4.57)	3.42(4.38)	3.69(4.72)	V	0.034	-
d_3	3.86(4.94)	3.86(4.95)	3.43(4.95)	3.72(4.76)	3.61(4.620	3.69(4.73)	DV	0.047	0.142
mean	3.80(4.86)	3.84(4.91)	3.71(4.91)	3.60(4.61)	3.46(4.430	3.68(4.71)			
Season III									
d_1	2.60(3.32)	2.74(3.51)	2.73(3.50)	2.62(3.36)	2.06(2.64)	2.55(3.27)	D	0.022	0.086
d_2	2.54(3.25)	2.74(3.51)	2.82(3.61)	2.6(3.32)	2.06(2.64)	2.55(3.27)	V	0.019	-
d_3	3.64(4.66)	3.72(4.76)	3.72(4.76)	3.9(4.99)	3.62(4.63)	3.72(4.76)	DV	0.035	-
mean	2.92(3.74)	3.07(3.93)	3.0993.96	2.26(2.89)	2.59(3.31)	2.94(3.77)			

Figures in parenthesis are transformed values

Season III

Only dates of transplanting resulted significant difference in rice bug attack. Early transplanting resulted in less pest attack than later transplanting.

4.2.5 Incidence of leaf roller

4.2.5.1 Incidence of leaf roller at active tillering stage (Table 146)

Season I

Leaf roller incidence was influenced by dates of transplanting, varieties and their interactions. No leaf roller incidence was observed in v_4. v_1 ,v_2 and v_3 were on par with v_5 on d_1 and d_2 transplanting. On d_3, v_1 and v_3 were on par and was more susceptible than v_2 and v_5 which were on par.

Season II

Leaf roller incidence was influenced by dates of transplanting, varieties and their interactions. No leaf roller incidence was observed in v_4. v_1 ,v_2 and v_3 were on par with v_5 on d_1 and d_3. On d_2 v_1 had less leaf roller incidence than v_3 and v_5 and was on par with v_2.

Season III

Dates of transplanting, varieties and their interactions significantly influenced leaf roller incidence. No leaf roller incidence was observed in v_4. v_1 reported lesser incidence than v_3, v_5 and v_2 on d_1. v_1 ,v_2 and v_3 were on par with v_5 on d_2 while v_5 had fewer incidences than v_1, v_2 and v_3 which were on par on d_3.

4.2.5.2 Incidence of leaf roller at panicle initiation stage (Table 147)

Season I

Leaf roller incidence was influenced by dates of transplanting and varieties. Delayed transplanting resulted in higher leaf roller incidence. Incidence of leaf roller was absent in v_4 on all dates of transplanting while v_1, v_2 and v_3 were on par with local variety on d_1 and d_3 while v_1 recorded lesser incidence than v_2 and v_3 on d_2.

Season II

Leaf roller incidence was influenced by dates of transplanting, varieties their interaction. Early transplanting resulted in lesser leaf roller incidence. Incidence of leaf roller was absent in v_4. In general on all dates of transplanting v_1, v_2 and v_3 were on par with v_5 except with a difference with v_5 having less disease incidence than v_3 on d_1.

Season III

Only varietal difference was seen. Incidence of leaf roller was absent in v_4. No significant difference in leaf roller incidence was observed between other varieties.

4.2.5.3 Incidence of leaf roller at heading stage (Table 148)

Season I

Leaf roller incidence was influenced by dates of transplanting, varieties their interactions. Leaf roller incidence was absent in v_4. On d_2 and d_3, v_2, v_3 and v_5 were on par and v_1 had more leaf roller incidence than these varieties. Significant difference in leaf roller attack among these varieties were observed on d_1, with maximum attack in v_5 and minimum attack in v_2.

Season II

Leaf roller incidence was influenced by varieties and its interaction with dates planting. Kanchana had more leaf roller attack on all dates of transplanting except in d_2 where it was on par with v_3. v_3 had lesser incidence than v_1 and v_5 on d_1 and v_2 on d_3. v_1 and v_3 were on par and were highly attacked by leaf roller than v_2 and v_5 which were on par on d_2.

Season III

Here only varietal differences were observed. v_1 was on par with v_2 and had higher leaf roller attack than v_5 and v_3 which were also on par.

Table 146 Incidence of leaf roller(damaged leaves hill^{-1})as influenced by different dates of transplanting and varieties at active tillering stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.32(1.15)	0.35(1.16)	0.39(1.18)	0(1.00)	0.23(1.11)	0.26(1.12)	D	0.023	0.088
d_2	0.88(1.37)	0.81(1.35)	0.84(1.36)	0(1.00)	0.82(1.35)	0.67(1.28)	V	0.018	0.059
d_3	1.26(1.51)	1.03(1.43)	1.16(1.47)	0(1.00)	0.82(1.35)	0.85(1.31)	DV	0.038	0.115
mean	0.82(1.36)	0.73(1.31)	0.80(1.34)	0(1.00)	0.62(1.27)	0.60(1.25)			
Season II									
d_1	1.48(1.57)	1.12(1.45)	1.20(1.48)	0(1.00)	1.23(1.49)	1.00(1.40)	D	0.021	0.083
d_2	2.05(1.75)	2.55(1.88)	2.79(1.95)	0(1.00)	2.61(1.90)	2.00(1.70)	V	0.034	0.111
d_3	3.05(2.01)	2.98(2.00)	2.98(1.99)	0(1.00)	2.94(1.98)	2.39(1.80)	DV	0.047	0.142
mean	2.19(1.78)	2.22(1.78)	2.32(1.81)	0(1.00)	2.26(1.79)	1.80(1.63)			
Season III									
d_1	1.37(1.54)	2.38(1.84)	2.58(1.89)	0(1.00)	2.42(1.85)	1.75(1.62)	D	0.022	0.086
d_2	3.02(2.00)	3.05(2.01)	3.07(2.02)	0(1.00)	2.84(1.96)	2.39(1.80)	V	0.019	0.063
d_3	3.44(2.11)	3.43(2.11)	3.41(2.10)	0(1.00)	1.70(1.64)	2.39(1.79)	DV	0.035	0.104
mean	2.61(1.88)	2.95(1.99)	3.02(2.00)	0(1.00)	2.32(1.82)	2.18(1.74)			

Figures in parenthesis are transformed values

Table 147 Incidence of leaf roller(damaged leaves hill^{-1}) as influenced by different dates of transplanting and varieties at panicle initiation stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.6(1.26)	0.52(1.23)	0.57(1.25)	0(1.00)	0.57(1.25)	0.45(1.20)	D	0.009	0.035
d_2	0.53(1.24)	0.83(1.35)	0.81(1.35)	0(1.00)	0.73(1.32)	0.58(1.25)	V	0.016	0.051
d_3	0.81(1.34)	0.76(1.33)	0.83(1.35)	0(1.00)	0.78(1.33)	0.64(1.27)	DV	0.030	-
mean	0.65(1.28)	0.7(1.30)	0.74(1.32)	0(1.00)	0.69(1.30)	0.56(1.24)			
Season II									
d_1	0.82(1.35)	0.84(1.36)	0.90(1.38)	0(1.00)	0.73(1.32)	0.66(1.28)	D	0.006	0.025
d_2	1.37(1.54)	1.41(1.55)	1.29(1.51)	0(1.00)	1.34(1.53)	1.08(1.43)	V	0.010	0.032
d_3	1.4(1.55)	1.40(1.55)	1.49(1.58)	0(1.00)	1.55(1.60)	1.18(1.45)	DV	0.017	0.052
mean	1.2(1.48)	1.22(1.49)	1.23(1.49)	0(1.00)	1.21(1.48)	0.97(1.39)			
Season III									
d_1	0.64(1.28)	2.77(1.94)	0.98(1.41)	0(1.00)	0.84(1.360	1.05(1.40)	D	0.056	-
d_2	1.32(1.52)	1.3(1.52)	1.45(1.57)	0(1.00)	1.64(1.62)	1.14(1.45)	V	0.074	0.240
d_3	1.25(1.50)	0.8(1.340	2.56(1.89)	0(1.00)	1.44(1.56)	1.21(1.46)	DV	0.135	-
mean	1.07(1.43)	1.62(1.60)	1.66(1.62)	0(1.00)	1.31(1.51)	1.13(1.43)			

Figures in parenthesis are transformed values

4.2.5.4 Incidence of sheath rot (Table 149)

Season I

Only dates of transplanting influenced the sheath rot incidence in this season. Early transplanting resulted in lesser incidence.

Season II

Here only varietal differences was noticed. Local variety was less affected by this disease. Among high yielding varieties, incidence of sheath rot was less in v_4 and v_3 in comparison with v_1 and v_2.

Season III

Dates of transplanting, varieties and their interactions influenced the sheath rot incidence. Incidence was low when transplanted on d_1 for all varieties. When transplanted on d_1, the disease incidence was less in v_5 compared to v_4. When transplanted on d_2 there was a significant reduction in disease incidence in local variety compared to high yielding varieties. Among high yielding varieties, v_1 was more resistant compared to v_2 and v_3. A reduced disease occurrence was observed both in d_2 and d_3 transplanting and all the high yielding varieties were on par and less resistant than v_5 when transplanted on d_2.

4.2.5.5 Incidence of sheath blight

4.2.5.5.1 Incidence of sheath blight at active tillering stage(Table 150)

Season I

Varietal difference and its interaction with dates of transplanting significantly influenced sheath blight incidence. Incidence of sheath blight was absent in v_1, v_4 and v_5 while v_2 was more affected by sheath blight incidence than v_3.

Season II

The main effect of dates of transplanting, varieties and their interactions were significant. Early transplanting resulted in lesser leaf roller attack. Incidence of sheath blight was absent in v_1, v_4 and v_5, while v_3 had more attack than v_2 on d_3 and vice versa on d_1 and d_2.

Table 148 **Incidence of leaf roller(damaged leaves hill^{-1}) as influenced by different dates of transplanting and varieties at heading stage in different seasons at Pattambi**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	3.95(2.22)	2.74(1.93)	3.23(2.06)	0(1.00)	5.40(2.53)	3.06(1.95)	D	0.014	0.053
d_2	5.44(2.54)	4.66(2.38)	4.38(2.32)	0(0.00)	4.18(2.28)	3.73(2.10)	V	0.026	0.085
d_3	5.67(2.58)	4.64(2.38)	4.39(2.32)	0(1.00)	4.55(2.36)	3.85(2.13)	DV	0.038	0.113
mean	5.02(2.45)	4.01(2.240	4.00(2.24)	0(1.00)	4.71(2.39)	3.55(2.06)			
Season II									
d_1	5.41(2.53)	4.53(2.35)	4.38(2.32)	0(1.00)	4.81(2.41)	3.83(2.21)	D	0.017	0.067
d_2	5.46(2.54)	4.50(2.35)	5.13(2.48)	0(1.00)	4.48(2.34)	3.91(2.14)	V	0.018	-
d_3	5.87(2.62)	5.30.(2.51	4.63(2.37)	0(1.00)	4.78(2.40)	4.12(2.18)	DV	0.027	0.080
mean	5.58(2.56)	4.78(2.40)	4.71(2.39)	0(1.00)	4.69(2.39)	3.95(2.15)			
Season III									
d_1	4.0492.25)	4.05(2.25)	3.57(2.14)	0(1.00)	4.02(2.24)	3.14(1.97)	D	0.022	-
d_2	4.2(2.28)	3.95(2.22)	3.93(2.22)	0(1.00)	3.72(2.17)	3.16(1.98)	V	0.015	0.049
d_3	4.46(2.34)	4.36(2.32)	4.16(2.27)	0(1.00)	4.18(2.28)	3.43(2.04)	DV	0.023	-
mean	4.23(2.29)	4.12(2.26)	3.89(2.21)	0(1.00)	3.97(2.23)	3.24(2.00)			

Figures in parenthesis are transformed values

Table 149 **Incidence of sheath rot (% of affected tillers) as influenced by different dates of transplanting and varieties in different seasons at Pattambi**

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0.23(1.82)	0.28(1.85)	0.27(1.86)	0.25(1.83)	0.58(1.82)	0.32(1.85)	D	0.012	0.048
d_2	0.25(1.85)	0.30(1.88)	0.29(1.86)	0.29(1.86)	0.60(2.00)	0.35(1.89)	V	0.023	-
d_3	0.29(1.85)	0.33(1.88)	0.30(1.88)	0.31(1.85)	0.59(1.99)	0.36(1.90)	DV	0.040	-
mean	0.26(1.84)	0.30(1.87)	0.29(1.87)	0.28(1.86)	0.59(1.94)	0.34(1.88)			
Season II									
d_1	2.30(2.41)	2.11(2.43)	2.19(2.44)	2.15(2.36)	2.20(2.32)	2.19(2.39)	D	0.017	-
d_2	2.39(2.44)	2.66(2.44)	2.37(2.32)	2.43(2.40)	2.55(2.37)	2.48(2.39)	V	0.036	0.036
d_3	2.64(2.42)	2.83(2.43)	2.85(2.43)	2.75(2.34)	2.95(2.30)	2.80(2.38)	DV	0.108	-
mean	2.44(2.42)	2.53(2.43)	2.47(2.40)	2.44(2.37)	2.57(2.33)	2.49(2.39)			
Season III									
d_1	7.00(2.06)	7.08(2.12)	7.33(2.15)	7.75(2.08)	7.25(1.91)	7.28(2.06)	D	0.063	0.063
d_2	7.58(2.08)	7.83(2.12)	7.92(2.12)	7.92(2.09)	7.00(1.91)	7.65(2.06)	V	0.052	0.052
d_3	6.75(2.38)	7.50(2.40)	7.75(2.40)	7.17(2.45)	7.25(2.37)	7.28(2.40)	DV	0.019	0.056
mean	7.11(2.17)	7.47(2.21)	7.67(2.22)	7.61(2.21)	7.17(2.06)	7.40(2.17)			

Figures in parenthesis are transformed values

Season III

Dates of transplanting, varieties and their interactions significantly influenced sheath blight incidence. Early transplanting resulted in lesser disease incidence. Incidence of sheath blight was absent in v_1, v_4 and v_5 while v_3 had more attack than v_2 on d_3 and vice versa on d_1 and d_2.

4.2.5.5.2 Incidence of sheath blight at panicle initiation stage (Table 151)

Season I

Dates of transplanting, varieties and their interactions significantly influenced sheath blight incidence. Earlier transplanting resulted in lesser disease incidence. Incidence of sheath blight was absent in v_1, v_4 and v_5 while the disease incidence was significantly higher in v_2 on d_1 and v_3 on d_3 and these two varieties were on par in d_2.

Season II

Dates of transplanting, varieties and their interactions were significant. Earlier transplanting resulted in lesser disease incidence. Incidence of sheath blight was absent in v_1, v_4 and v_5 while v_2 and v_3 were on par on all dates of transplanting.

Season III

Varieties and its interaction with dates of transplanting significantly influenced sheath blight incidence. Sheath blight incidence was absent in v_1, v_4 and v_5 while v_2 and v_3 were on par and was affected by sheath blight incidence on all dates of transplanting except with a difference for v_3 having a lesser incidence than v_2 on d_3.

4.2.5.5.3 Incidence of sheath blight at heading stage (Table 152)

Season I

Only varietal difference was observed. Sheath blight incidence was absent in v_1, v_4 and v_5 while v_2 was more affected than v_3.

Table 150 Incidence of sheath blight(% of affected tillers) as influenced by different dates of transplanting and varieties at transplanting stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0(1.00)	2.52(1.88)	2.19(1.79)	0(1.00)	0(1.00)	0.94(1.33)	D	0.0042	-
d_2	0(1.00)	2.37(1.84)	2.68(1.92)	0(1.00)	0(1.00)	1.01(1.35)	V	0.0049	0.0159
d_3	0(1.00)	2.54(1.88)	2.34(1.83)	0(1.00)	0(1.00)	0.98(1.34)	DV	0.0117	0.0350
mean	0(1.00)	2.48(1.86)	2.40(1.84)	0(1.00)	0(1.00)	0.98(1.34)			
Season II									
d_1	0(1.00)	2.52(1.88)	2.33(1.82)	0(1.00)	0(1.00)	0.97(1.34)	D	0.0023	0.0090
d_2	0(1.00)	2.53(1.88)	2.46(1.86)	0(1.00)	0(1.00)	1.00(1.35)	V	0.0046	0.0149
d_3	0(1.00)	2.49(1.87)	2.74(1.93)	0(1.00)	0(1.00)	1.05(1.36)	DV	0.0051	0.0154
mean	0(1.00)	2.51(1.87)	2.51(1.87)	0(1.00)	0(1.00)	1.01(1.35)			
Season III									
d_1	0(1.00)	2.18(1.78)	1.78(1.67)	0(1.00)	0(1.00)	0.79(1.29)	D	0.0036	0.0142
d_2	0(1.00)	2.29(1.81)	2.09(1.76)	0(1.00)	0(1.00)	0.88(1.31)	V	0.0564	0.0184
d_3	0(1.00)	2.14(1.77)	2.40(1.84)	0(1.00)	0(1.00)	0.91(1.32)	DV	0.1032	0.0309
mean	0(1.00)	2.20(1.79)	2.09(1.76)	0(1.00)	0(1.00)	0.89(1.31)			

Figures in parenthesis are transformed values

Table 151 Incidence of sheath blight (% of affected tillers) as influenced by different dates of transplanting and varieties at panicle initiation stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0(1.00)	2.72(1.93)	2.68(1.92)	0(1.00)	0(1.00)	1.08(1.37)	D	0.0017	0.0066
d_2	0(1.00)	2.77(1.94)	2.77(1.94)	0(1.00)	0(1.00)	1.11(1.38)	V	0.0011	0.0035
d_3	0(1.00)	2.72(1.93)	2.71(1.93)	0(1.00)	0(1.00)	1.09(1.37)	DV	0.0032	0.0097
mean	0(1.00)	2.86(1.96)	2.92(1.98)	0(1.00)	0(1.00)	1.16(1.39)			
Season II									
d_1	0(1.00)	2.44(1.85)	2.48(1.87)	0(1.00)	0(1.00)	0.98(1.34)	D	0.0030	0.0117
d_2	0(1.00)	2.73(1.93)	2.68(1.92)	0(1.00)	0(1.00)	1.08(1.37)	V	0.0047	0.0154
d_3	0(1.00)	2.92(1.98)	2.81(1.94)	0(1.00)	0(1.00)	1.15(1.39)	DV	0.0103	0.0310
mean	0(1.00)	2.7(1.92)	2.66(1.91)	0(1.00)	0(1.00)	1.07(1.37)			
Season III									
d_1	0(1.00)	2.73(1.93)	2.49(1.87)	0(1.00)	0(1.00)	1.04(1.36)	D	0.0038	-
d_2	0(1.00)	2.73(1.93)	2.68(1.92)	0(1.00)	0(1.00)	1.08(1.37)	V	0.0059	0.0059
d_3	0(1.00)	2.81(1.95)	2.74(1.93)	0(1.00)	0(1.00)	1.11(1.38)	DV	0.0068	0.0202
mean	0(1.00)	2.76(1.94)	2.64(1.91)	0(1.00)	0(1.00)	1.08(1.37)			

Figures in parenthesis are transformed values

Season II

Only varietal difference was noticed. Sheath blight incidence was absent in v_1, v_4 and v_5 while v_2 and v_3 were affected by sheath blight and were on par.

Season III

The main effect of dates of transplanting, varieties and their interactions were significant. Sheath blight incidence was absent in v_1, v_4 and v_5 Later transplanting resulted in higher disease incidence. On d_1 transplanting v_3 was having more incidence than v_2 and vice versa on d_1 and d_2 transplanting.

4.2.5.5.4 Incidence of sheath blight at beginning of grain filling stage (Table 153)

Season I

Main effect of varieties and its interaction with dates of transplanting significantly influenced the sheath blight incidence. Sheath blight incidence was absent in v_1, v_4 and v_5 while v_2 and v_3 were on par and was on all dates of transplanting except with a difference for v_3 having a lesser incidence than v_2 on d_2.

Season II

The main effect of dates of transplanting, varieties and their interactions were significant. Sheath blight incidence was hundred per cent free for v_1, v_4 and v_5 while varieties v_2, v_3 were on par on d_1. On d_3, v_2 had less incidence than v_3 and vice versa on d_2.

Season III

Main effect of varieties and its interaction with dates of transplanting was significant. Sheath blight incidence was hundred per cent free for v_1, v_4 and v_5 while v_2 and v_3 were on par in d_1 and v_3 was less affected than v_2 on d_2 and just the reverse in d_3 .

Table 152 Incidence of sheath blight (% of affected tillers) as influenced by different dates of transplanting and varieties at heading stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0(1.00)	3.35(2.09)	3.27(2.07)	0(1.00)	0(1.00)	1.32(1.43)	D	0.0091	-
d_2	0(1.00)	3.52(2.13)	3.31(2.08)	0(1.00)	0(1.00)	1.37(1.44)	V	0.0177	0.0578
d_3	0(1.00)	3.73(1.18)	3.25(2.06)	0(1.00)	0(1.00)	1.40(1.45)	DV	0.0153	-
mean	0(1.00)	3.53(2.13)	3.28(2.07)	0(1.00)	0(1.00)	1.36(1.44)			
Season II									
d_1	0(1.00)	3.09(2.02)	3.06(2.01)	0(1.00)	0(1.00)	1.23(1.41)	D	0.0136	-
d_2	0(1.00)	2.95(1.99)	3.49(2.12)	0(1.00)	0(1.00)	1.29(1.42)	V	0.0187	0.0611
d_3	0(1.00)	3.44(2.11)	3.18(2.04)	0(1.00)	0(1.00)	1.32(1.43)	DV	0.0249	-
mean	0(1.00)	3.16(2.04)	3.24(2.06)	0(1.00)	0(1.00)	1.28(1.42)			
Season III									
d_1	0(1.00)	2.59(1.90)	2.85(1.96)	0(1.00)	0(1.00)	1.09(1.37)	D	0.0039	0.0153
d_2	0(1.00)	3.00(2.00)	2.90(1.97)	0(1.00)	0(1.00)	1.18(1.39)	V	0.0101	0.0331
d_3	0(1.00)	3.19(2.05)	3.09(2.02)	0(1.00)	0(1.00)	1.26(1.41)	DV	0.0084	0.0253
mean	0(1.00)	2.93(1.98)	2.95(1.99)	0(1.00)	0(1.00)	1.18(1.39)			

Figures in parenthesis are transformed values

Table 153 Incidence of sheath blight (% of affected tillers) as influenced by different dates of and varieties at beginning of grain filling stage in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	0(1.00)	4.87(2.42)	4.82(2.41)	0(1.00)	0(1.00)	1.94(1.57)	D	0.0047	-
d_2	0(1.00)	4.98(2.45)	4.88(2.42)	0(1.00)	0(1.00)	1.97(1.57)	V	0.0060	0.0194
d_3	0(1.00)	5.43(2.54)	4.85(2.42)	0(1.00)	0(1.00)	2.06(1.59)	DV	0.0099	0.0297
mean	0(1.00)	5.09(2.47)	4.85(2.42)	0(1.00)	0(1.00)	1.99(1.58)			
Season II									
d_1	0(1.00)	4.58(2.36)	4.46(2.34)	0(1.00)	0(1.00)	1.81(1.54)	D	0.0062	0.0242
d_2	0(1.00)	4.87(2.42)	4.61(2.37)	0(1.00)	0(1.00)	1.90(1.56)	V	0.0086	0.0279
d_3	0(1.00)	4.72(2.39)	5.61(2.57)	0(1.00)	0(1.00)	2.07(1.59)	DV	0.0141	0.0422
mean	0(1.00)	4.72(2.39)	4.89(2.34)	0(1.00)	0(1.00)	1.93(1.56)			
Season III									
d_1	0(1.00)	4.46(2.34)	4.45(2.33)	0(1.00)	0(1.00)	1.78(1.53)	D	0.0020	-
d_2	0(1.00)	4.61(2.37)	4.82(2.29)	0(1.00)	0(1.00)	1.89(1.53)	V	0.0092	0.0299
d_3	0(1.00)	4.40(2.32)	4.61(2.37)	0(1.00)	0(1.00)	1.80(1.54)	DV	0.0088	0.0262
mean	0(1.00)	4.49(2.34)	4.63(2.33)	0(1.00)	0(1.00)	1.82(1.53)			

Figures in parenthesis are transformed values

4.2.6 Soil characters

4.2.6.1 Organic carbon content of soil (Table 154a, 154 b ,154 c, and 154 d)

Seasons I, II and III

Organic carbon content of soil was not significantly influenced either by different dates of transplanting or varieties at all stages of observation.

4.2.6.2 pH of soil (Table 155a, 155b,155c and 155d)

Seasons I, II and III

Neither different dates of transplanting nor varieties significantly influenced the pH of soil at different stages of observation.

4.2.6.3 CEC of soil (Table 156a, 156b, 156 c, and 156 d)

Seasons I, II and III

CEC of soil was not influenced by either different dates of transplanting or varieties in all stages of observation.

Experiment II :

Influence of agro meteorological parameters on grain yield

Correlation analysis was done on the grain yield data for a period of twenty five years (1960-1985) from a permanent manurial experiment at Regional Agricultural Research Station, Pattambi to develop the best fitting crop weather model using step wise regression. The experimental results are presented below.

In *virippu* season maximum temperature, minimum temperature, number of rainy days, evening relative humidity, sunshine hours and evaporation during the period from planting to active tillering were found to have correlation with yield. Correlation between yield and evaporation was negative and significant (-0.5678) (Table 157) of which the direct effect of evaporation was –0.1573 (Table158). This was enhanced by its indirect effect especially minimum temperature (-0.2528). The correlation of direct effect of

Table 154 a Organic carbon content (%) of initial soil as influenced by different dates of transplanting and varieties in different seasonss at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.55	1.56	1.53	1.58	1.60	1.56	D	0.015	-
d_2	1.54	1.61	1.65	1.56	1.54	1.58	V	0.025	-
d_3	1.45	1.54	1.44	1.47	1.44	1.47	DV	0.035	-
mean	1.51	1.57	1.54	1.54	1.53	1.54			
Season II									
d_1	1.54	1.54	1.52	1.56	1.58	1.55	D	0.007	-
d_2	1.52	1.57	1.60	1.53	1.53	1.55	V	0.010	-
d_3	1.44	1.52	1.42	1.46	1.41	1.45	DV	0.022	-
mean	1.50	1.54	1.51	1.52	1.51	1.52			
Season III									
d_1	1.52	1.51	1.48	1.54	1.56	1.52	D	0.016	-
d_2	1.50	1.54	1.56	1.50	1.51	1.52	V	0.000	-
d_3	1.42	1.50	1.41	1.44	1.40	1.43	DV	0.000	-
mean	1.48	1.52	1.48	1.49	1.49	1.49			

Table 154 b Organic carbon content (%) of soil as influenced by different Dates of transplanting and varieties at 30 DAS in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.52	1.52	1.50	1.54	1.56	1.53	D	0.015	-
d_2	1.51	1.58	1.61	1.54	1.51	1.55	V	0.025	-
d_3	1.42	1.51	1.40	1.42	1.41	1.43	DV	0.035	-
mean	1.48	1.54	1.51	1.50	1.50	1.50			
Season II									
d_1	1.50	1.51	1.48	1.52	1.56	1.51	D	0.007	-
d_2	1.49	1.53	1.55	1.49	1.49	1.51	V	0.010	-
d_3	1.40	1.49	1.38	1.42	1.37	1.41	DV	0.022	-
mean	1.46	1.51	1.47	1.48	1.47	1.48			
Season III									
d_1	1.48	1.47	1.44	1.50	1.54	1.49	D	0.016	-
d_2	1.47	1.52	1.53	1.49	1.48	1.50	V	0.000	-
d_3	1.41	1.48	1.38	1.42	1.38	1.41	DV	0.000	-
mean	1.45	1.49	1.45	1.47	1.47	1.47			

Table 154 c Organic carbon content (%) of soil as influenced by different Dates of transplanting and varieties at 60 DAS in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.53	1.52	1.50	1.55	1.57	1.54	D	0.015	-
d_2	1.52	1.58	1.59	1.53	1.52	1.55	V	0.025	-
d_3	1.43	1.51	1.41	1.45	1.41	1.44	DV	0.035	-
mean	1.49	1.54	1.50	1.51	1.50	1.51			
Season II									
d_1	1.51	1.50	1.48	1.53	1.55	1.51	D	0.007	-
d_2	1.48	1.53	1.56	1.51	1.49	1.52	V	0.010	-
d_3	1.42	1.50	1.39	1.42	1.39	1.42	DV	0.022	-
mean	1.47	1.51	1.48	1.48	1.48	1.48			
Season III									
d_1	1.51	1.48	1.46	1.51	1.54	1.50	D	0.016	-
d_2	1.47	1.52	1.53	1.47	1.48	1.49	V	0.000	-
d_3	1.39	1.47	1.38	1.41	1.38	1.41	DV	0.000	-
mean	1.46	1.49	1.46	1.46	1.46	1.47			

Table 154 d Organic carbon content (%) (%) of soil as influenced by different dates of transplanting and varieties at harvest in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	1.50	1.49	1.48	1.52	1.54	1.51	D	0.015	-
d_2	1.50	1.56	1.57	1.51	1.49	1.52	V	0.025	-
d_3	1.40	1.48	1.37	1.41	1.39	1.41	DV	0.035	-
mean	1.47	1.51	1.47	1.48	1.47	1.48			
Season II									
d_1	1.48	1.47	1.45	1.50	1.52	1.48	D	0.007	-
d_2	1.44	1.50	1.53	1.47	1.47	1.48	V	0.010	-
d_3	1.39	1.47	1.36	1.39	1.36	1.39	DV	0.022	-
mean	1.44	1.48	1.45	1.45	1.45	1.45			
Season III									
d_1	1.48	1.45	1.44	1.49	1.51	1.47	D	0.016	-
d_2	1.44	1.48	1.49	1.44	1.45	1.46	V	0.000	-
d_3	1.37	1.43	1.35	1.38	1.35	1.38	DV	0.000	-
mean	1.43	1.45	1.43	1.43	1.44	1.44			

Table 155 a pH of initial soil as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	6.21	6.26	6.20	6.20	6.18	6.21	D	0.015	-
d_2	6.17	6.22	6.23	6.25	6.27	6.23	V	0.025	-
d_3	6.25	6.24	6.24	6.20	6.25	6.24	DV	0.035	-
mean	6.21	6.24	6.22	6.22	6.24	6.23			
Season II									
d_1	6.23	6.24	6.24	6.23	6.16	6.22	D	0.007	-
d_2	6.24	6.21	6.28	6.24	6.22	6.24	V	0.010	-
d_3	6.20	6.23	6.23	6.28	6.21	6.23	DV	0.022	-
mean	6.22	6.23	6.25	6.25	6.20	6.23			
Season III									
d_1	6.21	6.21	6.22	6.20	6.27	6.22	D	0.016	-
d_2	6.22	6.23	6.22	6.20	6.24	6.22	V	0.000	-
d_3	6.22	6.25	6.20	6.25	6.24	6.23	DV	0.000	-
mean	6.22	6.23	6.21	6.22	6.25	6.23			

Table 155 b pH of soil as influenced by different dates of transplanting and varieties at 30 days after transplanting in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	6.36	6.41	6.38	6.38	6.34	6.38	D	0.015	-
d_2	6.34	6.39	6.43	6.46	6.44	6.41	V	0.025	-
d_3	6.43	6.41	6.42	6.37	6.42	6.41	DV	0.035	-
mean	6.38	6.40	6.41	6.40	6.40	6.40			
Season II									
d_1	6.44	6.44	6.45	6.45	6.40	6.44	D	0.007	-
d_2	6.46	6.44	6.43	6.46	6.46	6.45	V	0.010	-
d_3	6.38	6.46	6.46	6.44	6.43	6.43	DV	0.022	-
mean	6.43	6.45	6.45	6.45	6.43	6.44			
Season III									
d_1	6.45	6.44	6.42	6.44	6.47	6.45	D	0.016	-
d_2	6.44	6.46	6.44	6.44	6.43	6.44	V	0.000	-
d_3	6.46	6.47	6.42	6.46	6.48	6.46	DV	0.000	-
mean	6.45	6.46	6.43	6.45	6.46	6.45			

Table 155 c pH of soil as influenced by different dates of transplanting and varieties at 60 days after transplanting in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	6.53	6.54	6.50	6.55	6.55	6.53	D	0.015	-
d_2	6.55	6.55	6.56	6.53	6.56	6.55	V	0.025	-
d_3	6.54	6.56	6.55	6.52	6.56	6.54	DV	0.035	-
mean	6.54	6.55	6.54	6.53	6.56	6.54			
Season II									
d_1	6.56	6.58	6.56	6.55	6.51	6.55	D	0.007	-
d_2	6.57	6.53	6.57	6.56	6.59	6.56	V	0.010	-
d_3	6.53	6.56	6.55	6.58	6.54	6.55	DV	0.022	-
mean	6.55	6.56	6.56	6.56	6.55	6.56			
Season III									
d_1	6.54	6.54	6.57	6.55	6.56	6.55	D	0.016	-
d_2	6.54	6.55	6.55	6.54	6.56	6.55	V	0.000	-
d_3	6.54	6.57	6.53	6.59	6.59	6.56	DV	0.000	-
mean	6.54	6.55	6.55	6.56	6.57	6.55			

Table155 d pH of soil as influenced by different dates of transplanting and varieties at harvest in different seasonss at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	6.20	6.22	6.20	6.21	6.20	6.21	D	0.015	-
d_2	6.22	6.22	6.22	6.18	6.22	6.21	V	0.025	-
d_3	6.22	6.25	6.22	6.16	6.21	6.21	DV	0.035	-
mean	6.21	6.23	6.21	6.18	6.21	6.21			
Season II									
d_1	6.22	6.23	6.25	6.24	6.20	6.23	D	0.007	-
d_2	6.23	6.25	6.26	6.26	6.23	6.25	V	0.010	-
d_3	6.24	6.26	6.26	6.26	6.24	6.25	DV	0.022	-
mean	6.23	6.25	6.26	6.25	6.22	6.24			
Season III									
d_1	6.21	6.25	6.27	6.25	6.26	6.25	D	0.016	-
d_2	6.27	6.23	6.24	6.26	6.24	6.25	V	0.000	-
d_3	6.22	6.23	6.23	6.22	6.27	6.23	DV	0.000	-
mean	6.23	6.24	6.25	6.24	6.26	6.24			

Table 156 a CEC (C mol kg^{-1}) of initial soil as influenced by different dates of transplanting and varieties in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	14.51	14.42	14.49	14.51	14.50	14.49	D	0.021	-
d_2	14.44	14.52	14.41	14.49	14.58	14.49	V	0.029	-
d_3	14.47	14.55	14.41	14.45	14.56	14.49	DV	0.024	-
mean	14.47	14.50	14.43	14.48	14.55	14.49			
Season II									
d_1	14.47	14.47	14.46	14.47	14.47	14.47	D	0.008	-
d_2	14.47	14.46	14.44	14.48	14.50	14.47	V	0.005	-
d_3	14.47	14.47	14.48	14.48	14.51	14.48	DV	0.025	-
mean	14.47	14.47	14.46	14.47	14.49	14.47			
Season III									
d_1	14.43	14.44	14.50	14.45	14.49	14.46	D	0.012	-
d_2	14.47	14.49	14.49	14.42	14.47	14.47	V	0.012	-
d_3	14.45	14.45	14.45	14.45	14.46	14.45	DV	0.037	-
mean	14.45	14.46	14.48	14.44	14.47	14.46			

Table 156 b CEC(C mol kg^{-1}) of soil as influenced by different dates of transplanting a varieties at 30 days after transplanting in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	14.49	14.41	14.47	14.50	14.48	14.47	D	0.017	-
d_2	14.43	14.51	14.40	14.41	14.58	14.46	V	0.025	-
d_3	14.46	14.51	14.39	14.46	14.54	14.47	DV	0.034	-
mean	14.46	14.48	14.42	14.46	14.53	14.47			
Season II									
d_1	14.44	14.46	14.45	14.45	14.45	14.45	D	0.017	-
d_2	14.49	14.45	14.42	14.46	14.48	14.46	V	0.009	-
d_3	14.44	14.45	14.46	14.46	14.46	14.46	DV	0.063	-
mean	14.46	14.45	14.44	14.46	14.47	14.46			
Season III									
d_1	14.42	14.42	14.48	14.44	14.48	14.45	D	0.015	-
d_2	14.46	14.48	14.48	14.41	14.45	14.46	V	0.015	-
d_3	14.44	14.44	14.44	14.44	14.44	14.44	DV	0.035	-
mean	14.44	14.45	14.47	14.43	14.46	14.45			

Table 156 c CEC(C mol kg $^{-1}$) of soil as influenced by different dates of transplanting a varieties at 60 days after transplanting in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	14.47	14.41	14.46	14.48	14.47	14.46	D	0.015	-
d_2	14.42	14.50	14.39	14.40	14.57	14.46	V	0.025	-
d_3	14.45	14.49	14.39	14.45	14.53	14.46	DV	0.035	-
mean	14.45	14.47	14.41	14.44	14.52	14.46			
Season II									
d_1	14.43	14.45	14.43	14.43	14.44	14.44	D	0.007	-
d_2	14.47	14.44	14.41	14.44	14.47	14.45	V	0.010	-
d_3	14.43	14.44	14.45	14.45	14.45	14.44	DV	0.022	-
mean	14.44	14.44	14.43	14.44	14.46	14.44			
Season III									
d_1	14.41	14.41	14.46	14.43	14.47	14.44	D	0.016	-
d_2	14.44	14.47	14.47	14.40	14.44	14.44	V	0.012	-
d_3	14.43	14.42	14.43	14.43	14.42	14.43	DV	0.036	-
mean	14.43	14.43	14.45	14.42	14.44	14.43			

Table 156 d CEC(C mol kg $^{-1}$) of soil as influenced by different dates of transplanting and varieties at harvest in different seasons at Pattambi

Dates of transplanting	Varieties								
Season I	v_1	v_2	v_3	v_4	v_5	mean	Effect	SE	CD
d_1	14.47	14.41	14.46	14.48	14.46	14.46	D	0.013	-
d_2	14.42	14.50	14.39	14.40	14.56	14.45	V	0.021	-
d_3	14.44	14.48	14.38	14.44	14.52	14.45	DV	0.031	-
mean	14.44	14.46	14.41	14.44	14.51	14.45			
Season II									
d_1	14.42	14.44	14.43	14.42	14.44	14.43	D	0.006	-
d_2	14.47	14.43	14.40	14.43	14.47	14.44	V	0.032	-
d_3	14.42	14.44	14.44	14.44	14.45	14.44	DV	0.056	-
mean	14.44	14.44	14.43	14.43	14.45	14.44			
Season III									
d_1	14.40	14.40	14.46	14.42	14.46	14.43	D	0.015	-
d_2	14.43	14.46	14.47	14.39	14.43	14.44	V	0.014	-
d_3	14.42	14.41	14.42	14.42	14.42	14.42	DV	0.029	-
mean	14.42	14.43	14.45	14.41	14.44	14.43			

Table 157 Correlation of yield with weather variables for virippu

Weather parameters	Planting to AT	AT to PI	PI to flowering	Flowering to harvest	Planting to PI	Planting to flowering	Planting to harvest
Max.temp	- 0.5995 **	- 0.2064	- 0.2332	- 0.2292	-0.4720 *	- 0.4358 *	- 0.4202 *
Min temp	- 0.6343**	- 0.1767	- 0.3136	- 0.2383	-0.5150 **	- 0.4776 *	- 0.4224*
Rain fall	0..3566	- 0.0825	- 0.0018	- 0.0166	0.1999	0.1367	0.0932
Rainy days	0.4438*	0.1291	0.2332	0.0274	0.3401	0.3358	0.2713
RH-I	0.3557	0.2107	0.2957	0.2165	0.3237	0.3528	0.3484
RH-II	0.4897 *	0.1082	0.2551	0.0477	0.3559	0.3478	0.3038
Sun shine	0.5927 **	- 0.0858	0.1358	0.0640	0.4109 *	0.3624	0.3065
Wind speed	-0.0509	0.2336	0.2506	0.2460	0.1116	0.1818	0.2177
Evaporation	-0.5678 **	- 0.2508	-0.6108**	- 0.2735	-0.4564 *	-0.5805**	-0.5565 **

Table 158 Path analysis for virippu season

Max.temp (x_1)	Min. temp (x_2)	RH-II (x_3)	Number of rainy days (x_4)	Sunshine (x_5)	Evaporation (x_6)
-0.2528	-0.0046	-0.0851	-0.0595	-0.0085	-0.1573
-0.3117	-0.0042	-0.0841	-0.0542	-0.0178	-0.1275
-0.1981	-0.0066	-0.0644	-0.0426	-0.2124	-0.1102
0.2261	0.0038	0.0792	0.0747	-0.0651	0.1251
0.2705	0.0044	0.0969	0.0611	-0.0812	0.1381
0.0092	0.0023	-0.0131	-0.0081	0.6001	0.0022

Residue=0.2833

maximum temperature was – 0.3117 and its correlation with yield was – 0.5995. Maximum indirect effect for maximum temperature was seen with evaporation (- 0.1275). All the indirect effects were negative and the direct and indirect effects summed up to its correlation with yield. Seventy two per cent of the variation in yield attributed to these climatological parameters viz., evaporation, maximum temperature, minimum temperature, number of rainy days, evening relative humidity and sunshine.

In *mundakan* season evaporation, maximum temperature and sunshine hours during the period from planting to active tillering were found to have correlation with yield. The correlation of yield with evaporation was negative and significant (- 0.5493) (Table159)while its direct effect was – 0.4679 (Table160). The indirect effect via maximum temperature and sunshine hours is summed up to this correlation. The correlation of maximum temperature with yield was significant and negative (-0.4543) of which the contribution of maximum temperature directly was – 0.2807. The indirect effect amount to this correlation. The contribution of sunshine hours with yield was positive and significant (0.4480). The direct and indirect effect resulted in this contribution. The direct contribution of sunshine hours was almost equal to its indirect effect via. maximum temperature. Forty six per cent of the variation in yield was accounted for these climatological parameters viz., evaporation, maximum temperature and sunshine hours.

Table 159 Correlation of yield with weather variables for mundakan

Weather parameters	Nursery to AT	AT to PI	PI to flowering	Flowering to harvest	Nursery to PI	Nursery to flowering	Nursery to harvest
Max. temp	-0.4543*	-0.0421	-0.0144	0.2842	-0.3166	-0.2611	-0.1385
Min. temp	-0.3373	-0.4046 *	-0.2618	0.1260	-0.4225 *	-0.3936	-0.2510
Rain fall	0.1661	-0.3067	0.5583 **	0.0544	0.0207	0.1117	0.1124
Rainy days	0.1156	-0.0812	0.3945	-0.0549	0.0594	0.1460	0.1839
RH-I	0.1120	0.0808	-0.0032	-0.1667	0.1080	0.0840	-0.0017
RH-II	0.2668	0.5068 *	0.0348	-0.2513	0.6920 **	0.2292	0.0652
Sun shine	0.4480 *	-0.2150	0.1297	0.0394	0.1044	0.1467	0.1306
Wind speed	-0.0771	0.2112	-0.1730	0.1037	-0.1955	-0.2260	-0.2112
Evaporation	-0.5493**	-0.2173	-0.0992	-0.0550	-0.4914 *	-0.3987*	-0.3121

Table No 160 Path analysis for mundakan season

Max.temp (x_1)	Sunshine (x_2)	Evaporation (x_3)
-0.0418	-0.0396	-0.4679
-0.2807	-0.1041	-0.0697
0.1674	0.1746	0.1060

Residue=0.5372

Table 161 Correlation of yield with yield attributing characters

Sl. no	character	correlation coefficient					
		Vellayani			Pattambi		
		Season I	Season II	Season III	Season I	Season II	Season III
1	Plant height at harvest	-0.7250**	-0.0308	0.4453	-0.1867	-0.4366	0.4040
2	Number of tillers at harvest	0.6110*	0.4492	0.3526	-0.4089	-0.5836*	-0.2596
3	LAI (flowering)	0.6450**	0.3778	0.3232	0.2583	0.0958	0.4146
4	Panicle number	0.4180**	0.4038	0.3928	0.3916	0.4273	0.3156
5	Number of filled grains per panicle	0.6818**	0.3183	0.0645	0.0933	0.0318	0.3242
6	Thousand grain weight	0.3850**	0.8771**	0.1481	0.3879	0.2352	0.2161
7	Straw yield	0.4170	0.4959	0.7694**	0.2842	0.2346	0.2628

Discussion

DISCUSSION

The important findings from the results of the present investigation both at Instructional Farm, College of Agriculture, Vellayani and Regional Agricultural Research Station, Pattambi and the important findings of the correlation analysis of the data collected for a period of twenty five years (1960-1985) from a permanent manurial experiment at Regional Agricultural Research Station, Pattambi are discussed in this chapter.

5.1 Experiment I

5.1.1 Effect of dates of transplanting on growth and yield of rice

A critical analysis of the results of the experiments revealed marked response of the crop to various dates of transplanting.

During the first crop season at Vellayani, June 1st transplanting registered maximum dry matter production by registering a grain yield of 4826 kg ha^{-1} (Fig. 3a) and straw yield of 5368 kg ha^{-1} (Fig.4a). The better dry matter production (Fig.5) noticed may be due to the direct reflection of the positive response of growth attributes like plant height, tiller number, leaf area index (Fig. 7) and yield attributes like panicles $hill^{-1}$, filled grains $panicle^{-1}$ and thousand grain weight (Table 161). The June 1st transplanted crop has produced 31per cent more grain yield than June 30th transplanting.

The better performance of early transplanted crop in this study might be because of the congenial climatic conditions experienced by the crop. The June 1st transplanted crop has experienced higher mean morning (92.27 per cent) and evening relative humidity (76.63 per cent), high mean maximum (30.07°C) and minimum temperature (24.45°C) during the crop growth (Appendix IIa). The June 1st transplanted crop had higher plant height as it was exposed to higher temperature. Similar findings of increase in plant height with higher temperature

Fig. 3a Grain yield (kg ha^{-1}) as influenced by different dates of transplanting and varieties in different seasons -Vellayani

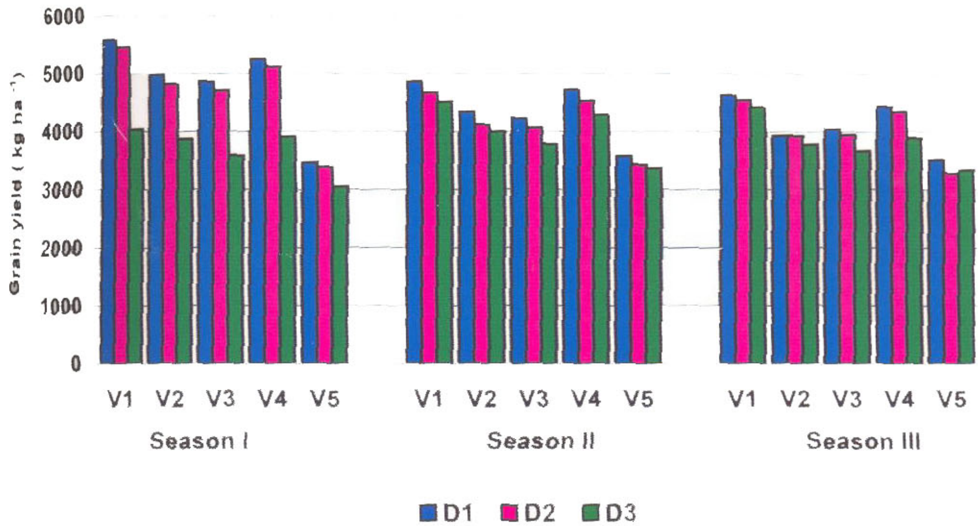


Fig. 3b Grain yield (kg ha^{-1}) as influenced by different dates of transplanting and varieties in different seasons- Pattambi

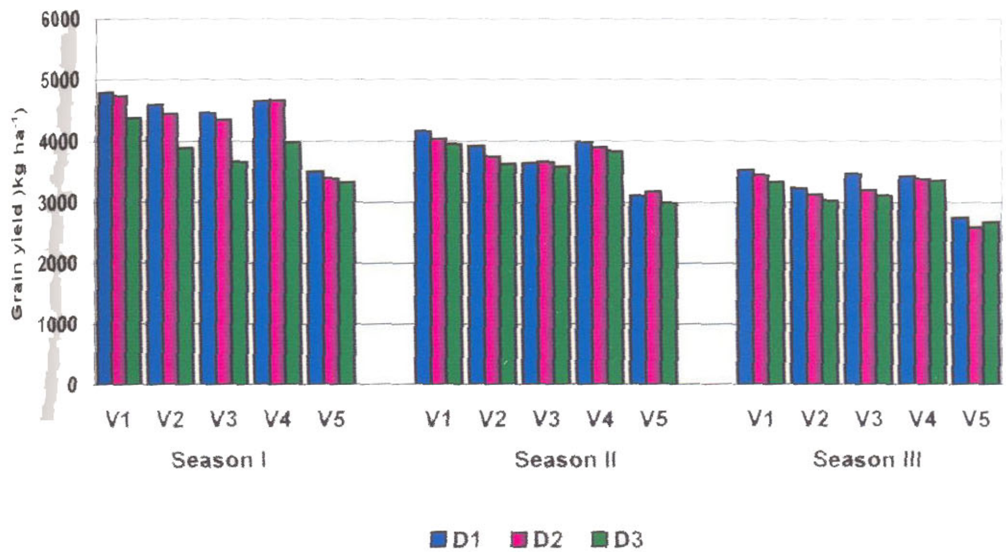


Fig. 4 a Straw yield (kg ha^{-1}) as influenced by different dates of transplanting and varieties in different seasons-Vellayani

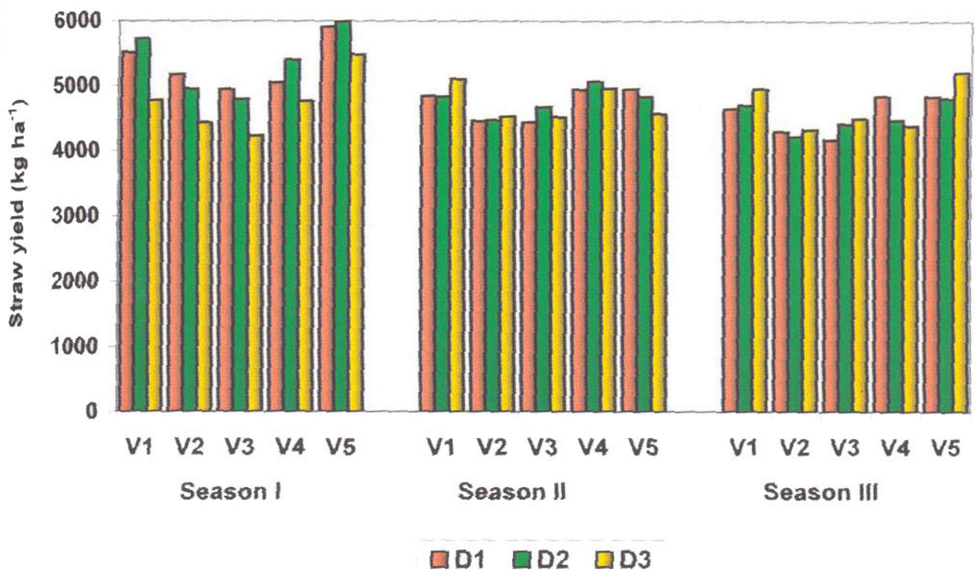


Fig. 4 b Straw yield (kg ha $^{-1}$) as influenced by different dates of transplanting and varieties in different seasons-Pattambi

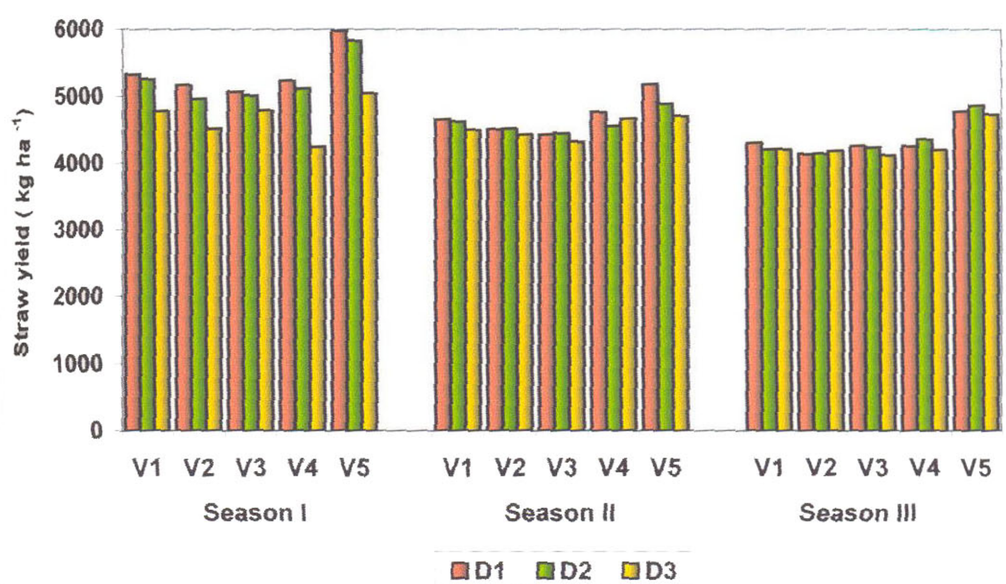


Fig.5 TDMP as influenced by different dates of transplanting and varieties in different seasons- Vellayani

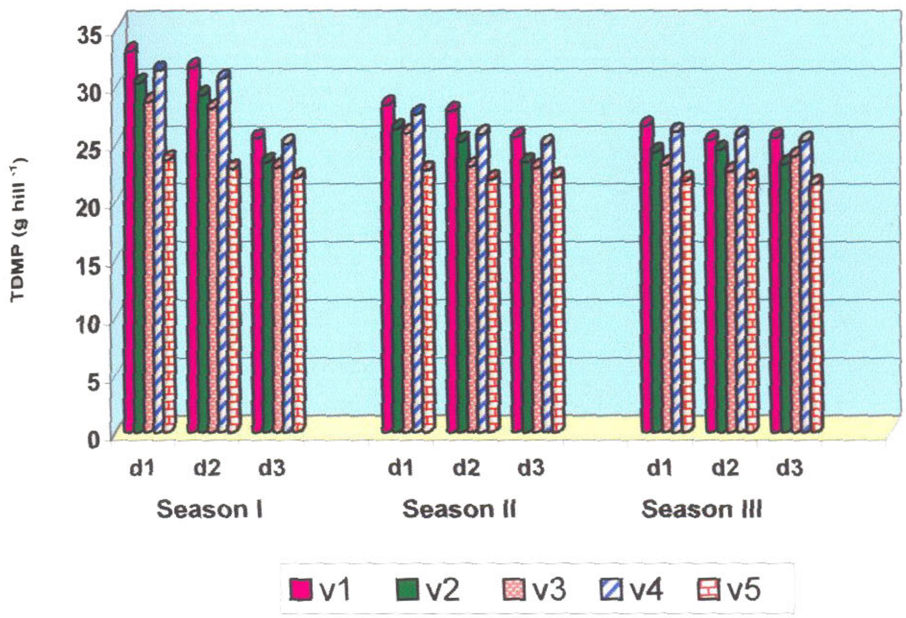


Fig. 6 TDMP as influenced by different dates of *transplanting* and varieties in different seasons - Pattambi

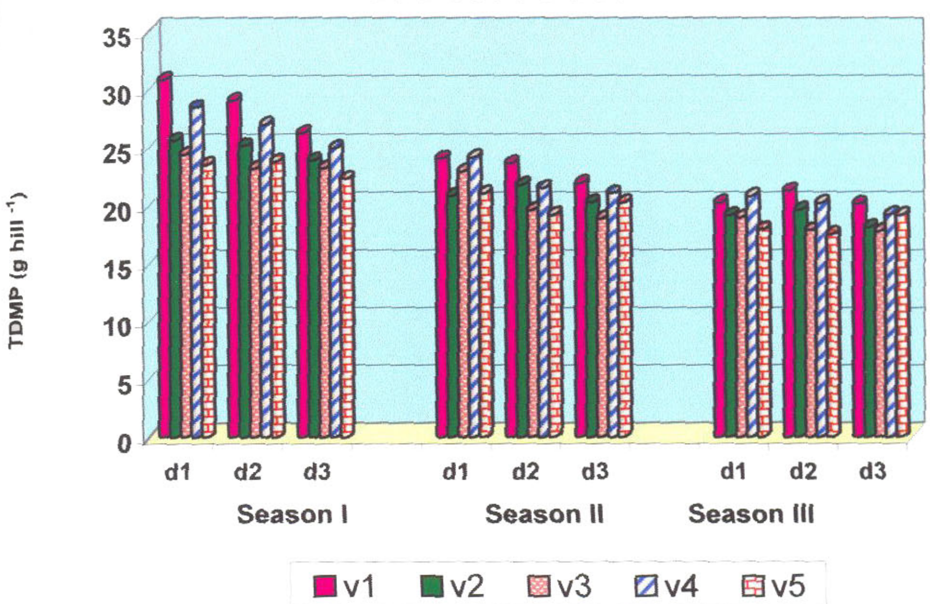


Fig.7 LAI as influenced by different dates of transplanting and varieties in different seasons- Vellayani

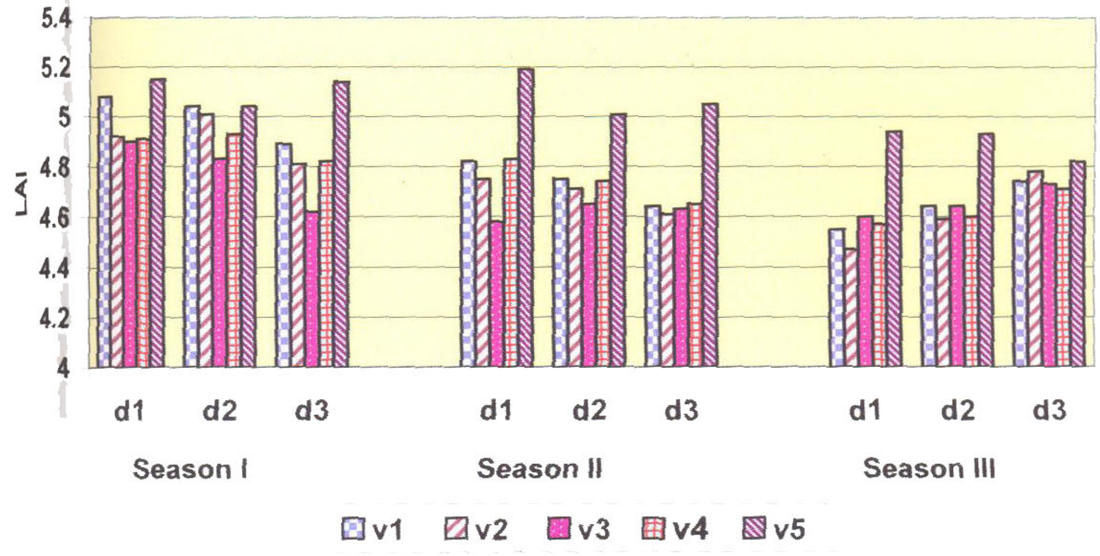
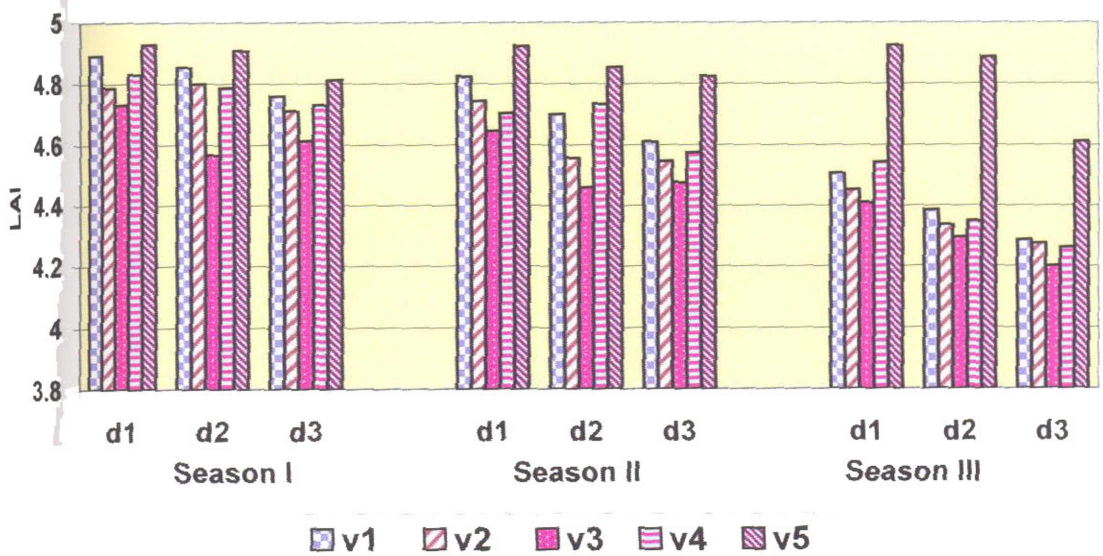


Fig. 8. LAI as influenced by different dates of transplanting and varieties in different seasons - Pattambi



and decrease in plant height with lower temperature had been reported by Chae *et al.* (1980) and Khushu *et al.* (1988). Fairly higher temperature with consistently higher values for minimum temperature could have influenced the tiller production favourably for June 1st transplanted crop. Increase in tiller production of rice under higher temperature has been reported by Moniperumal (1989). The increased tiller production might be the reason for increased leaf number and LAI for June 1st transplanted crop which in turn resulted in higher grain yield. Gangwar and Ahmedi (1990) also reported similar results of more number of productive tillers per unit area, filled grains panicle^{-1}, thousand grain weight and higher grain yield for early transplanting within June or lately by the 1st week of July. Drastic reduction in grain yield due to late planting has been reported by Kempanne (1960), Rao and Murthy (1982) and Babu (1988).

At Vellayani during the *mundakan* season also early transplanting on October 1st produced maximum dry matter production (Fig.5). The growth attributes like plant height, leaf number, LAI (Fig.7) and yield attributes like filled grains panicle^{-1}, thousand grain weight were higher for October 1st transplanting and lower for October 30th transplanting. Similar results of increased growth and yield attributes like number of total spikelet, filled grains, percentage of filled grains, total dry matter production, harvest index and grain yield for early transplanted crops was reported by Latif (1982). The October 1st transplanted crop had produced the highest grain yield of 4342 kg ha^{-1}(Fig.3b). The October 1st transplanted crop had enjoyed ideal maximum temperature (29.99°C), minimum temperature (23.46°C) and rainfall (734.54 mm) compared to other two transplanting dates. These favourable meteorological parameters might have positively influenced the crop yield in early transplanted rice. The higher minimum temperature experienced constantly during this season might be the reason for increased tiller production as evidenced by the study of Moniperumal (1989). The higher rainfall received during vegetative stage enhanced the water availability to the crop and this might have helped for the increase in the growth attributes. Rainfall obtained during tillering phase also might have enabled healthy crop growth and hence higher grain yield. Similar positive correlation of yield and rainfall during vegetative phase has been reported by Sreelatha (1989). Samui *et al.* (1998) also found that rainfall up to 900 mm received during planting to maturity stage increased the grain yield. In the present study, a total rainfall of 734.54 mm received from planting to maturity for October 1st transplanted crop might have helped in increasing the grain yield. Latif (1982) also observed late September to early October as the best time of planting for *mundakan* rice.

During the third crop season at Vellayani, January 1st transplanted crop produced higher grain yield (4104 kg ha^{-1}) (Fig.3c) than other transplanting dates. Yield attributes like filled grains panicle^{-1}, thousand grain weight and grain chaff ratio were higher for January 1st transplanting and lower for January 30th transplanting. This might be the reason for increased crop yield in early transplanted rice in this season. Earlier transplanting in third crop season had enjoyed weather condition favourable for the growth and yield of rice. Higher temperatures of mean maximum (31.95°C) and mean minimum (23.72 °C) experienced by the crop during the growth period of January 30th transplanting might have reduced the carbohydrate content per plant resulting in lower tiller production. This is in conformity with the findings of Sreelatha (1989). January 30th transplanted crop have experienced a mean maximum temperature of 32.25 °C and 32.41°C and mean minimum temperature of 23.64°C and 24.76°C during reproductive phase and ripening phases respectively. Higher maximum and lower minimum temperature during later period might have affected the translocation of food materials to grains and this might be the reason for lesser number of filled grains in this date of transplanting. Satake and Yoshida (1978) also reported a high percentage of sterility in rice due to high temperature.

At Pattambi also during the first crop season, June 1st transplanting had higher grain yield of 4399 kg ha^{-1} (Fig. 3b). The June 1st transplanting had higher plant height, dry matter production (Fig 6), LAI (Fig.8) and yield attributing character like number of panicles hill^{-1} and filled grains panicle^{-1}. The weather parameters prevailed during the growth of June 1st transplanting was favorable for better expression of growth and yield. The June 1st transplanted crops received higher mean morning relative humidity (93.81 per cent) and mean evening relative humidity (74.46 per cent), high mean maximum temperature of 29.42°C and mean minimum temperature of 23.06°C and 1504.30 mm of rainfall during its growth stage (Appendix II b). These favourable meteorological parameters might have positively influenced the crop yield in early transplanted rice. Samui *et al.* (1998) observed optimum value of minimum temperature (23.5°C) and maximum temperature (29.1°C) for obtaining higher yield. Similar temperature ranges received in this study might be the reason for higher yield for early transplanting in this season.

During the second crop season at Pattambi the growth characters like TDMP (Fig. 6), LAI (Fig. 8) and yield attributing characters like filled grains $panicle^{-1}$, panicles $hill^{-1}$ and grain yield (Fig. 3b) were higher for October 1st transplanting and it was on par with October 15th transplanting. The meteorological parameters like mean maximum temperature (31.61°C), minimum temperature (22.60°C) and rainfall (260.21 mm) of October 1st transplanting were favourable for growth and yield attributing characters. October 15th transplanted crops also experienced favourable weather condition like mean maximum temperature (31.63°C), minimum temperature (22.28°C) and rainfall (218.53 mm) for the development of better growth and yield attributing characters. But, a high wind speed of 8.54 kmh^{-1} experienced by October 30th transplanted crops during the ripening phase might have resulted in the increased spikelet sterility leading to reduced number of filled grains per panicle. This resulted in reduced grain yield. Sreelatha (1989) and Viswambharan *et al.* (1989) reported similar findings of lower filled grain production due to increased spikelet sterility owing to higher wind speed during the period from heading to maturity.

During the third crop season at Pattambi, maximum dry matter production (Fig. 6) was recorded by January 1st transplanting. Transplanting on this date produced a grain yield of 3279 kg ha^{-1} (Fig.3b). The early transplanted crop had experienced lower mean morning and evening relative humidity of 79.21 per cent and 38.18 per cent respectively, and a mean maximum temperature of 33.83°C and mean minimum temperature of 21.82°C. Because of this favourable weather, the growth attributes like maximum LAI, leaf number and yield attributing characters like filled grains panicle^{-1}, thousand grain weight and grain chaff ratio were higher for January 1st transplanting. The observation of (Munakata *et al.*1967) that the yield process developed properly when the maximum and minimum temperatures were below 34°C and 22°C respectively and bright sun sunshine hours of more than eight hours day^{-1}, further strengthens the present finding. Alexander *et al.* (1991) also observed that the ill effect of mean maximum temperature beyond 34° C is counteracted by a minimum temperature below 22° C up to 18° C. The January 15th and 30th transplanted crops experienced a mean maximum temperature of 34.02° C and 34.15° C and a mean minimum temperature of 22.00° C and 22.14°C respectively (Appendix IIb). This temperature regime might have reduced the yield by reducing the duration of their life span for grain filling probably through a higher heat unit accumulation in unit time. This might have led to poor grain filling and rise in percentage of chaff production and hence resulted in reduced yield in January15th and January 30th transplanting. Alexander *et al.* (1991) have also documented similar results.

5.1.2 Effect of date of transplanting on nutrient uptake

Increased uptake of nitrogen, phosphorus and potassium was noticed on earlier transplanting at both locations in all seasons. In first crop season, uptake of nitrogen, phosphorus and potassium by June 1st transplanted crop was comparable with June 15th transplanting and lower uptake was registered by June 30th transplanting. A similar trend in uptake of these nutrients were observed for second and third crop seasons with higher nitrogen, phosphorus and potassium uptake for October 1st and January 1st transplanting, which were comparable with October 15th and January 15th transplanting respectively. Lowest uptake was registered by October 30th transplanting for second crop season and January 30th transplanting for third crop season.

Unfavourable weather conditions, especially higher temperature prevailed during the growth of June 30th, October 30th and January 30th transplanted crop at both locations were the reason for the decreased dry matter production, which resulted in lower nutrient uptake. In this study the uptake of nitrogen, phosphorus and potassium showed a reverse trend with increase in temperature. Similar results were obtained by Baba *et al.* (1953) and according to them, high temperature inhibited the absorption of salts by rice plant. A similar finding of negative response of potassium uptake to temperature and solar radiation was recorded by Krishnakumar and Subramanian (1991).

5.1.3 Varietal variation in the expression of growth, productivity and nutrient uptake parameters

In all seasons at both locations similar trend in growth and yield attributes, nutrient uptake and pest and disease incidence were observed by same varieties.

At Vellayani during the first crop season high yielding varieties registered 32-52 per cent increase in yield while in second and third crop seasons the increase was 18 to 37 per cent and 15 to 34 per cent compared to local variety. At Pattambi the yield increase of high yielding varieties over Ptb-10 ranged from 22 to 36 per cent, 17 to 31 per cent and 17 to 29 per cent during the first, second and third crop seasons respectively. Among the rice varieties tried, Kanchana (v_1) consistently out yielded other varieties followed by Kairali (v_4). The local variety (Ptb-10) registered the lowest grain yield. Kanchana took more number of days to reach physiological maturity. This increased duration of Kanchana might have increased the uptake of nutrients and translocation of assimilates to sink leading to higher grain yield. The longer duration of grain filling period might have resulted in higher grain yield. Similar correlation between longer duration taken for grain filling period and greater grain yield in rice has been reported by Tanaka and Vergara(1967). The increased number of filled grains panicle^{-1} and higher number of panicles hill^{-1} for Kanchana and Kairali might have contributed for the higher grain yield for these varieties. For Jyothi when compared to Kanchana and Kairali though there is no variation in the number of days to reach physiological maturity, a reduction in yield was observed. This could be attributed to the reduction in the number of panicles hill^{-1}, filled grains per panicle and thousand grain weight. The local variety was taller than other high yielding varieties and recorded lesser tiller production and higher LAI. The local variety tried in this experiment had broader leaves than other varieties, thus contributing to higher LAI, even though the tiller number was lower (Tables 22 and 99).

TDMP was highest for the local variety up to the beginning of grain filling stage in all seasons. The tall nature of Ptb-10 resulted in the increased TDMP. More than this, the larger leaf area per unit area occupied by local variety provided the source for enhanced photosynthesis and accumulation of sink resulting in higher growth than other varieties. The uptake of nitrogen, phosphorus and potassium was significantly higher for local variety up to the beginning of grain filling stage at both locations in all seasons. This might be due to the increased TDMP by the same varieties up to this stage. However, at harvest local variety had lesser grain yield than other high yielding varieties, which accounted for lesser TDMP at that stage. The ability of high yielding varieties like Kanchana and Kairali for efficient translocation of photosynthates from source to sink has resulted in higher grain yield for these varieties, which in turn enhanced TDMP. The enhanced root proliferation and better nutrient assimilation of high yielding varieties along with the enhanced TDMP might have resulted in increased uptake of nitrogen, phosphorus and potassium by Kanchana and Kairali. More over the local variety was taller and had more vegetative growth and thus more nutrient uptake during the early stages of crop growth. But for high yielding varieties, the short stature and reduced vegetative growth during early stages of crop growth resulted in lower nutrient content during early stages. However the efficiency of absorption and subsequent utilization and translocation of nutrients has resulted in improved grain yield, high TDMP and thus higher nutrient uptake for these varieties.

5.1.4 Effect of dates of planting and varieties on incidence of pests and diseases

In all seasons on all dates of transplanting at both locations, the varieties Kanchana, Kairali and Ptb-10 were found free from the incidence of gall midge and sheath blight and Kairali was free from the attack of leaf roller. This is in agreement with the finding of Kerala Agricultural University (KAU,1996).

In all seasons at both locations incidence of gall midge, leaf roller, rice bug, sheath blight and sheath rot were higher for late transplantations. Similar findings of reduced pests and diseases incidence in early maturing and early transplanted varieties have been reported by Litsinger *et al.* (1987). Low incidence of pests and diseases in early planted rice was also reported by Moniperumal (1989).

Increased sheath rot incidence in late transplanted crop was noticed in this study. Extremely high incidence of sheath rot on crops planted from mid June was observed by Srinivasan (1977). Singh *et al.*(1986) also observed similar results. Escaping from rice bug infestation for early planted crops were observed by Sundararaju (1986) and Suharto and Noch (1987). A similar observation of escape from rice bug in early transplanted crops were also noticed in the present study.

In early transplanted crop when the infection stage of the pest and microbes are over, the inoculums would be finding a place in late transplanted crop. In the case of late transplanting, the surrounding crop might have completed their susceptible growth stages and the entire pest inoculums would be feeding or confining to these late transplanted crops. Hence, the incidence is more late transplanted crop.

5.1.5 Interaction effect of dates of transplanting and varieties on growth and yield.

Significant interaction between varieties and dates of transplanting on grain yield was observed in *virippu* season both at Vellayani and Pattambi. Interactions between dates of transplanting and varieties revealed that in all these seasons, at both locations the rice varieties Kanchana out yielded other varieties closely followed by Kairali, and the local variety recorded the lowest grain yield. In first crop season at Vellayani the highest grain yield was registered by Kanchana for June 1st transplanting (5587 kg ha^{-1}), while for the second crop, October 1st transplanting registered the highest grain yield of (4557 kg ha^{-1}). For the third crop season, January 1st transplanting was found to be superior in terms of yield, (4627 kg ha^{-1}). At Pattambi the highest grain yield was registered by Kanchana for June 1st transplanting (4787 kg ha^{-1}) in first crop season.

The higher number of filled grains $panicle^{-1}$ and panicles $hill^{-1}$ for Kanchana and Kairali and the benefits of early transplanting might have contributed for higher grain yield for theses varieties. For local variety also among the different dates of transplanting ,early transplanting was found significant. Though the varietal influence of local variety was less in yield, the beneficial effect of weather parameters during early transplanting might have favoured an increase in yield over other dates of transplanting.

A similar trend in grain yield was obtained from the variety Kanchana at Pattambi also The variety Kanchana performed well with a grain yield of 4787 kg ha^{-1}, 4158 kg ha^{-1} and 3530 kg ha^{-1} from rice transplanted on 1st of June, October and January respectively during the first, second and third crop seasons. The increased grain yield might be due to the positive response of growth attributes like plant height, leaf number and leaf area index, which in turn favourably influenced the yield and yield attributes like filled grains $panicle^{-1}$, thousand grain weight, grain chaff ratio and harvest index for the variety Kanchana. So also the congenial weather during early transplanting favoured crop growth and yield. The combined effect of varieties and weather in early transplanted crop registered significant influence for varieties x dates of transplanting interactions. More over Kanchana took more number of days to reach physiological maturity in early transplanting. This increased duration of Kanchana along with increased grain filling period might have improved the uptake of nutrients and translocation of assimilates to sink leading to higher grain yield. Similar correlation between longer duration of grain filling period and greater grain yield in rice has been reported by Tanaka and Vergara (1967).

5.2 Crop weather relationships

Each crop species will have an optimum temperature range, below and above of which a disturbance is induced in the metabolic processes. In this study at both locations it is evident that at all growth stages viz., vegetative, reproductive and ripening stages increase in maximum temperature reduced the grain yield (Fig.9a, 9 b, 9c,10a,10b and 10c). From the study conducted by Satake and Yoshida,(1978) it is clear that high temperature induced sterility in rice, and heading time is the most sensitive stage to high temperature. For spikelet sterility high temperature was the second detrimental factor before anthesis, but it was the most detrimental factor after anthesis. At ripening stage higher temperature was found to reduce the grain yield by reducing the duration of ripening period. In the present study also a reduction in total duration was also observed due to higher temperature.

At both locations yield reduction was observed with an increase in evaporation at all stages of plant growth (Fig.9a,9b,9c,10a,10 b and 10 c). The decreased availability of moisture to plants due to increased loss of moisture from soil at higher evaporation rate might be the reason for this.

At Vellayani a higher rainfall during reproductive and ripening phases reduced the grain yield (Figs.9 b and 9c). This might be due to the variation in distribution of rainfall in this location and also due to heavy rainfall during vegetative phase. Severe grain yield reduction was noticed by Venketeswarlu (1976) due to variability in rainfall , which associated with an untimely cessation at the reproductive stage. Whereas at Pattambi, in general a positive relation ship was observed between grain yield and rainfall. At all stages of plant growth, higher rainfall increased grain yield and lower rainfall decreased grain yield (Figs.10a,10b and 10c). Similar positive relationship between grain yield and rain fall was reported by Pillai,1995.

Fig. 9 a Grain yield (kg ha^{-1}) as influenced by weather parameters during vegetative phase at Vellayani

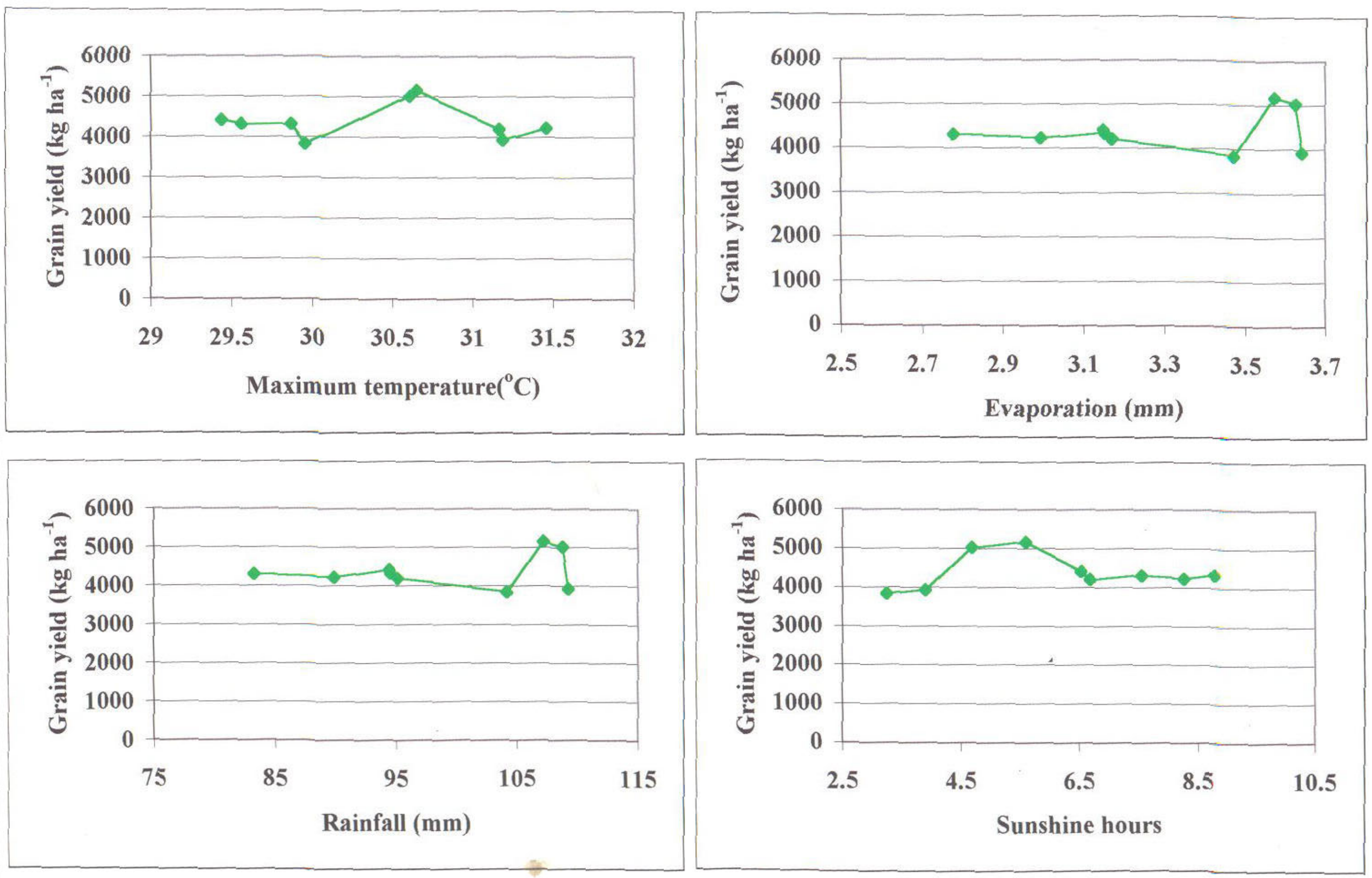


Fig. 9 b Grain yield (kg ha^{-1}) as influenced by weather parameters during reproductive phase at Vellayani

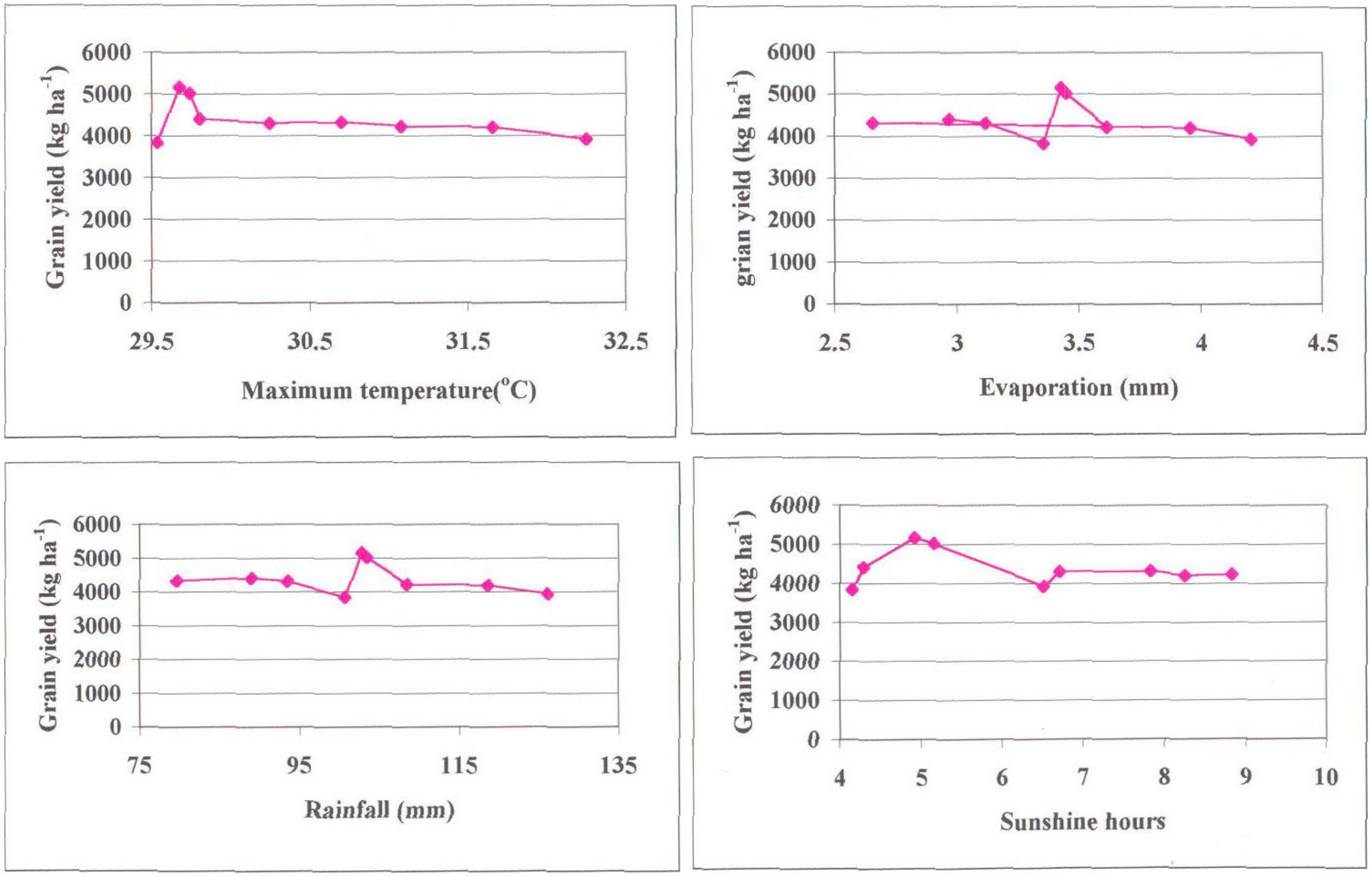


Fig.9c Grain yield as influenced by weather parameters during ripening phase at Vellayani

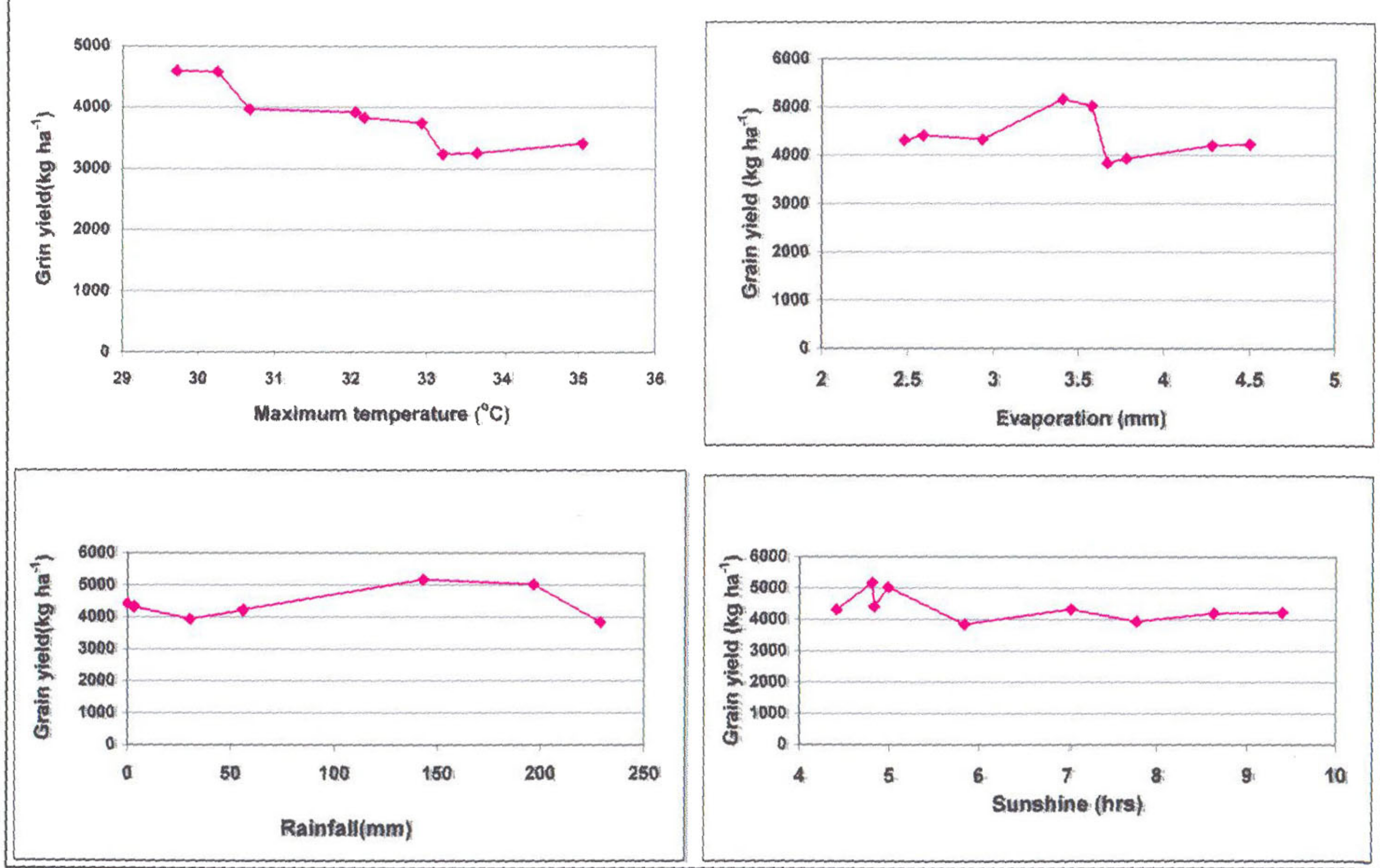


Fig.10a Grain yield (kg ha^{-1})as influenced by weather parameters during vegetative phase at Pattambi

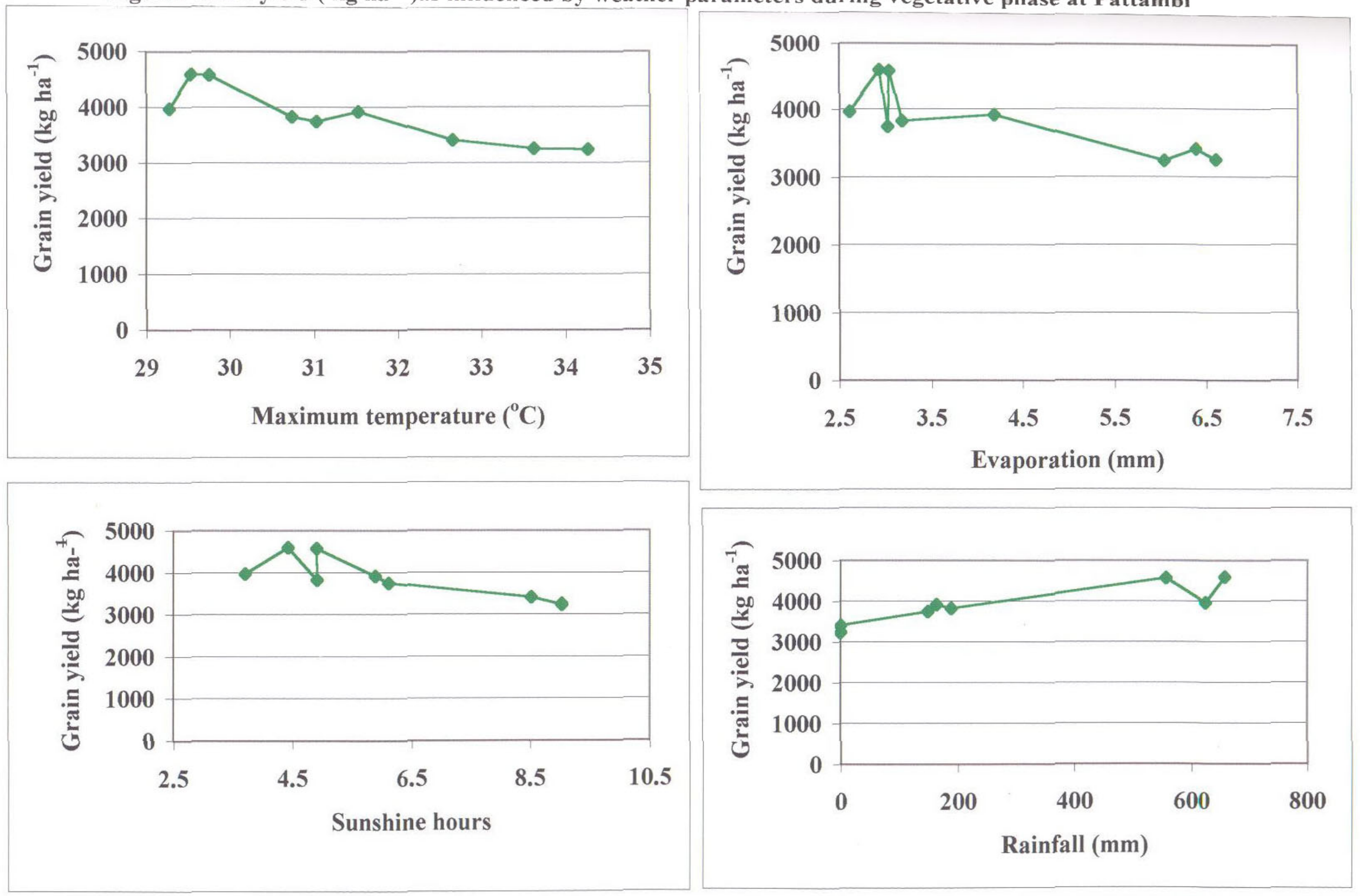


Fig.10 b Grain yield (kg ha^{-1}) as influenced by weather parameters during reproductive phase at Pattambi

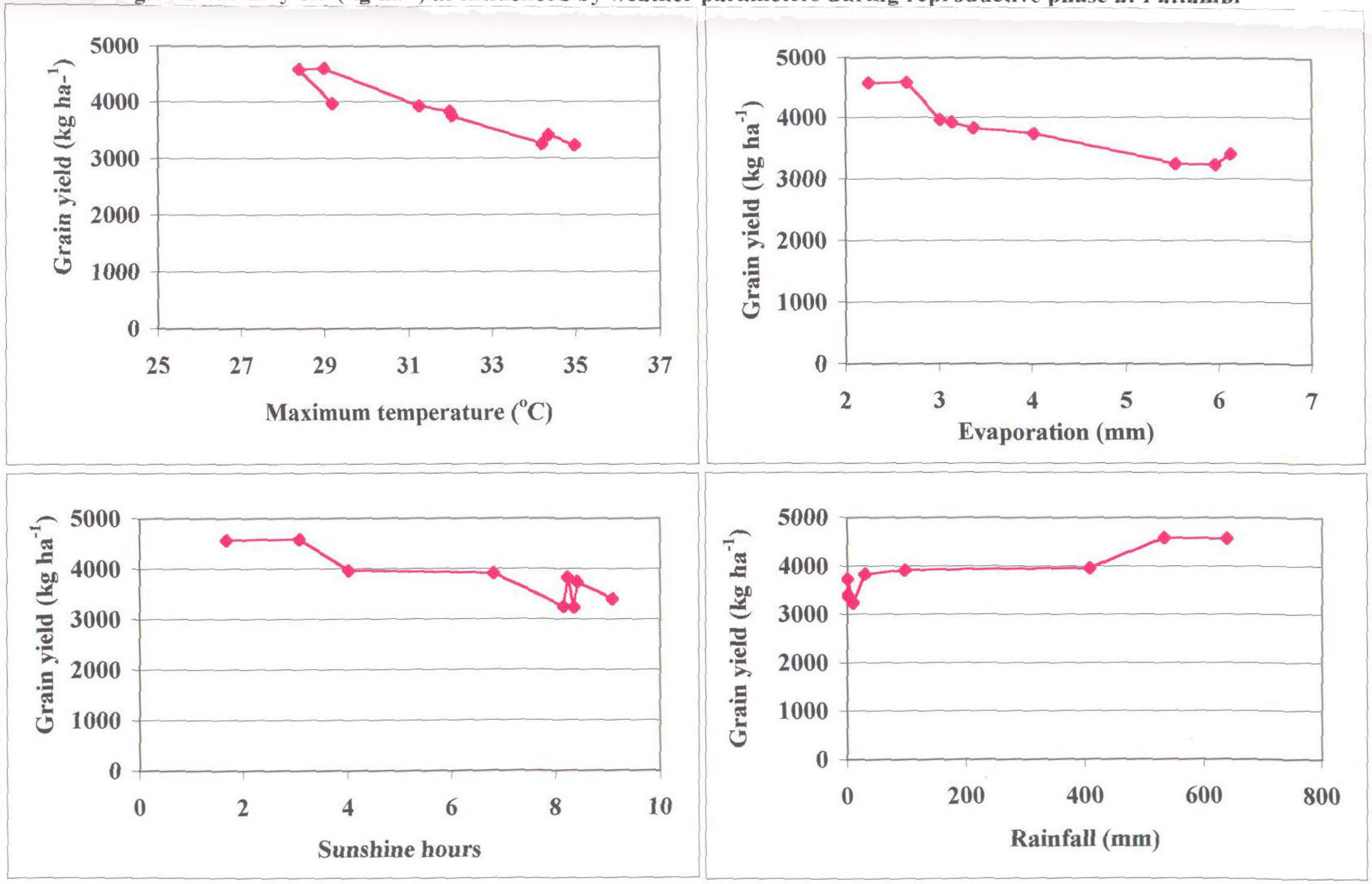
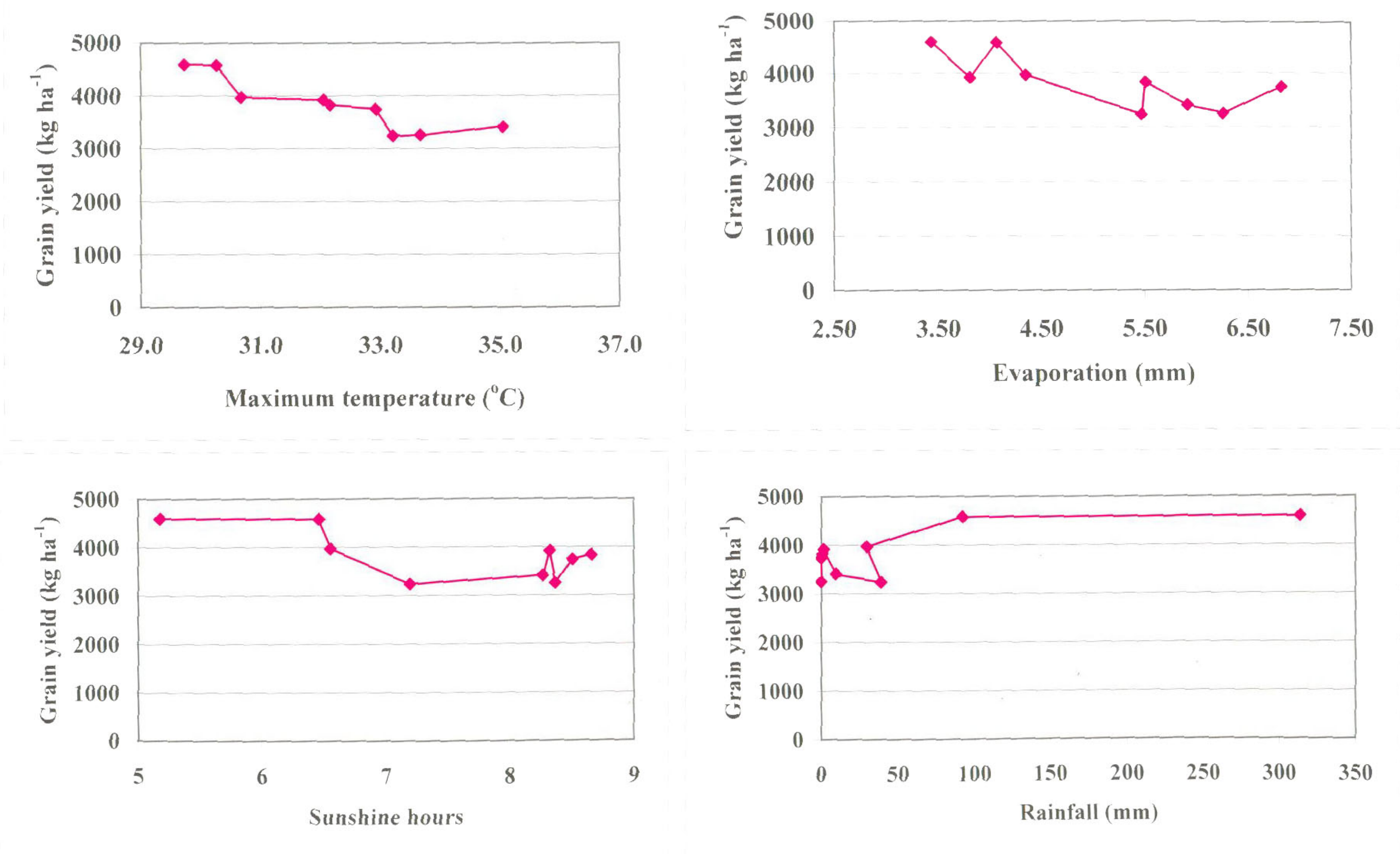


Fig.10c Grain yield (kg ha-1)as influenced by weather parameters during ripening phase at Pattambi



At both locations a negative relationship was observed between grain yield and sunshine hours during the reproductive phase (Figs.9b and 10b). This might be due to the effect of high temperature associated with high intensity of solar radiation.

5.3 Influence of agro meteorological parameters on grain yield

Influence of different agro meteorological parameters prevailed during different pheno phases on grain yield by correlations and linear regression analysis (Table 158) revealed that in *virippu* season the increase in temperatures (both maximum and minimum) and evaporation at different stages of rice growth had a negative influence on grain yield. A significant negative correlation between yield and the minimum temperature at 30 days after transplanting was reported by De Datta and Zarate (1970). Similar findings of reduction in yield due to higher maximum and minimum temperature during tillering, ear initiation and maturity was reported by Huda *et al* (1975). Sreelatha (1989) also reported negative correlation of maximum temperature and yield during vegetative and early ripening period of rice .

In the present study, it was also noticed that weather parameters like mean number of rainy days, evening relative humidity and sunshine hours from planting to active tillering stage and daily sunshine hours from planting to panicle initiation stage had a positive influence on grain yield. Results of three stage analysis viz., planting to panicle initiation, planting to flowering and planting to harvest revealed that in all stages, mean maximum temperature, mean minimum temperature, and mean evaporation were negatively correlated with grain yield. The mean daily sunshine hours was positively correlated with grain yield from planting to panicle initiation stage.

The path analysis study done using the different agro-meteorological parameters and grain yield (Table159)also revealed that mean maximum temperature, mean minimum temperature, and mean evaporation during the period from planting to active tillering stage are negatively correlated with grain yield giving a significantly negative direct effect of -0.5995 ,

- 0.6343 and -0.5678 respectively. The weather parameters like number of rainy days, evening relative humidity and mean daily sunshine hours had significant positive direct effect. All the indirect effects were observed to be negative.

Though significant correlation was observed between minimum temperature and yield, its direct effect was negligible. The negative indirect effects via, evaporation, maximum temperature and solar radiation was mainly responsible for this correlation. The direct effect of rainy days was less though it had significant correlation with yield. Indirect effects of rainy days via evaporation and maximum temperature, are the major contributors of this correlation. A similar result was also observed with evening relative humidity. The correlation between solar radiation and yield was 0.6001, which might have been contributed to sunshine itself. The study also revealed that the different weather parameters considered accounted to 72 per cent yield variation and this could be inferred that the weather parameters studied are of high significance in determining rice yield.

Sreelatha (1989) observed a similar positive correlation of rainfall during vegetative phase on grain yield of rice. De Datta (1981) also observed that rice required fairly high humidity for proper growth and flowering. In the present study the favourable weather parameters like rain fall, evening relative humidity and sunshine hours during the crop period enhanced the growth and thus yield theirby registering a positive correlation of the weather parameters with yield. Raghavan (1996) also reported similar results of better yield with increase in relative humidity at nursery stage.

Higher solar radiation during the vegetative stage stimulates the growth by increasing photosynthesis, hence dry matter production, and yield. Narayanaswamy (1994) also reported that cumulative solar radiation and cumulative day length during vegetative phase had a positive influence on grain yield.

Multiple regression equation fitted using different agro meteorological parameters and yield is as follows

$$Y = 4716.423 - 84.56352\, x_1 - 84.6451\, x_2 + 30.1407\, x_3 + 5.3717\, x_4 + 89.8037\, x_5 - 53.5544\, x_6$$

$$(R^2 = 0.7166)$$

Y = Expected grain yield (kg ha $^{-1}$)

x_1 = Mean maximum temperature (Planting to active tillering)(° C)

x_2 = Mean minimum temperature (Planting to active tillering)(° C)

X_3 = Mean number of rainy days (Planting to active tillering)

X_4 = Mean evening relative humidity (Planting to active tillering)(%)

X_5 = Mean hours bright sunshine (Planting to active tillering)

X_6 = Mean evaporation (Planting to active tillering)(mm)

At Pattambi during the *mundakan* season, the grain yield was negatively correlated with mean evaporation, mean maximum temperature, mean temperature and was positively correlated with evening relative humidity from planting to active tillering stage (Table160). The negative influence of maximum temperature during this stage on yield was in conformity with findings of Huda *et al.* (1975) and Sreelatha (1989). The positive influence of mean relative humidity at nursery stage on grain yield was also observed by Haseena Raghavan (1996). The mean minimum temperature during active tillering to panicle initiation stage was negatively correlated with yield while sunshine hours during the same period had a positive influence. The negative correlation of yield with minimum temperature during early periods of crop growth was in conformity with the findings of De Datta and Zarate(1970) and Huda *et al.* (1975). Sreelatha (1989) from her studies on rice also observed a positive relationship between yield and total solar radiation during 5 to15 days before 50 per cent heading. She also observed a positive correlation of grain yield with rainfall from panicle initiation to flowering. The results of the present study are in line with this.

On analysis of the influence of minimum temperature and evaporation on grain yield from nursery to panicle initiation stage, a negative correlation can be observed, while duration of sunshine hours had a positive influence on grain yield.

Result of three stage analysis viz., planting to panicle initiation, planting to flowering and planting to harvest revealed that during planting to panicle initiation stage, mean minimum temperature, and mean evaporation were negatively correlated with grain yield while the mean daily sunshine hours was positively correlated with grain yield.

Path analysis study for *mundakan* season revealed significant negative correlation of mean maximum temperature, mean daily sunshine hours and mean evaporation had the maximum negative direct effect of –0.0396 and the minimum negative direct effect was by evaporation (-0.4679). The three parameters accounted to 54 per cent yield variation during *mundakan* season.

Multiple regression equation worked out by including significant agro meteorological parameters like mean maximum temperature, mean evening relative humidity and mean evaporation has given a R^2 value of 0.4629 only. 46.29% of the variance of mundakan crop yield can be explained by the weather parameters like mean minimum temperature, and mean evaporation during the period from planting to active tillering stage.

Multiple regression analysis of different agro meteorological parameters with yield given below answered more than 46 per cent variation in yield

$$Y = 11038.93 - 229.5176\, x_1 + 52.888\, x_2 - 396.7442\, x_3$$

Where Y = Expected yield (kg ha^{-1})

x_1 = Mean maximum temperature (Planting to active tillering)(° C)

x_1 = Mean hours bright sunshine (Planting to active tillering)

x_3 = Mean evaporation (Planting to active tillering) (mm)

The multiple regression equations worked out for predicting the grain yield (Fig.11a and 11 b) gives the fit between observed and predicted values of *virippu* and *mundakan* crop yield.

Fig. 11a Observed and predicted grain yield (kg ha^{-1})-virippu

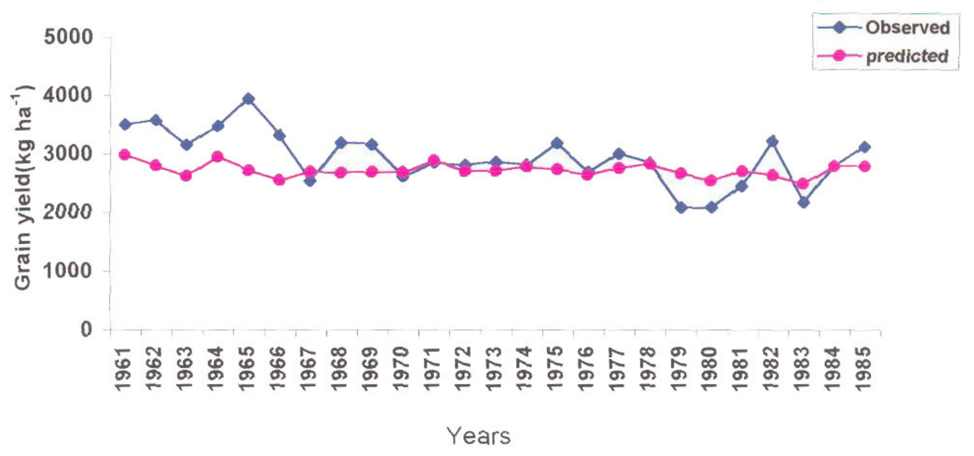
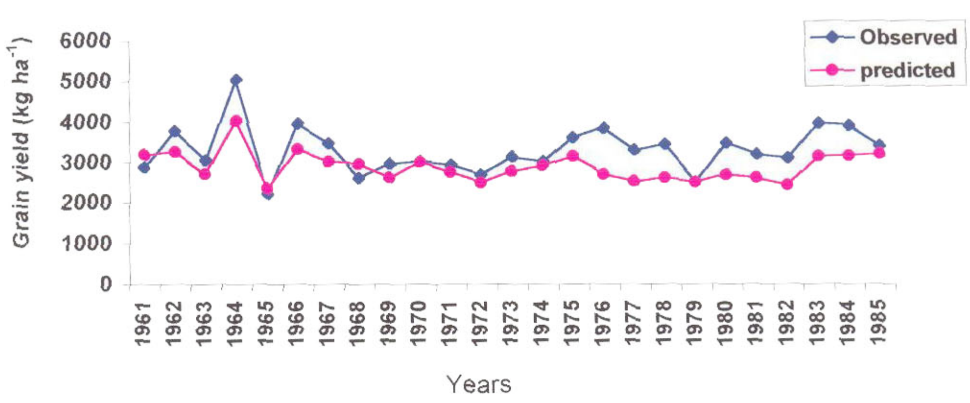


Fig. 11b Observed and predicted grain yield (Kg ha^{-1}) - mundakan



Summary

SUMMARY

The present investigation entitled "Crop weather modeling in rice (*Oryza sativa* .L) consisted of two experiments. In first experiment, the effect of three dates of transplanting in three seasons viz.,*virippu, mundakan and puncha* (1st, 15th and 30th the of June, October and January) on the growth and yield of four high yielding rice varieties (Kanchana, Jyothi, Matta Triveni and Kairali) and a local variety (Ptb-10) were evaluated in strip plot design at two locations viz., College of Agriculture, Vellayani, Thiruvananthapuram and Regional Agricultural Research Station (RARS), Pattambi, Palakkad. In the second experiment correlation analysis was done on the grain yield data for a period of twenty five years (1960-1985) from a permanent manurial experiment at Regional Agricultural Research Station, Pattambi.

The salient findings from the results of the study conducted are *summer*ised below

1. In all seasons at both locations late transplanting showed a reduction in plant height and the local variety Ptb-10 was the tallest one compared to other high yielding varieties at all stages of plant growth.

2. In *virippu* season, June 1st transplanting recorded maximum TDMP at panicle initiation, and harvest stages at Vellayani and at transplanting, panicle initiation and harvest stages at Pattambi. In *mundakan* season October 1st transplanting recorded maximum TDMP at active tillering, panicle initiation and harvest stages at Vellayani and transplanting, panicle initiation and beginning of grain filling stages at Pattambi. January 1st transplanting registered maximum TDMP at active tillering and panicle initiation stages at Vellayani

and at active tillering and heading stages at Pattambi in *puncha* season. At both locations, the local variety Ptb-10 recorded maximum TDMP up to beginning of grain filling stage whereas it recorded the lowest TDMP at harvest.

3. During *virippu* season, higher DMP of leaf was registered at panicle initiation, beginning of grain filling and harvest stages both at Vellayani and Pattambi for June 1st transplanting, whereas for *mundakan* crop at Vellayani higher DMP of leaf was noted at active tillering, panicle initiation, heading and beginning of grain filling stages for October 1st transplanting. At Pattambi the same date of transplanting recorded higher DMP of leaf at panicle initiation, heading and beginning of grain filling stages during *mundakan season.* January 1st transplanting recorded higher DMP of leaf at active tillering, panicle initiation and harvest stages at Vellayani and at active tillering, heading, beginning of grain filling and harvest stages at Pattambi in *puncha* season. At all stages of plant growth in all seasons at both locations the lowest DMP of leaf was recorded by Ptb-10.

4. Earlier transplanting registered maximum DMP of stem at all stages in *virippu* and *except* at harvest in *mundakan* and only at harvest stage in *puncha* at both locations. At all stages of plant growth, in all seasons at both locations the highest DMP of stem was recorded by Ptb-10.

5. At Vellayani in *virippu* season earlier transplanting recorded maximum number of tillers and the variety Kanchana produced higher number of tillers and was on par with Jyothi and Kairali in all seasons. At Pattambi in all seasons the variety Kanchana produced higher number of tillers and was on par with Kairali .

6. In *virippu* season, June 30th transplanting recorded lower LAI, both at active tillering and harvest stages at Vellayani and at panicle initiation, heading, beginning of grain

filling, and harvest stages at Pattambi. In *mundakan* season October 1st transplanted varieties had more LAI than later transplanting, at transplanting, panicle initiation, heading and beginning of grain filling stages at Vellayani and at panicle initiation, heading, beginning of grain filling and harvest stages at Pattambi. At Vellayani in *puncha* season higher LAI was recorded for January 1st transplanting at active tillering stage whereas at Pattambi, LAI at all stages except active tillering stage was higher for the same planting date. Ptb-10 registered maximum LAI up to beginning of grain filling stage at both locations during these seasons.

7. In *virippu* season at both locations varieties transplanted on June 1st had maximum leaf number. October 1st transplanting of *mundakan* crop produced more number of leaves at panicle initiation stage at Vellayani and at panicle initiation, beginning of grain filling, and harvest stages at Pattambi. In *puncha* season January 1st transplanted crop had more number of leaves at panicle initiation, heading and beginning of grain filling stages at Vellayani and at panicle initiation and heading stages at Pattambi. In all seasons at all stages of plant growth at both locations the lowest leaf production was for Ptb-10.

8. In all seasons at Vellayani early transplanting took more number of days to reach 50 per cent flowering and physiological maturity. At Pattambi transplanting on June 1st showed delay in flowering and physiological maturity during *virippu* season. During all seasons the varieties Kanchana, Jyothi and Kairali took maximum and Ptb-10 took minimum number of days to attain 50 per cent flowering and physiological maturity.

9. Transplanting on June 1st had registered more number of panicle hill^{-1} in *virippu* season at Pattambi. At both locations in all seasons the variety Kanchana produced higher number of panicle hill^{-1} whereas the local variety produced the least.

10. In all seasons early transplanting registered more number of filled grains panicle^{-1} at both locations. In *virippu* season, the varieties Kanchana, Jyothi and Kairali had maximum number of filled grains panicle^{-1} at Vellayani and the varieties Kanchana and Kairali had maximum number of filled grains panicle^{-1} at Pattambi. In *mundakan* and *puncha* seasons the variety Kanchana had maximum number of filled grains panicle^{-1} at Vellayani. In *mundakan* season at Pattambi the variety Kanchana registered maximum and Ptb-10 produced the minimum number of filled grains . No significant difference in filled grain number was observed among different varieties during *puncha* season.

11. Late transplanting reported to have lesser 1000 grain weight in both *mundakan* and *puncha* seasons at Vellayani. In *virippu* season Matta Triveni registered the lowest 1000 grain weight whereas in *mundakan* season Kanchana, Kairali and Ptb-10 were superior and on par and had higher 1000 grain weight. The varieties Kanchana and Kairali were superior and on par in *puncha* season. At Pattambi during all seasons Kanchana registered maximum thousand grain weight and was on par with Kairali and Jyothi. The other varieties like Matta Triveni and Ptb-10 recorded the lowest 1000 grain weight.

12. At both locations in all seasons late transplanting reduced the grain chaff ratio than earlier transplanting. At Vellayani the variety Kairali and Matta Triveni were reported to have maximum grain chaff ratio during *virippu* and *mundakan* seasons respectively. In *puncha* season Ptb-10 was reported to have the lowest grain chaff ratio. At Pattambi in all seasons minimum grain chaff ratio was registered by Ptb-10 and all other varieties were on par.

13. At both locations grain yield was reduced by late transplanting at all seasons. Similarly in both locations the variety Kanchana out yielded other varieties. The grain yield at Vellayani and Pattambi were 5587 kg ha^{-1} and 4787 kg ha^{-1} for June 1st transplanting and 4757 kg ha^{-1} and 4158 kg ha^{-1} for October 1st transplanting and 4627 kg ha^{-1} and 3530 kg ha^{-1} for January 1st transplanting. Ptb-10 recorded the lowest grain yield at both locations in all seasons.

14. With respect to straw yield, at Vellayani June 1st transplanting and June 15th transplanting were superior and were on par and the local variety Ptb-10 registered maximum straw yield in *virippu* season. Kanchana recorded highest straw yield and on par with Kairali and Ptb-10 in *mundakan* season and in *puncha* season Ptb-10 recorded maximum straw yield and was on par with Kanchana. At Pattambi in all seasons Ptb-10 was reported to have higher straw yield than other varieties.

15. June 30th transplanting in *virippu* season and January 30th transplanting in *puncha* season had the lowest HI at Vellayani while at Pattambi during *puncha* season, January 1st transplanting recorded maximum HI. Ptb-10 had lowest HI in all seasons at both locations.

16. June 1st transplanting registered maximum nitrogen uptake up to heading stage at Vellayani and up to panicle initiation stage at Pattambi during *virippu* season. For *mundakan* crop, October 1st transplanting resulted in higher nitrogen uptake up to panicle initiation stage at Vellayani and in all stages at Pattambi. In *puncha* season January 1st transplanting recorded maximum nitrogen uptake at all stages except heading stage at Vellayani and only in panicle initiation stage at Pattambi. In all seasons at both locations earlier transplanting registered higher nitrogen uptake by straw and grain. At both locations in all seasons and stages, Ptb-10 registered maximum uptake of nitrogen by biomass whereas the uptake by straw was the maximum for Kanchana. No significant

difference in nitrogen uptake by grain was observed at both locations in all seasons.

17. Maximum phosphorus uptake by biomass was registered by June 1st transplanting at active tillering, heading and beginning of grain filling stages at Vellayani and up to the beginning of grain filling stage at Pattambi in *virippu* season. Earlier transplanting had higher phosphorus uptake both at transplanting and active tillering in *mundakan* season at Pattambi. At Vellayani at transplanting and active tillering stages earlier transplanting registered maximum phosphorus uptakeby biomass in *puncha* season. Earlier transplanting registered maximum phosphorus uptake by straw and grain at both locations in all seasons. At both locations Ptb-10 registered the highest phosphorus uptake by biomass whereas the uptake by straw was maximum for Kanchana at all stages and seasons. Kanchana registered higher phosphorus uptake by grain in *virippu* and *puncha* seasons at Vellayani and only in *puncha* season at Pattambi.

18. Potassium uptake by biomass was least for June 30th transplanting in all stages in *virippu* season at Vellayani while at Pattambi lesser values were registered at transplanting , active tillering and panicle initiation stages. In *mundakan* and *puncha* seasons of Vellayani potassium uptake was more at active tillering and panicle initiation stages for early transplanted crop. At pattambi early transplanting had higher potassium uptake only at transplanting stage during *mundakan* and *puncha* seasons. At all stages and seasons Ptb-10 registered the highest phosphorus uptake by boimass whereas maximum uptake of potassium by straw was for Kanchana at Vellayani..

19. In general late transplanting resulted in reduced gall midge population. The varieties Kanchana, kairali and Ptb-10 found to be resistant to gall midge and sheath blight on all dates of transplanting. In comparison to local variety, all the high yielding varieties registered lower rice bug attack. Kairali was completely free from leaf roller incidence

and maximum incidence was observed in local variety. Earlier transplanting resulted in lesser sheath rot incidence and this disease incidence was significantly less in local variety compared to high yielding varieties.

20. Neither different dates of transplanting nor varieties influenced the organic carbon, pH and CEC of soil at different stages of observations in both locations.

21. In *virippu* season significant negative correlation was noticed between yield and evaporation (-0.5678). The influence of maximum temperature on yield was negative and significant. Sunshine hours had a significant positive correlation with yield (0.4480). 46 per cent of this variation in grain yield was accounted by weather parameters viz., evaporation, maximum temperature and sunshine hours. 72 per cent of variation in grain yield was attributed to climatological parameters viz., evaporation, maximum temperature, minimum temperature, number of rainy days, evening relative humidity and sunshine hours.

22. In Mundakan season only evaporation, maximum temperature and sun shine hours were found to have correlation with yield. The influence of maximum temperature on yield was negative and significant. Sunshine hours had a significant positive correlation with yield (0.4480). 46 per cent of this variation in grain yield was accounted by weather parameters viz., evaporation, maximum temperature and sunshine hours.

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* Originals not seen

Appendices

Appendix Ia

Weather parameters during the crop growth period at Vellayani-1998-1999

Month	Temperature (°C)		Relative humidity(%)		Wind speed (kmh⁻¹)	Total Rainfall (mm)	Evapo-ration (mm)	Sunshine (hrs)
	Max.	Min.	Morning	Evening				
May	32.85	25.09	87.55	69.87	4.00	214.00	4.13	6.50
June	31.75	25.46	95.68	79.83	4.00	484.10	3.71	3.89
July	29.68	24.19	88.16	74.06	5.39	105.70	3.33	4.94
Aug	29.92	23.77	89.42	73.48	4.65	139.30	3.43	4.85
Sept	29.53	25.55	93.03	75.77	3.53	260.60	3.54	4.39
Oct	29.65	23.04	90.29	77.03	3.55	427.60	2.90	5.09
Nov	29.88	23.21	93.63	72.53	3.50	356.00	2.97	5.03
Dec	30.87	22.20	91.84	73.65	3.13	142.40	2.40	4.39
Jan	31.15	21.24	91.90	71.00	3.00	5.20	3.15	7.57
Feb	34.67	25.14	104.76	75.18	4.11	85.80	4.14	9.71
Mar	32.56	23.68	90.23	65.84	3.74	56.00	4.15	8.85
Apl	31.37	24.90	91.57	75.27	5.03	147.20	3.87	6.51

Appendix Ib

Weather parameters during the crop growth period at Pattambii-1999-2000

Month	nperature (°C)		Relative humidity(%)		Wind speed (kmh⁻¹)	Total Rainfall (mm)	Evapo-ration (mm)	Sunshine (hrs)
	Max.	Min.	Morning	Evening				
May	31.10	23.80	92.00	70.00	3.70	467.20	3.90	5.10
June	29.80	23.10	94.00	73.00	3.50	658.00	3.50	4.90
July	28.90	22.80	94.00	79.00	4.00	708.10	2.70	2.30
Aug	29.90	23.30	92.00	70.00	4.20	150.60	3.70	5.60
Sept	31.70	23.30	92.00	60.00	3.70	39.80	4.80	6.80
Oct	30.80	23.50	92.00	68.00	2.10	278.30	3.10	4.60
Nov	31.60	22.20	87.00	56.00	3.50	42.70	3.90	7.90
Dec	32.20	21.40	79.00	44.00	6.80	0.80	5.10	8.70
Jan	33.70	21.90	75.00	36.00	7.50	0.00	4.90	8.90
Feb	34.10	21.70	84.00	40.00	4.20	9.50	6.40	8.10
Mar	36.10	23.30	85.00	39.00	4.30	0.00	6.10	8.40
Apl	34.70	24.80	87.00	53.00	5.00	56.40	5.50	6.90

Appendix IIa

Mean meteorological parameters prevailed during the total crop growth period at Vellayani (1998-1999)

Dates of transplanting	Temperature (°C)		Relative humidity(%)		Wind speed (kmh^{-1})	Total Rainfall (mm)	Evapo-ration (mm)	Sunshine (hrs)
	Max.	Min.	Morning	Evening				
June 1st	30.07	24.45	92.27	76.63	1.78	523.50	3.47	5.11
June 15th	30.05	24.35	92.03	76.30	1.56	512.91	3.55	4.94
June 30th	29.78	24.25	92.58	76.24	1.04	567.78	3.57	4.41
October1st	29.99	23.46	93.81	75.93	0.58	734.54	2.90	5.22
October 15th	30.22	23.26	94.14	76.77	0.47	620.54	2.79	6.23
October 30th	30.61	23.06	94.22	76.95	0.51	322.00	2.91	7.88
January 1st	31.63	22.80	94.41	71.47	0.29	139.06	3.64	8.83
January 15th	31.82	23.12	94.11	71.15	0.33	138.71	3.80	7.86
January 30th	31.95	23.72	93.13	68.86	0.67	149.83	4.03	6.06

Appendix IIb

Mean meteorological parameters prevailed during the total crop growth period at Pattambi (1999-2000)

Dates of transplanting	Temperature (°C)		Relative humidity(%)		Wind speed (kmh^{-1})	Total Rainfall (mm)	Evapo-ration (mm)	Sunshine (hrs)
	Max.	Min.	Morning	Evening				
June 1st	29.42	23.06	93.81	74.46	4.35	1504.30	3.01	4.23
June 15th	29.47	23.14	93.65	73.71	4.37	1286.55	3.12	4.35
June 30th	29.71	22.41	93.40	71.73	4.43	1061.57	3.32	4.76
October1st	31.61	22.60	88.16	56.71	3.57	260.21	3.71	7.01
October 15th	31.63	22.28	85.18	53.74	4.50	218.53	4.02	7.27
October 30th	32.00	22.16	82.73	49.91	5.84	149.13	4.62	7.68
January 1st	34.02	22.00	79.45	38.49	4.89	9.50	6.14	8.62
January 15th	33.83	21.82	79.21	38.18	5.27	9.50	6.13	8.52
January 30th	34.15	22.14	81.72	39.94	5.42	48.58	5.82	8.19

Appendix IIIa

Mean meteorological parameters prevailed during different growth phases at Vellayani -1998-1999

Dates of transplanting	Temperature (°C)		Relative humidity(%		Wind speed (kmh^{-1})	Total Rainfall (mm)	Evapo-ration (mm)	Sunshine (hrs)
	Max.	Min.	Morning	Evening				
Vegetative phase								
June 1st	30.65	24.63	92.77	77.43	0.20	107.20	3.57	5.60
June 15th	30.61	24.22	92.00	75.89	0.20	108.79	3.63	4.69
June 30th	29.96	24.06	91.88	77.56	0.20	104.16	3.47	3.24
October1st	29.44	23.82	93.63	78.93	0.33	94.47	3.15	6.53
October 15th	29.56	23.69	93.71	78.43	0.33	83.29	2.78	7.56
October 30th	29.87	23.46	92.75	75.38	0.40	84.58	3.15	8.79
January 1st	31.45	22.23	95.31	79.95	0.67	89.85	2.99	8.26
January 15th	31.16	22.11	94.89	74.32	0.80	95.13	3.17	6.69
January 30th	31.19	22.75	94.61	66.39	0.93	109.26	3.64	#REF!
Reproductive phase								
June 1st	29.68	24.12	91.13	76.40	3.07	102.80	3.43	4.92
June 15th	29.74	24.34	91.70	77.00	2.67	103.40	3.45	5.16
June 30th	29.54	24.61	92.77	76.10	2.20	100.70	3.36	4.16
October1st	29.81	23.25	93.17	74.23	0.47	89.00	2.97	4.29
October 15th	30.25	23.36	93.50	71.73	0.20	93.50	3.12	6.70
October 30th	30.70	23.36	94.30	74.03	0.47	79.70	2.66	7.82
January 1st	31.08	22.37	94.52	65.93	0.13	108.50	3.62	8.82
January 15th	31.66	22.91	94.72	69.50	0.07	118.70	3.96	8.24
January 30th	32.25	23.64	93.32	68.83	0.07	126.20	4.21	6.51
Ripening phase								
June 1st	29.89	24.59	92.90	76.07	2.07	143.10	3.41	4.81
June 15th	29.81	24.48	92.40	76.01	1.80	196.70	3.58	4.99
June 30th	29.83	24.07	93.10	75.05	0.73	228.90	3.87	5.83
October1st	30.73	23.30	94.63	74.63	0.93	0.00	2.59	4.83
October 15th	30.84	22.74	95.20	80.13	0.87	3.20	2.48	4.41
October 30th	31.26	22.37	95.60	81.43	0.67	3.20	2.93	7.03
January 1st	32.35	23.79	93.40	68.53	0.07	56.00	4.30	9.40
January 15th	32.63	24.35	92.73	69.63	0.13	56.00	4.26	8.63
January 30th	32.41	24.76	91.47	71.37	1.00	30.20	4.23	7.77

Appendix IIIb

Mean meteorological parameters prevailed during different growth phases at Pattambi -1999-2000

Dates of transplanting	Temperature (°C)		Relative humidity(%)		Wind speed (kmh^{-1})	Total Rainfall (mm)	Evapo-ration (mm)	Sunshine (hrs)
	Max.	Min.	Morning	Evening				
Vegetative phase								
June 1st	28.99	22.84	94.30	77.43	3.72	532.80	2.65	3.08
June 15th	28.39	22.74	94.50	80.20	4.16	638.50	2.25	1.68
June 30th	29.18	23.10	93.13	74.53	4.42	407.90	3.00	4.02
October1st	31.24	22.43	90.03	60.57	2.31	95.90	3.13	6.81
October 15th	31.98	22.08	84.73	51.57	4.29	29.20	3.37	8.23
October 30th	32.03	21.73	82.27	47.97	5.62	0.80	4.02	8.41
January 1st	34.35	21.13	79.17	34.70	5.23	0.00	6.12	9.09
January 15th	34.19	21.90	83.47	39.93	4.38	9.50	5.53	8.16
January 30th	34.97	22.59	84.03	38.73	4.43	9.50	5.96	8.35
Reproductive phase								
June 1st	29.54	23.10	94.31	73.92	3.51	657.80	2.93	4.43
June 15th	29.76	23.13	94.14	73.05	3.49	556.05	3.04	4.91
June 30th	29.27	22.93	94.49	76.23	3.56	624.07	2.61	3.71
October1st	31.52	23.50	91.84	60.92	2.90	162.91	4.18	5.89
October 15th	30.74	23.49	92.21	66.67	2.21	188.53	3.17	4.92
October 30th	31.03	22.67	90.68	62.00	3.36	148.33	3.02	6.12
January 1st	32.65	22.19	75.06	41.26	5.15	0.00	6.38	8.52
January 15th	33.63	21.69	74.40	35.80	7.35	0.00	6.60	9.03
January 30th	34.27	21.21	79.85	35.00	7.55	0.00	6.03	9.03
Ripening phase								
June 1st	29.72	23.22	92.83	72.03	5.81	313.70	3.43	5.18
June 15th	30.26	23.34	92.30	67.87	5.47	92.00	4.07	6.46
June 30th	30.67	23.18	92.57	64.43	5.31	29.60	4.35	6.55
October1st	32.05	21.87	82.60	48.63	5.51	1.40	3.80	8.32
October 15th	32.17	21.26	78.60	43.00	7.00	0.80	5.51	8.66
October 30th	32.93	22.08	75.23	39.77	8.54	0.00	6.82	8.51
January 1st	35.05	22.67	84.13	39.50	4.30	9.50	5.91	8.27
January 15th	33.66	21.86	79.77	38.80	4.09	0.00	6.25	8.37
January 30th	33.21	22.62	81.27	46.10	4.28	39.08	5.47	7.19

CROP WEATHER MODELLING IN RICE (*Oryza sativa*.L)

BY

SAJITHA RANI, T

ABSTRACT OF THE THESIS

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Faculty of Agriculture
Kerala Agricultural University

Department of Agronomy
COLLEGE OF AGRICULTURE
VELLAYANI - THIRUVANANTHAPURAM - 695 522

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Abstract

ABSTRACT

Rice is intimately involved in the culture as well as in the food ways and economy of Indians especially Keralites. The demand of rice is expected to increase by 70 per cent over the next 30 years, primarily due to rapid population growth and by 2010, the rice production has to be increased from the current level of 7.7 lakh tonnes to 21 lakh tonnes. To achieve this objective, the strategy should be to increase the total production. This can be accomplished by increasing the acreage under rice and by enhancing the productivity per unit area.

Climate plays an important role in rice production. Rice is vulnerable to change in weather and its cultivation continues to be a risky enterprise under unfavourable environment, despite advances made in rice production technologies. Within any season, long days and humid conditions with adequate rains or water supply help towards satisfactory vegetative growth of the rice plant while bright weather and short days with a diminishing supply of water favour the flowering phase. Cloudiness which leads to low light, extreme temperatures, variation in rainfall, and high relative humidity affect growth, yield attributes and productivity. To some extend rice has genetic potentiality to tolerate the adverse weather conditions and hence an appropriate cultivar may enable the farmer to avoid or lessen the problems from climatic stresses.

Two field experiments were conducted at College of Agriculture, Vellayani during 1998-1999 and at RARS, Pattambi during 1999-2000 to assess the performance of four high yielding rice varieties namely Kanchana, Jyothi, Matta Triveni, Kairali and one local variety Ptb-10 in three dates of planting in each season viz.,. 1st, 15th and 30th of June, October and January, to find out the best varieties and best dates of planting in each season. It was also aimed to develop the best fitting crop weather model using step wise regression.

In all seasons at both locations earlier dates of transplanting resulted in higher TDMP, more number of days to reach 50 per cent flowering and physiological maturity, higher grain yield and straw yield and higher harvest index. The nutrient uptake was also higher for earlier transplanting. The earlier transplanting also escaped from the severity of pests and diseases.

Kanchana, Kairali and Jyothi registered similar values for number of days taken to 50 per cent flowering, physiological maturity and number of filled grains per panicle during all seasons at Vellayani. In all seasons the nitrogen, phosphorus and potassium uptake by straw and grain were lower for local variety. Kanchana consistently out yielded other varieties followed by Kairali and the local variety Ptb-10 registered the lowest grain yield.

At Pattambi also during all seasons number of days taken to 50 per cent flowering and physiological maturity were similar for Kanchana, Kairali and Jyothi. In all seasons the nitrogen, phosphorus and potassium uptake by straw and grain were lower for local variety. Highest grain yield was registered by Kanchana followed by Kairali in all seasons except third season where it was on par with Kairali. The lowest grain yield was registered by local variety.

At both locations , all the high yielding varieties registered lower rice bug attack than local variety. Kairali and Kanchana were found resistant to sheath blight and gall midge

At both locations similar trend in growth and yield attributes, nutrient uptake and pest and disease incidence were observed in all the seasons. Result of this investigation revealed that early transplanting of rice and cultivation of high yielding varieties Kanchana would increase the productivity per unit area. Yield prediction equation with weather variables will act as a tool for improving the productivity of rice.

Grain yield data for a period of twenty five years (1960-1985) from a permanent manurial experiment at Regional Agricultural Research Station, Pattambi was subjected to correlation analysis to develop the best fitting crop weather model using step wise regression. In *virippu* season 72 per cent of the variation in yield was attributed to climatological parameters viz., evaporation, maximum temperature, minimum temperature, number of rainy days, evening relative humidity and sunshine hours. In *mundakan* season 46 per cent of variation in yield was accounted for the climatological parameters viz., evaporation, maximum temperature and sunshine hours