DIFFERENTIAL RESPONSE OF TWO MEDIUM DURATION RICE VARIETIES TO TIME OF PLANTING AND GRADED DOSES OF NITROGEN

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Differential response of two medium duration rice varieties to time of planting and graded doses of nitrogen" 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 any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara,
December, 1982.

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CERTIFICATE

Certified that this thesis entitled "Differential response of two medium duration rice varieties to time of planting and graded doses of nitrogen" is a record of research work done independently by Sri.P.H. LATIF under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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Introduction

INTRODUCTION

India which has the largest area under rice cultivation (38.6 million hectares) has the lowest yield per hectare (1.667 tonnes/ha). The need for achieving food self sufficiency has been repeatedly stressed ever since independence.

Rice is the most important food crop of Kerala occupying an area of 8.44 lakh hectares. Out of this 3.98 lakh hectares are cultivated during the 2nd crop season (mundakan). The average yield of rice in this season is generally higher than that of the Ist crop (viruppu). The scope of extending the area under rice in this state is very much limited. Therefore the only scope for increased production is to resort to intensive cultivation.

The yield of rice plant is governed by both genetic and environmental factors. Though photo insentive rice varieties can be grown through out the year irrespective of the season, their growth and yield very largely depending upon the various weather factors that prevail during the growing season.

A combination of temperature, photoperiod and light intensity however determines the growth period, crop performance and productivity.

A major part of the area in second crop (mundakan) season is double cropped land and the time of planting depends on the harvest of the first crop (virippu). The cropping period of the first crop varies subject to the vagaries of the south west monsoon. This will finally reflect on the planting time of the second crop season. Sometimes the farmers are forced to delay the planting time, which is found to reduce yield. The experimental evidence to show the influence of time of planting on growth and yield of rice is not adequate.

Responsiveness to nitrogen is one of the major factors contributing to differential capacities of rice varieties to give high grain yields. Sreedharan and George (1968) obtained yield response upto 160 kg N/ha with IR-8. Bathkal and Patil (1970) obtained yield response upto 200 kg N/ha with optimum level at 150 kg N/ha. But there is very little information regarding the effect of planting time on the response of dwarf indica varieties to nitrogen.

Nutrient absorption by rice is greatly influenced by temperature and other weather factors (Lin. 1976). Study of the uptake of nutrients in successive planting time as influenced by various weather factors will help in soil fertility management for rice. It may also help to recommend agronomic practices like nitrogen application for overcoming the ill effects of late planting.

The present investigation was therefore under taken with the following broad objectives in view.

1. To study the influence of time of transplanting on growth and yield of two medium duration high yielding varieties of rice, Jaya and Sabari.

2. To study the effect of planting time on the response of rice varieties to nitrogen.

3. To find out the optimum time of planting rice in mundakan season.

4. To ascertain whether the ill effects of late planting can be mitigated by nitrogen application.

Review of Literature

REVIEW OF LITERATURE

Even with the modern, photo insensitive, high yielding rice varieties the expression of full yield potential to a great extent is decided by the weather conditions that prevail during their growth period. The weather conditions during its growth period, greatly decide its response to added inputs (Tanaka *et al*., 1964; Mahapathra, 1969). As opined by Stansel (1966), the planting date has a dominant effect on both temperature and light conditions during which a crop is grown.

The literature available on the response of rice cultivars to different time of planting, levels of nitrogen, and their influence on growth characters and yield components are briefly reviewed in this chapter.

1. Response of rice varieties to time of planting.

1.1 Growth characters

The influence of time of planting on plant height has been reported by many workers. Tanaka *et al*. (1964) observed higher plant height during wet season than during dry season. Delay in transplanting from the normal time was found to decrease plant height (Majid and Ahmed, 1975). This effect of planting time on plant height is due to the variations inthe weather parameters during the growing period of the crop. Lin (1976) observed that high temperature during growing period resulted in dwarf plants with small leaves, whereas Kang and Hue (1976) noticed that lower temperature during nursery period resulted in higher plant height.

Tanaka et al. (1964) found that the tiller production was higher during rainy season than in dry season. But, Chatterjee et al. (1970) were of the opinion that the tillering period was shorter during the rainy season as compared to dry cool season. A low temperature during early growth stages was found to decrease tillering (Ghosh, 1961; Tanaka et al., 1968; and Samato, 1973). Vergara et al. (1970) observed that high temperature increased the tillering rate, but decreased the final number of tillers at harvest by shortening the tillering period. Lin (1976) reported that high temperature led to increased production of ineffective tillers.

1.2 Days to 50 per cent flowering

September plantings of rice cultivars CO-30 and Bhavani were observed to take the least number of days for flowering, compared to earlier plantings (Palaniswamy *et al.*, 1968 and Ramdoss and Subramanian, 1980). Majid and Ahmed (1975) noted a decrease in the number of days to flowering when planting was delayed beyond June 16th during kharif season. Faw and Johnson (1975) also found that delayed planting resulted in early flowering and the difference in flowering date by delay in planting time was less pronounced as the season progressed. Kang and Hue, (1976) also observed that earlier planting resulted in prolonged growing period and longer delay in earing.

Biswas *et al.* (1975) opined that sowing dates had significant effect on date of flowering as it affected the heat sum required for flowering. Hosoi (1976) observed that earing date of early maturing cultivars was more sensitive to temperature than that of late maturing cultivars, but the relative date of earing was not affected. Kang and Hue (1976) reported that duration from transplanting to earing increased with increase in average air temperature.

1.3 Days to maturity

Generally high temperature is reported to shorten the growing period of rice (Noguchi, 1960).

Mahapathra *et al.* (1973) reported that temperature summation for short and medium duration rice varieties varied from 3000°C to 3300°C and it was 3500°C for long duration varieties. Vergara *et al.*(1970) opined that minimum temperature had the best negative correlation with growth duration and this correlation was higher than that of temperature summation. According to Subbiah and Morachan (1979), the prevailing mean temperature in degrees centigrade at the vegetative phase significantly influenced the duration of the crop.

Lozano and Abruna (1977) found the number of days to harvest varied with the date of sowing. The crop sown in June took minimum number of days (81) whereas that sown in December took maximum number of days (117) to harvest.

1.4 Yield characters

1.4.1 Productive tillers

According to Halappa *et al.* (1974) and Ramdoss and Subramanian (1980) early planted crop produced more number of productive tillers than late planted crop.

The percentage of productive tillers was found to be lower in wet season than in dry season (Tanaka _et al._, 1964).

Matsushima and Tsunoda (1958) found the day temperature of 31°C and night temperature of 21°C were the optimum for increased production of panicles. Nel and Small (1969) reported that low night temperature increased ear number.

1.4.2 Length of panicle, spikelets/panicle and filled grains per panicle.

Mahapathra and Badekar (1968) reported July planting of medium duration rice cultivars resulted in lengthier panicle than the late sown crop. Ramdoss and Subramanian (1980) also got similar results. They also got more number of spikelets per panicle with early planting than late sown crop.

Murata and Togari (1972) observed that temperature was positively correlated with spikelet number. The solar radiation three weeks before and four weeks after heading was found to be strongly associated with spikelet production.

Variation in time of planting of rice is noted to bring about significant variation in the number of filled grains per panicle. Delayed planting significantly reduced the number of filled grains (Palaniswamy et al., 1968; Majid and Ahmed, 1975; and Nho et al., 1976). Delayed planting decreased the percentage of filled grains (Liou, 1975 and Nho et al., 1976). The spikelet sterility was minimum in early planted crop and increased with delayed planting (Majid and Ahmed, 1975; Faw and Johnson, 1975 and Ramdoss and Subramanian, 1980).

Nel and Small (1969) opined that low night temperature increased number of grains per panicle. Chen et al. (1974) reported that the day and night temperature of 30°C/20°C was optimum for the production of increased percentage of fully matured grains. They also found that reduced light intensity decreased percentage of filled grains.

Evans (1972) reported grain filling was very poor in the absence of light. Wada et al. (1973) observed that, under conditions of low light intensity, low air temperature decreased the fertility. On the other hand, there was no decrease in fertility of grains at low temperature when light intensity was not reduced.

1.4.3 1000 Grain weight

Delay in transplanting decreased 1000 grain weight (Liou, 1975; KAU, 1980; Annual Report, 1979/80). Ramdoss and Subramanian (1980b) were of the opinion that the test weight of grains being a general character was not influenced by different sowing dates.

Lower temperature in the range of 17^{o}C to 30^{o}C during ripening phase increased 1000 grain weight (Suzuki <u>et al</u>., 1966; Kanegava, <u>et al</u>., 1969; Nel and Small, 1969). Chen <u>et al</u>. (1974) were of the opinion that day and night temperatures of 25^{o}C and 20^{o}C respectively were found to be the optimum for increasing the 1000 grain weight.

Matsushima (1957) and Lenka (1969) observed a decrease in 1000 grain weight under reduced light conditions.

Thus, planting time has a significant influence on all the growth as well as yield characters. Generally, a delay in planting time negatively influences all the aforesaid characters.

1.5 Grain and straw yield

The growth rate and yield of rice is considerably affected by the time of planting.

Palaniswamy *et al*. (1968) found the yield of Japonica x Indica cultures were significantly reduced when planted beyond early October. But with CO-30 rice cultivar, the highest yield was obtained when it was sown during the later half of August. Sowing beyond September markedly decreased yield. September sowing of four rice cultivars Vijaya, Patna, Bala and Jayanthi gave maximum yield; October sowing had the minimum yield (Nanda *et al*., 1976). IR 20 gave similar results during samba season (Balasubramanian *et al*., 1978). But it was reported that high yielding medium duration varieties gave very good yield when sown in October. Early sowing decreased yield (KAU 1980, Annual Report, 1979-80).

During the kharif season, highest grain yield was obtained in June sown crop. Delayed sowing significantly reduced yield (Majid and Ahmed, 1975; Vasitha *et al*., 1970; Nho *et al*., 1976; Lozano and Abruna, 1977; Subbarayalu, 1978; KAU 1980, Annual Report 1979-80; Sarma *et al*., 1981).

Gopalakrishnan *et al*. (1975) obtained significant increase in grain yield when Co-36 was planted on July 28th than earlier or delayed plantings. Shahi *et al*. (1976); Shahi *et al*. (1977) Bhattacharya (1977) also got similar results. But Ramdoss and

and Subramanian (1980) obtained highest grain yield with July 1st planting of IR 20 and Bhavani. Bhavani was best suited for early planting and IR 20 for late planting.

The results of a monthly planting trial of 10 years duration conducted at IRRI, revealed that the best time of planting in the descending order of preference was January, February, December, March, November June, July, April, May, August, October and September (IRRI 1979, Annual Report 1978).

However, Mandal and Mahapathra (1968) could not get any significant difference in yield among the three monthly planting dates, June 16th, July 16th and August 16th with long duration varieties at CRRI, Cuttack.

Grain yield of rice is determined by the solar radiation at the reproductive phase (Moomaw et al., 1967; Hayashi, 1972; Sheik Davood et al., 1973; De Datta, 1973 Lerch, 1976). Mayr (1967) recorded a positive correlation of solar radiation at vegetative stage with grain yield. A high solar radiation accompanied by a low temperature during 25 days period before flowering was found to give the maximum grain yield at Los Banos (IRRI 1974, Annual Report 1973).

Lee (1971) also got similar results. High temperature and high light intensity seemed to interact with each other to decrease the photosynthetic rate (Yamada, 1955).

Tanaka and Vergara (1967) reported a negative correlation between rice yield and mean daily temperature at ripening phase. De Datta and Zarate (1970) observed high negative correlation between maximum air temperature at the early vegetative phase and grain yield of rice cultivar H4. Kel and Small (1969) noted that low light temperature increased yield while Papadakis (1970) reported high night temperature decreased yield. Lin (1976) was of opinion that high temperature during early stages of panicle formation reduced yield. Moranchan et al. (1974) obtained a positive correlation with relative temperature disparity factor and yield levels.

Ghildayal and Jana (1967) found that relative humidity (R.H) was negatively correlated with solar radiation and got an increase in yield with decrease in relative humidity, and increase in solar radiation. High relative humidity during post flowering stage appeared to have a detrimental effect on yield (CRRI, 1967). Ghosh (1970) observed a strong detrimental effect of the number of rainy days at the grain ripening phase.

Palaniswamy *et al*. (1968) obtained more straw yield with normal (Late September - early October) and late plantings (mid October) than early plantings. Nel and Small (1969) reported that low night temperature increased straw yield. Ramdoss and Subramanian (1980) got higher straw yield with delay in sowing. They observed that maximum temperature as well as sunshine had negative effect on straw yield, whereas a positive effect was obtained with minimum temperature.

1.6 Dry matter production grain straw ratio and harvest index.

Faw and Johnson (1975) found that late sowing reduced dry matter production. Lerch (1976) obtained highest dry matter production when IR-8 was sown on 10th January. Kang and Hue (1976) observed that lower temperature during nursery period of rice gave higher dry matter production. Lower average temperature and longer period of sunshine from transplanting to panicle initiation gave greater total dry weight. Average air temperature of 25°C resulted in rapid dry matter accumulation.

Tanaka *et al*. (1964); Yoshida and Ahn (1968) reported that the panicle straw ratio was lower during wet season, than in dry season, presumably due to the low contribution of assimilates stored before flowering to grain. Low light intensity at heading enhanced translocation of stored carbohydrate to grain giving a high grain straw ratio (Yoshida, 1972).

Hayashi (1967) observed a high harvest index with early cultivation in dry season than in wet season.

1.7 Grain protein content

Honsu (1971) suggested that weather conditions influenced grain protein content. Denium (1971) observed that high light inteisity exhausted N reserve and diminished the crude protein content, but increased the percentage of carbohydrate. Protein content was found to increase with high light intensity only at very high N levels.

De Datta et al. (1972) found that grain protein content was high in wet season and low in dry season.

Nanda et al. (1976) found that grain protein content was maximum with July sowing and minimum with September sowing. The total crude protein content was the highest for January-August crop. However, Stansel et al. (1965) recorded a high grain protein content and increased utilization of nitrogen in summer months.

1.8 Nutrient uptake

Moomaw and Vergara (1964) and Lin (1976) found that high air temperature at early stages decreased nutrient absorption and reduced vegetative growth. However, Chiu et al. (1961) were of the opinion that high temperature resulted in increased absorption of N, P and K.

2. Effect of rice varieties to nitrogen
2.1 Growth characters

The effect of nitrogen on growth characters is well recognised. Increase in height of plant with nitrogen application is reported by many workers (Kalyanikutty et al., 1969; Raju and Rao, 1969; Koyama et al., 1973 and Rego, 1973). However Eunus and Sadeque (1974) found plant height was unaffected by applied nitrogen.

Das Gupta (1969); Kalyanikutty (1969); Tanaka (1972) Rego (1973) observed an increase in tiller number per plant with addition of nitrogen.

2.2 Yield characters
2.2.1 Productive tillers

Chaudhary et al. (1969) observed a positive correlation between number of productive tillers and nitrogen levels in T (N) I and IR-8. Similar results were obtained by Pande and Singh (1970), Izhizuka (1971); Koyama et al. (1973); Nair et al. (1973) and Eunus and Sadeque (1974). Padmaja (1976) reported from pot culture studies that the percentage of productive tillers increased with increase in applied nitrogen upto 60 ppm.

2.2.2 Length of panicle and number of spikelets per panicle.

A positive correlation between the length of panicle and levels of nitrogen was observed by Chaudhary et al. (1969). Kalyanikutty et al. (1969) reported an increase in panicle length with addition of nitrogen under wider spacing.

Tanaka et al. (1964) observed a decrease in the number of spikelets per panicle with high nitrogen levels and mutual shading of leaves. Tanaka (1972) observed that with heavy nitrogen application even though many tiller and panicle primordia per unit land area are produced the number of spikelets per panicle would be less, since there were many sinks when compared to the capacity of the source.

2.2.3 Number of filled grains per panicle

Chaudhary et al. (1969) obtained a positive correlation between number of fertile grains per panicle and nitrogen levels in rice varieties T (N) 1 and IR 8. Similar results were obtained by Kalyanikutty et al. (1969); Pande and Singh (1970); Ishizuka (1971); Nair et al. (1973) and Koyama et al. (1973).

However, Saisoong et al. (1969) and Eunus and Sadeque (1974) failed to get an increase in number of filled grains per panicle with increased nitrogen levels.

Tanaka et al. (1964) observed decrease in percentage of filled grains with high nitrogen application. However Ota and Yamada (1965) observed that spikelet sterility did not increase much due to nitrogen application in high nitrogen responsive varieties, but was reported to increase upto 100 per cent in low nitrogen responsive varieties.

2.2.4 1000 Grain weight

Grain number per unit area was decided by the availability of carbo-hydrate and hence 1000 grain weight did not increase with nitrogen dressing. (Baba, 1961; Pande and Singh, 1970; Ishizuka, 1971; Koyama et al., 1973 and Eunus and Sadeque, 1974).

However Kalyanikutty et al. (1969) reported an increase in 1000 grain weight with addition of nitrogen. Padmaja (1976) also observed an increase in

1000 grain weight upto 20 ppm of added nitrogen, in pot culture studies.

Generally application of nitrogen is found to influence both growth and yield characters positively.

2.3 Grain yield and straw yield

Increase in grain yield with nitrogen application is an established fact.

Kumara and Takeda (1962) observed that under low levels of nitrogen, grain yield increased remarkably with increments of nitrogen, though the rate of increase in yield diminished as the nitrogen supply increased. Similar results were obtained by Toth and Tothne (1976), Sharma et al. (1976) and Singh et al. (1977).

The yield response of rice to nitrogen is found to vary with cultivars.

Chiu et al. (1965) observed yield response upto 120 kg N/ha with Japonica varieties. Chandler et al. (1966); and Kurup and Sreedharan (1971) got yield response upto 105 kg N/ha with dwarf medium varieties. Yield response upto 160 kg N/ha was obtained with rice cultivar IR 8 (Sreedharan and George, 1968), Similar results were obtained by Kalyanikutty et al. (1969);

Mahatim Singh and Singh (1972); Kadrekar and Mehta (1975), Varma et al.(1975) Lerch (1976) and Singh et al.(1977). Taichung (Native) 1 was found to respond upto 200 kg N/ha with optimum level of 150 kg N/ha. (Bathkal and Patil 1970 and Rego, 1973). Raghavan Pillai and George (1973) and Pillai et al. (1975) obtained yield response only upto 80 kg N/ha with short duration Indica varieties.

Lal et al. (1973) obtained yield response upto 120 kg N with cultivars IR 8 and Padma. Similar results were obtained by Varma (1973) with cultivar Jaya and Gopalakrishnan et al. (1975) with cultivar CO-36.

Khatua et al. (1975) concluded that yield response of the same cultivar varied with soil types. Jaya responded upto 120 kg N/ha in alluvial soil types whereas it was 60 kg in laterite and 120 kg N/ha in red soils.

Osada (1967) found the grain yield in rice under high N fertilization is often determined by percentage of ripened grains. Sanchez et al. (1973) opined that increase in yield due to N application was primarily a function of effective tillers and panicle size. Migel et al. (1978) found that yield of rice depended on the proportion and the rate of N and P fertilisers. Optimum rate was found to be 4N + 4P + 2K.

However, heavy application of nitrogen beyond an optimum level is noted to induce a negative response (IRRI 1963; Tanaka et al., 1966 and Padmaja, 1976).

Das Gupta (1969) obtained increased dry matter production by nitrogen fertilizer with two varieties of swamp rice. Similar results were obtained by Varma (1972), Beye (1977), Haque (1977) and Chinnaswamy and Chandrasekharan (1977).

Murayama et al. (1955) observed that with low nitrogen level, the starch which accumulated in the straw before heading provided as much as 40 per cent of the total starch in grain, but with high nitrogen level, it provided less than 10 per cent, tending to decrease the grain straw ratio. Similar results were obtained by Tanaka et al. (1964); Osado (1967) and Yoshida (1972). However, Sanchez et al. (1973) could get an increase in grain straw ratio with high levels of nitrogen.

Response to applied nitrogen varied with planting time. The optimum nitrogen level for rice was reported to be far higher in dry season that in wet season.

2.4 Nutrient uptake

Sadanandan et al. (1969) reported that nitrogen uptake was rapid to start with and the rise was marked during the flowering phase. The nitrogen per cent in the plant decreased with growth. The uptake of nitrogen increased with nitrogen application and the nutrient per cent increased while the uptake increased. Maximum utilization of nitrogen occurs during tillering and flowering phase. Uptake of N and P, N and K were significantly correlated. Thirunavukkarasu, et al. (1978) observed that Nitrogen content in plant increased after each split application. There was a general drop at around 67 days after transplanting. Muthuswamy (1973) observed a very high degree of relationship between nitrogen, phosphorus and potassium uptake at flowering and final yield.

Varma (1972) and Khan and Pathak (1976) observed that nitrogen content in grain and straw increased with increasing nitrogen rates. But Khan and Pathak (1976) noted a negative response with higher levels of nitrogen. Varma (1972) noticed that percentage of nitrogen translocated to the grain decreased with increasing nitrogen levels. Also, nitrogen translocation to the grain was found to decrease with increasing phosphorus rates.

However, Loganathan and Raj (1972) found that nitrogen uptake was not affected by variation in dosage of nitrogen supplied to soil even with 160 kg N/ha. Also Bredero (1965) observed that nitrogen was absorbed independently of the pattern and rate of nitrogen application provided sufficient soil nitrogen was available for uptake.

Kanwar and Sehgal (1962) Bredero (1965), Ramanujam (1967) Sadayappan and Kolandai Swamy (1978) reported that phosphorus and potassium uptake was determined by nitrogen uptake. Sadanandan et al. (1969) found phosphorus uptake was found to be significantly correlated with nitrogen uptake and with potassium uptake. Varma (1972) observed that percentage of phosphorus translocation to the grain decreased with increasing nitrogen levels. Sadayappan and Kolandaiswamy (1978) reported that phosphorus content of grain increased steadily with nitrogen levels. However, Loganathan and Raj (1972) found that nitrogen had little effect on phosphorus and potassium absorption by paddy straw; and phosphorus absorption by grain.

Thus it is seen that nitrogen uptake by plant is independent of P & K uptake but uptake of P and K is dependent on nitrogen uptake.

2.5 Grain protein content

Increase in grain protein content with increasing levels of nitrogen have been reported by many workers (Kadrekar and Mehta 1975; Kothandaraman, 1975; Pisharody et al. 1976; Ravindra et al. 1977 and Sadayappan and Kolandaswamy, 1978). Kadrekar and Mehta (1975) observed linear increase in protein content with increased levels of nitrogen in cultivar IR-8, while they observed a negative response to higher levels of nitrogen in cultivar Patni 6.

However Muthuswamy et al. (1973) could not get any increase in protein content by different levels of nitrogen ranging from 0 - 160 kg/ha, in high yielding cultivars viz. Karuna, Kanchi and Cauvery grown in Tamil Nadu.

It has been reported that an increase in protein content beyond a certain level of nitrogen was generally accompanied by a decrease in the grain yield (IRRI 1974, Annual Report 1973).

Materials and Methods

MATERIALS AND METHODS

The present investigation was undertaken to study the differential response of two medium duration rice varieties, Jaya and Sabari, to four different time of planting and three levels of nitrogen, during the mundakan season.

1. Materials

1.1 Site, climate and soil

Site

The experiment was conducted at the Research Station and Instructional Farm, Mannuthy, Trichur. The farm is situated at 12° 32' north latitude and 74° 20' east longitude at an altitude of 22.25 meters above mean sea level.

Climate

This area enjoys a typical humid climate. The details of the meteorological data during the cropping period are presented in appendix 1 and figure 1

Soil

The soil of the experimental area was moderately well drained medium clay loam the chemical characteristics of which are presented in Table 1.

Fig. 1 Weather data during the cropping period of the experiment presented as daily average per week.

Table 1 Analysis of soil before the start of the experiment

	Content in soil %	Method used
Total nitrogen	0.098	Microkjeldahl method
Available P_2O_5	0.0032	In Bray-I extract, chlorostanous - reduced molybdophophoric acid blue colour method
Available K_2O	0.008	In neutral normal ammonium acetate extract - flame photometric
Total P_2O_5	0.0624	In HC1 extract chlorostanous - reduced molybdophosphoric blue colour method in hydrochloric acid system
Total K_2O	0.3861	In HC1 extract - flame photometric
pH	5.2	1:2.5 soil solution ratio, using a pH meter

Cropping history

The experimental field was double cropped wet land where high yielding varieties were grown continuously for the last five years on recommended fertilizer doses.

1.2 Season

The experiment was conducted during the mundakan season of 1980-81. The cropping period extended from

1st of September 1980 to 24th of February 1981.

1.3 Varieties

The varieties used for the experiment were Jaya, a high yielding dwarf medium duration variety evolved by hybridisation (T(N) x T 141) and selection at AICRIP, Hyderabad - and Sabari, a high yielding dwarf indica variety evolved by hybridization and (IR-8 x Annapoorna) selection at Rice Research Station, Pattambi. Jaya has white, long bold grain and Sabari has red, long bold grain. Jaya has a duration of 120 to 125 days and Sabari 100 to 135 days and both the varieties have very high yield potentials. The seeds were obtained from Research Station and Instructional Farm, Mannuthy.

1.4 Manures and fertilizers

Farm yard manure at the rate 5000 kg/ha was applied uniformly as basal dressing. It was of following composition.

N 0.41 per cent; P 0.23 per cent and K 0.39 per cent. Besides this lime at the rate of 600 kg/ha was applied uniformly.

Fertilizers with the following analyses were used for the experiment.

Ammonium sulphate	20.5 per cent N
Super phosphate	16 per cent P_2O_5
Muriate of potash	60 per cent K_2O

2. Methods

2.1 Design and layout

The experiment was laid out in split plot design.

Details of treatments

The treatments consisted of combination of four dates of planting and two varieties in the whole plot and three levels of nitrogen in the sub plot.

Whole plot treatments

a) Time of planting	Abbreviation (T)
1. September 25th	T_1
2. October 10th	T_2
3. October 25th	T_3
4. November 9th	T_4

Varieties	(V)
1. Jaya	V_1
2. Sabari	V_2

<u>Sub plot</u>

Nitrogen levels	(N)
1. 60 kg N/ha	n_1
2. 90 kg N/ha	n_2
3. 120 kg N/ha	n_3

The procedure followed for the allocation of various treatments to different plots was in accordance with random number table. The layout plan is shown in Fig.1. The details of layout are furnished below.

Number of blocks	3
Number of treatments/block	24
Total experimental area	0.22 hectare
Gross plot size	6 x 5 m^2
Spacing	20 cm x 10 cm
Border rows	2
Net plot size	5.2 x 4.6 m^2

2.2 Nursery

The seedlings for each time of planting were raised separately. The nursery area was thoroughly ploughed and puddled, and sprouted seeds of Jaya and Sabari were sown on well prepared seed beds. The first sowing was on 1st of September and subsequent sowings were done on 16th September, 1st October and 16th October.

Fig. 2 Layout plan of the experiment in split plot design.

2.3 Field culture

2.3.1 Preparation of main field

The field was thoroughly ploughed and puddled using a power tiller and levelled.

Farm yard manure at the rate of 5000 kg/ha was applied and uniformly spread, 10 days before the field preparation. Lime was applied at the rate of 350 kg/ha at final ploughing. Standing water was allowed in the field and the field was drained the following day.

The experimental plot was laid out into blocks with whole plots and sub plots.

2.3.2 Manuring

Half the dose of nitrogen and potash and full dose of phosphorus were applied as basal dressing. The fertilizers were incorporated into the corresponding plots and the field was levelled. Phosphorus and potassium were applied as per Package of Practices Recommendations at the rate of 45 kg/ha each. Nitrogen at 60 kg, 90 kg and 120 kg/ha was applied to the sub plots corresponding to n_1, n_2 and n_3 levels. One fourth of nitrogen was applied as top dressing 25 days after planting, and the balance one fourth of nitrogen and half of potassium 45 days after planting. The field was drained one day before top dressing and reflooded in the evening after fertilizer application.

2.3.3 Transplanting

The plots were drained and 25 day old seedlings were transplanted at a spacing of 20 cm x 10 cm with two seedlings/hill at a depth of about 3 cm in 1.5 cm of standing water. In the case of delayed planting the concerned plots were puddled and levelled again, before planting to avoid the hardening of the soil.

2.3.4 After cultivation

Gap filling was done with seedlings of same age, one week after planting. The water level in the field was subsequently raised to 5 cm and was maintained upto ten days before harvest. Hand weeding was done on 25th day and 45th day after planting prior to top dressing of fertilizers.

2.3.5 Plant protection

The crop was sprayed with Ekalux in the vegetative phase to control stemborers, leaf minors and leaf rollers. BHC 10 per cent, was dusted to control rice bug at the grain filling stage.

2.3.6 Harvesting

When more than 85 per cent of the panicles in each plot matured harvesting was done.

3. Observations recorded

The following observations were recorded.

3.1 Growth characters

1. Plant height.
2. Number of tillers.
3. Number of days to 50 per cent flowering.
4. Number of days to maturity.

3.2 Observations at harvest

1. Productive tillers
2. Percentage of productive tillers
3. Length of panicle
4. Total number of spikelets (flowers)/panicle
5. Number of filled grains per panicle
6. Percentage of filled grains
7. Thousand grain weight
8. Grain yield
9. Straw yield
10. Dry matter production
11. Harvest index
12. Grain straw ratio

3.3 Plant analysis

Plant components were analysed for the following nutrients on 30th and 60th days after planting and at harvest.

3.3.1 Nitrogen content in plant parts

1. Percentage of nitrogen in grain
2. Percentage of nitrogen in straw

3.3.2 Phosphorus content in plant parts

1. Percentage of phosphorus in grain
2. Percentage of phosphorus in straw

3.3.3 Potassium content in plant parts

1. Percentage of phosphorus in grain
2. Percentage of phosphorus in straw

3.3.4 Uptake of nitrogen by plant parts

1. Uptake of nitrogen by grain
2. Uptake of nitrogen by straw
3. Total uptake of nitrogen by the plant

3.3.5 Uptake of phosphorus by plant parts

1. Uptake of phosphorus by grain
2. Uptake of phosphorus by straw
3. Total uptake of phosphorus by plant

3.3.6 Uptake of potassium by plant parts

1. Uptake of potassium by grain
2. Uptake of potassium by straw
3. Total uptake of phosphorus by plant

3.3.7 Quality characters

1. Protein content of grain

4. Sampling procedure

Observations on the growth characters, height, number of tillers per hill and productive tillers were taken from 15 plants included in a sampling unit of 50 cm x 50 cm. For chemical analysis, a sampling unit of 1 x 0.8 m^2 was earmarked in one side of the plot eliminating the border rows. Four plants, at a stretch were uprooted at the 30th and 60th day after planting and at harvest. After each sampling, one row was left on all sides as border. These plants were used for determining the dry matter production and for chemical analysis at the above three stages.

For panicle length, number of spikelets and number of filled grains, the average of the middle panicles of all the hills in the sampling unit was worked out.

5. Details of observation procedure

5.1 Height of plants

Height of the plants was measured from ground level to the tip of the topmost leaf until flowering and to the tip of the panicle at harvest.

5.2 Tillers/hill

Tillers of all the hills in the sampling unit were counted and average worked out.

5.3 Days to 50 per cent flowering

Days to 50 per cent flowering was taken as the day when 50 per cent of the spikelets in the 1st panicle of all the hill in the sample unit completed flowering.

5.4 Days to maturity

Days to maturity was taken as days from sowing to harvest.

5.5 Productive tillers/hill and productive tillers/m^2

Total number of panicle bearing tillers in all the hills in the sampling unit were counted and the mean number calculated for one hill. This mean number multiplied by 50 gave productive tillers/m^2.

5.6 Percentage of productive tillers

Percentage of mean number of productive tillers to mean number of tillers at maximum tillering stage was worked out.

5.7 Length of panicle

Length of panicle was measured from the neck to the tip of the middle panicles of all the hills in two sampling units and mean length was obtained by averaging all the observations recorded treatmentwise.

5.8 Number of spikelets per panicle and number of filled grains/panicle

After measuring the length of panicle, the total number of spikelets and number of filled grains were counted separately and average worked out.

5.9 Thousand grain weight

Thousand grains of each treatment were counted separately and weighed.

5.10 Dry weight

Four sample plants were uprooted each at 30 day after planting, 60 days after planting and at harvest and were dried in a hot air oven at a temperature of 70°C for three days and the dry weight was recorded. At harvest, the panicle were separated from the sample plants and dry weight of straw and panicle were recorded separately. The total dry weight at harvest was obtained by adding straw and panicle weight.

5.11 Grain yield and straw yield

Plotwise final grain yield was taken after cleaning and drying in the sun for three to four days and per hectare yields were computed after deducting the area under destructive sampling.

Plotwise straw weight was recorded after complete drying and per hectare yields were computed as in the case of grain yield.

5.12 Harvest index

This is the percentage of grain weight to total plant weight and was calculated from grain and straw weight.

6. Chemical analysis

Plant samples collected at 30th day and 60th days after planting and at harvest were used for chemical analysis.

6.1 Total nitrogen content

Total nitrogen content was estimated by modified microkjeldahl method as given by Jackson (1967).

6.2 Uptake of nitrogen

This was calculated from the nitrogen content of the plant and the total dry weight of the sample plants for the three stages of growth. At harvest the uptake by straw and grain were added to get the total uptake. The uptake values were presented in kg/ha.

6.3 Total phosphorus content

Phosphorus content was estimated colorimetrically (Jackson, 1967) after wet digestion of the samples using 2:1 mixture of nitric acid and perchloric acid and developing the colour by the Vanadomolybdo phosphorus yellow colour method and read in a Perkin Elmer Spectrophotometer at 470 nm.

6.4 Uptake of phosphorus

This was estimated from the phosphorus content and the dry weight of the sample plants. At harvest the uptake by straw and grain were added to get the total uptake.

6.5 Total potassium content

Total potassium content in plant was estimated by flame photometric method after wet digestion of the samples using diacid mixture.

6.6 Uptake of potassium

This was calculated from the potassium content and the dry weight of the components. Uptake by grain and straw were added to get the total uptake at harvest.

6.7 Protein content

The percentage of protein was calculated from the percentage of nitrogen using the factor 5.95.

7. Statistical analysis

Data on yield, yield attributes, growth characters and those on chemical analysis were analysed by employing the technique of analysis of variance for split plot as suggested by Panse and Sukhatme (1967).

Results

RESULTS

The results of the present study on the differential response of two medium duration rice varieties, Jaya and Sabari, to time of planting and graded doses of nitrogen are furnished below.

1. Effect of time of planting, varieties and levels of nitrogen on growth characters

1.1 Height of plants

The observations on height of plants on 30th and 60th days after planting and at harvest were taken and analysed separately and presented in Table 2 and the analysis of variance in Appendix II.

It is evident from the Table that the mean plant height was significantly influenced by the different time of planting at all stages of growth. Early planting (T_1) recorded significantly higher plant height at all stages of crop growth over other dates of planting. The plant height showed a decreasing trend with delay in planting, the last planting (T_4) recording the least plant height at 30th day after planting and at harvest. At 60th day after planting, crop planted on 10th October recorded the lowest plant

Table 2 Effect of time of planting, varieties and levels of nitrogen on plant height at different stages of growth

Treatments	Height in cm		
	30th day	60th day	At harvest
Time of planting (T)			
T_1	52.23	72.73	78.11
T_2	46.67	59.96	72.74
T_3	45.98	62.23	69.05
T_4	43.83	64.65	67.03
F Test	Sig.	Sig.	Sig.
C D at 5%	4.21	4.14	2.75
S E m	-	-	-
Varieties (V)			
(V_1) Jaya	48.65	65.99	71.11
(V_2) Sabari	45.70	63.79	72.31
F Test	N.S.	N.S.	N.S.
C D at 5%	-	-	-
S E m	0.98	0.97	0.64
Nitrogen levels (N)			
N_1 (60 kg)	47.04	64.73	71.69
N_2 (90 kg)	46.23	64.25	71.89
N_3 (120 kg)	48.27	65.70	72.29
F Test	N.S.	N.S.	N.S.
C.D at 5%	-	-	-
S E m	0.64	0.61	0.62

height and thereafter showed a steady increase with delay in planting. At 30th day after planting, the plant height in the later plantings (T_2, T_3 and T_4) did not differ significantly. The plant height of the crop planted on 9th November (T_4) was significantly superior to that planted on 10th October (T_2) at 60th day after planting. But the crop planted on October 10th and October 25th (T_2 and T_3) and that planted on October 25th and November 9th (T_3 and T_4) did not differ significantly in plant height. At harvest, the plant height was observed to decrease progressively with delay in planting. Plant height in October 10th planting (T_2) was found to be significantly higher to that of the late plantings (T_3 and T_4). The plant height in late plantings (T_3 and T_4) were on par.

The varieties did not differ significantly in plant height in any of the stages of crop growth. But Jaya had higher plant height at 30th day and 60th day after planting. But at harvest Sabari recorded more plant height than Jaya.

The nitrogen levels also did not influence plant height significantly in any of the stages of growth, though, 120 kg N/ha (n_3) recorded slightly higher plant height in all stages of growth. The

Table 2(a) Combined effect of varieties and nitrogen levels on height of plants.

Varieties	Nitrogen levels			Mean
	N_1	N_2	N_3	
V_1	66.82	65.61	65.53	65.99
V_2	62.62	62.89	65.87	63.79
Mean	64.72	64.25	65.70	

C D at 5% = 2.475

interaction between variety and nitrogen levels significantly influenced plant height at 60th day after planting (Table 2 a). Jaya at 60 kg N/ha recorded the highest plant height. Plant height of Jaya showed a decreasing trend with higher levels of nitrogen, while in Sabari the plant height showed an increasing tendency with increasing levels of nitrogen. Plant height of Jaya at 60 kg N/ha was significantly superior to the height of Sabari both at 60 kg N/ha and 90 kg N/ha. None of the other interactions were significant.

1.2 Number of tillers per hill

The observations on number of tillers per hill on 30th, 60th day after planting and at harvest were recorded and analysed separately and the results are presented in Table 3 and Fig.4c The analysis of variance tables are given in Appendix III.

The time of planting significantly influenced the number of tillers produced at all stages of crop growth. The number of tillers per hill were highest at 60th day after planting and thereafter it declined at harvest. The late planting (T_3) recorded significantly higher number of tillers per hill at all

Table 3 Effect of time of planting, varieties and levels of nitrogen on tiller production at various stages of growth

Treatments	Mean number of tillers/hill		
	30th day after planting	60th day after planting	At harvest
Time of planting (T)			
T_1	6.63	7.52	7.43
T_2	7.19	8.87	6.85
T_3	10.80	10.75	9.84
T_4	8.94	9.53	8.33
F Test	Sig	Sig	Sig
C D at 5%	1.21	1.22	1.22
S E m	-	-	-
Varieties (V)			
(V_1) Jaya	8.17	8.46	7.74
(V_2) Sabari	8.61	9.87	8.48
F Test	N.S.	Sig.	N.S.
C D at 5%	-	0.865	-
S E m	0.282	-	0.284
Nitrogen levels (N)			
N_1 (60 kg)	8.32	9.08	7.87
N_2 (90 kg)	8.50	9.27	8.30
N_3 (120 kg)	8.35	9.15	8.17
F Test	N.S.	N.S.	N.S.
C D at 5%	-	-	-
S E m	0.246	0.225	0.204

stages of growth over other planting dates. Thirty days after planting, the late planting (T_4) was significantly superior to the early plantings (T_1 and T_2) which were on par. At 60th day after planting the crop planted on 9th November and 10th October (T_4 and T_2) produced significantly higher number of tillers per hill than the crop planted on 25th September (T_1). Crops planted on 9th November and 10th October were on par. At harvest, the crop planted on 9th November (T_4) was significantly superior to that planted on 10th October, but the early plantings (T_2 and T_1) were on par.

The varieties did not differ significantly in the number of tillers produced per hill at 30th day after planting and at harvest. The number of tillers per hill were markedly higher in Sabari at 60th day after planting. Sabari had slightly higher number of tillers than Jaya at all stages of growth.

The nitrogen levels were not effective in increasing the number of tillers per hill in any of the stages of crop growth, but 90 kg N/ha (n_2) recorded slightly higher number of tillers than 60 kg N/ha (n_1) per hill at all stages of crop growth. The interaction between time of planting, variety and nitrogen had significantly influenced the tiller production at harvest.

1.3 Days to 50 per cent flowering

The observations on the number of days to 50 per cent flowering were taken and analysed and the results are presented in Table 4, Fig. 3 and Appendix II.

The time of planting significantly affected the number of days to 50 per cent flowering. The early planted crop (T_1) took the least number of days to flower whereas the late planted crop (T_3) recorded largest number of days to flower, the difference being 17 days. The number of days taken for flowering increased markedly with delay in planting, the increase being in the order T_1, T_2, T_4 and T_3, and all were significantly different.

The varieties differed significantly in the number of days taken for flowering, Sabari took significantly higher number of days to flower than Jaya. The interaction effect of time of planting and variety significantly influenced the number of days to flowering (Table 4a). The late planting of Sabari (T_3)

Table 4 Effect of time of planting, varieties and levels of nitrogen on number of days to 50% flowering and maturity.

Treatments	Mean number of days	
	Flowering	Maturity
Time of planting (T)		
T_1	85.11	124.06
T_2	91.57	125.56
T_3	102.44	132.39
T_4	98.39	130.28
F Test	Sig	Sig
C D at 5%	0.62	0.51
S E m	-	-
Varieties		
(V_1) Jaya	90.69	124.64
(V_2) Sabari	98.06	131.50
F Test	Sig	Sig.
C D at 5%	0.43	0.34
S E m	-	-
Nitrogen levels (N)		
N_1 (60 kg)	94.25	128.04
N_2 (90 kg)	94.20	128.08
N_3 (120 kg)	94.67	128.08
F Test	N.S.	N.S.
C D at 5%	-	-
S E m	0.17	0.12

TABLE 4 (a)

Combined effect of time of planting and varieties on number of days to flowering

Varieties	Time of planting				Mean
	T1	T2	T3	T4	
V_1	80.65	90.67	98.66	92.39	90.57
V_2	89.57	92.44	106.22	103.88	98.05
Mean	85.11	91.55	102.44	98.13	94.31

CD at 5% - 0.88
SEm. - 0.28

Fig. 3 Influence of time of planting on, number of days to 50 per cent flowering and number of days to maturity.

took the longest period for flowering, followed by T_4 .

The nitrogen levels had no effect on flowering time. But the interaction affect of the time of planting, variety and nitrogen levels significantly influenced the days to 50 per cent flowering. None of the other interactions were found to affect the number of days to flowering.

1.4 Days to maturity

The observation on the number of days to maturity was recorded and analysed and the analysis of variance table are presented in Appendix II. The mean number of days to harvest corresponding to different treatment are presented in Table 4 and Fig. 3

It is evident from the table that time of planting significantly affected the number of days to maturity. Late planted crop (T_3) took the longest duration whereas the early planted crop (T_1) had the shortest duration. The duration of the crop increased progressively with delay in planting, but the late planting (T_3) took more number of days than the last planting (T_4).

The varieties significantly differed in their duration. Sabari took more number of days to mature

Table 4 (b) Combined effect of time of planting and varieties on number of days to maturity.

Varieties	Time of planting				Mean
	T_1	T_2	T_3	T_4	
V_1	120.33	120.44	130.33	127.44	124.63
V_2	127.77	130.44	134.44	133.11	131.44
Mean	124.05	125.44	132.38	130.27	

C D at 5% = 0.729

S E m = 0.24

than Jaya. The time of planting and variety interaction significantly influenced the duration of the crop (Table 4b). The duration of both Jaya and Sabari increased with delay in planting. But the late planted crop (T_4) had slightly shorter duration. Jaya and Sabari had the longest duration in 25th October planting (T_3). Duration of Sabari differed significantly in all the time of planting whereas duration of Jaya did not differ significantly in the early plantings (T_1 and T_2).

The nitrogen levels were not effective in influencing the duration of the crop.

2. Yield and yield attributes

2.1 Productive tillers

Observations on the number of productive tillers at harvest were taken and analysed and the analysis of variance is given in Appendix III. The mean number of productive tillers corresponding to the different treatments are given in Table 5 and Fig. 4c

It is evident from the table, that number of productive tillers per m^2 is significantly influenced by the time of planting. Number of productive tillers per m^2 showed an increasing trend with delay

Table 5 Effect of time of planting, varieties and levels of nitrogen on productive tillers, percentage of productive tillers, total number of spikelets, total number of filled grains and percentage of filled grains.

Treatments	Mean values				
	Productive tillers/ m2	%age productive tillers	Total spikelets	Filled grain	%age of filled grains
Time of planting (T)					
T_1	314.61	81.02	108.84	83.08	76.75
T_2	318.44	71.92	110.87	82.39	74.26
T_3	416.39	75.33	83.66	58.83	70.82
T_4	374.72	77.62	82.70	56.53	68.73
F Test	Sig.	N.S.	Sig.	Sig.	Sig.
C D at 5%	38.32	-	8.776	6.93	4.91
S E m	-	2.5	-	-	-
Varieties (V)					
(V_1) Jaya	340.14	77.71	97.78	70.96	72.44
(V_2) Sabari	371.94	75.24	95.56	69.45	72.83
F Test	Sig.	N.S.	N.S.	N.S.	N.S.
C.D. at 5%	27.10	-	-	-	-
S E m	-	1.77	2.046	1.615	1.14
Nitrogen levels (N)					
N_1 (60 kg)	344.17	75.38	90.32	66.27	73.66
N_2 (90 kg)	370.42	78.31	96.78	71.10	73.39
N_3 (120 kg)	353.54	75.72	102.46	73.25	70.96
F Test	N.S.	N.S.	Sig.	N.S.	N.S.
C D at 5%	-	-	10.78	-	-
S E m	9.33	1.46	-	2.75	1.49

in planting time but for a slight decrease in number of productive tillers observed in the late planted crop (T_4). The late planted crops (T_3 and T_4) recorded significantly higher number of panicles per m^2 than early planted crops (T_1 and T_2). The crop planted on 25th October (T_3) was significantly superior to that planted on all other dates and the 9th November planted crop (T_4) recorded significantly higher number of productive tillers compared to the early planted crops (T_2 and T_1). Though early planted crops (T_1 and T_2) were on par, T_2 recorded higher number of panicles than T_1.

The varieties differed significantly in the number of productive tillers. Sabari recorded significantly higher number of panicles than Jaya. The nitrogen levels did not significantly influence the number of productive tillers produced. But 90 kg N/ha (n_2) recorded higher number of panicles compared to 60 kg N/ha (n_1) and 120 kg N/ha (n_3). However, the time of planting, variety and nitrogen interaction was found to significantly influence the production of effective tillers.

2.2 Percentage of productive tillers

Observations on the percentage of productive tillers at harvest were taken and analysed and the analysis of variance tables are presented in Appendix III. The mean percentage of productive tillers corresponding to the different treatments are given in Table 5.

It is evident from the table that the time of planting did not significantly affect the percentage of productive tillers. The earliest planting (T_1) recorded the highest percentage of productive tillers. But 10th October planting (T_2) had the lowest percentage of productive tillers and there after showed an increasing trend with delay in planting time.

The varieties did not differ significantly in the percentage of productive tillers. But Jaya had higher percentage of productive tillers than Sabari.

The nitrogen levels had no influence on the percentage of productive tillers. But 90 kg N/ha (n_2) had higher percentage of productive tillers than 60 kg N/ha (n_1) and 120 kg N/ha (n_3).

2.3 Total number of spikelets (flowers) per panicle

The observations on the total number of spikelets were taken at harvest and analysed and the analysis of variance is given in Appendix IV. The mean number of total spikelets corresponding to the different treatments is given in Table 5 and Fig. 4.

The table clearly indicates that the total number of spikelets were significantly influenced by the time of planting. The early planted crops (T_1 and T_2) recorded the highest number of spikelets per panicle than the late planted crop (T_3 and T_4). The October 16th planting (T_2) had the highest number of spikelets per panicle and it was significantly higher than the late plantings (T_3 and T_4). The earliest planting (T_1) was also significantly superior to the late planting (T_3 and T_4). But the early plantings (T_1 and T_2) did not differ significantly in total number of spikelets. The late plantings (T_3 and T_4) were found to be on par.

The varieties did not differ significantly on the total number of spikelets produced, but Jaya had slightly higher number of spikelets per panicle than Sabari.

The nitrogen levels significantly influenced the total number of spikelets per panicle. The mean number of spikelets per panicle increased with increasing levels of nitrogen. Nitrogen at 120 kg/ha (n_3) recorded the highest number of spikelets per panicle and it was significantly higher to 60 kg N/ha (n_1). Application of 90 kg N/ha (n_2) produced higher number of spikelets than n_1, but did not differ significantly with 120 kg N/ha (n_3) in mean number of spikelets. None of the interactions were found to influence the total number of spikelets.

2.4 Number of filled grains per panicle

The observations on the number of filled grains per panicle were taken at harvest and analysed and analysis of variance table are presented in Appendix IV. The mean number of filled grains per panicle corresponding to the different treatments are presented in Table 5 and Fig.4

As evident from the table, the number of filled grains per [illegible] significantly varied with time of planting. The number of filled grains showed a decreasing trend with delay in planting time. Earliest planting (T_1) recorded the highest number of filled grains per panicle. The earlier planting (T_1 and T_2) had significantly higher number of filled grains per panicle than the late plantings (T_3 and T_4). But the early plantings (T_1 and T_2) and the late plantings (T_3 and T_4) were on par.

The varieties though did not differ significantly in the number of filled grains, Jaya recorded slightly higher number of filled grains per panicle than Sabari.

Eventhough, the nitrogen levels were not effective in increasing the number of grains per panicle significantly, there was a slight increase in the number of filled grains with increasing levels of nitrogen. Nitrogen at 90 kg/ha (n_2) had higher number of filled grains than 60 kg N/ha (n_1) and 120 kg N/ha (n_3) had higher number of filled grains than 60 kg N/ha (n_1) and 90 kg N/ha (n_2).

2.5 Percentage of filled grains

The observations on the percentage of filled grains were taken and analysed and analysis of variance tables are given in Appendix IV. The mean percentage of filled grains corresponding to the various treatments are presented in Table 5.

The time of planting had significant influence on the percentage of fertile grains. The highest percentage of filled grains was observed in early planting (T_1) and it decreased progressively with delay in planting time. Earliest planting (T_1) was found significantly superior to late plantings (T_3 and T_4). Early planting (T_2) was significantly superior to the late planting (T_4). Early plantings (T_1 and T_2) were on par and so were the October plantings (T_2 and T_3).

The varieties did not differ significantly in the percentage of fertile grains. But the time of planting and variety interaction significantly influenced the percentage of fertile grains (Table 5a). The earlier planting (T_1) of Sabari had the highest percentage of filled grains and it was significantly superior to its late planting (T_3) and also the late planting (T_4) of Jaya. In Sabari the percentage of filled grains decreased progressively with delay in planting. But no such trend was noted with Jaya. Early planting of Sabari(T_2) was significantly superior to its late planting (T_4). Jaya had the highest percentage of fertile grains in T_2 planting but did not significantly vary with other dates of planting.

Table 5 (a) **Combined effect of time of planting and varieties on percentage of filled grains.**

Varieties	Time of planting				Mean
	T_1	T_2	T_3	T_4	
V_1	73.36	74.04	69.59	72.78	72.44
V_2	80.23	74.47	72.04	64.62	72.83
Mean	76.74	74.25	70.81	68.73	

C D at 5% = 6.95

S E m = 2.29

The nitrogen levels were not effective in increasing the percentage of filled grains. But a gradual decrease in the percentage of filled grains was noted with increasing levels of nitrogen.

2.6 Percentage of spikelet sterility

The observation on the percentage of spikelet sterility was recorded at harvest and analysed, and analysis of variance tables are presented in Appendix IV. The mean percentage sterility corresponding to different treatment are presented in Table 6.

It is evident from the table that the percentage of spikelet sterility increased progressively with delay in planting. The late planting (T_4) had significantly higher percentage of sterile spikelets than earlier plantings (T_1 and T_2). The late planting (T_3) had significantly higher percentage of sterility than the earlier planting (T_1). The earlier plantings (T_1 and T_2) were on par so was late planting (T_3 and T_4). T_2 and T_3 were also on par.

The varieties did not significantly influence the sterility percentage. But time of planting, variety interaction significantly influenced the spikelet sterility (Table 6 a). In Sabari the sterility

Table 6 Effect of time of planting, varieties and levels of nitrogen on percentage of sterility, panicle length, branchlets/panicles and 1000 grain weight.

Treatments	Mean values			
	Sterility percentage	Panicle length	Branchlets per panicle	1000 grain weight
Time of planting (T)				
T_1	23.25	22.38	10.14	27.71
T_2	25.74	22.69	9.92	27.36
T_3	29.18	20.09	8.96	27.02
T_4	31.27	20.49	9.24	26.34
F Test	Sig.	Sig.	Sig.	N.S.
C D at 5%	4.91	0.641	0.383	-
S E m	-	-	-	0.35
Varieties (V)				
(V_1) Jaya	27.56	21.55	9.98	27.19
(V_2) Sabari	27.17	21.28	9.15	27.03
F Test	N.S.	N.S.	Sig.	N.S.
C.D at 5%	-	-	0.271	-
S E m	1.14	0.149	-	0.06
Nitrogen levels (N)				
N_1 (60 kg)	26.44	21.20	9.51	27.13
N_2 (90 kg)	26.60	21.24	9.55	26.92
N_3 (120 kg)	29.04	21.80	9.64	27.27
F Test	N.S.	N.S.	N.S.	N.S.
C D at 5%	-	-	-	-
S E m	1.49	0.222	0.129	0.214

Table 6 (a) Combined effect of time of planting and varieties on percentage sterility.

Varieties	Time of planting				Mean
	T_1	T_2	T_3	T_4	
V_1	26.63	25.95	30.41	27.22	27.55
V_2	19.86	25.72	27.95	35.32	27.16
Mean	23.11	25.73	29.18	31.27	

C D at 5% = 6.95

S E m = 2.29

percentage steadily increased with delay in planting time. Late planting (T_4) recorded the maximum sterility percentage. Jaya also showed an increasing trend. But late planting (T_3) had maximum sterile spikelets and early planting (T_2) had minimum sterility percentage.

The nitrogen levels increased the percentage of sterility with increasing levels of nitrogen. But the increase was not statistically significant.

2.7 Panicle length

The observations on panicle length were taken and analysed and analysis of variance is presented in Appendix V. The mean length of panicle corresponding to the different treatments are presented in Table 6

From the data it is evident that the time of planting significantly influences the panicle length. The length of panicle decreased steadily with delay in planting. Earlier plantings (T_1 and T_2) produced significantly higher panicle length than the late plantings (T_3 and T_4). Panicle length of earlier plantings (T_1 and T_2) were on par, and so was that of later plantings (T_3 and T_4). The earlier planting (T_2) recorded the highest panicle length.

The varieties did not differ significantly in panicle length, but Jaya had slightly higher panicle length than Sabari.

Nitrogen levels did not significantly increase the panicle length, but it slightly increased with higher levels of nitrogen. Panicle length at 90 kg N/ha was higher than that at 60 kg N/ha. Nitrogen at 120 kg/ha the highest panicle length.

2.8 Branchlets per panicle

The observations on the number of branchlets per panicle were taken after harvest and analysed. The analysis of variance is presented in Appendix V. The mean number of branchlets per panicle corresponding to the different treatments are given in Table 6.

As evident from the table, the time of planting significantly influenced the number of branchlets per panicle. The earliest planting (T_1) had significantly higher number of branchlets per panicle compared to the late plantings (T_3 and T_4). The number of branchlets per panicle showed a decreasing trend with delay in planting. The third planting (T_3) recorded the lowest number of branchlets per panicle, but the last planting (T_4) showed an increase in number of branchlets. Early planting (T_2) was found to have significantly higher number of branchlets than the late plantings (T_3 and T_4). Early plantings (T_1 and T_2) did not differ significantly and so was the late plantings (T_3 and T_4).

The number of branchlets were found to be significantly higher in Jaya than Sabari.

The levels of nitrogen did not significantly influence the number of branchlets per panicle. However it showed a slight increase with increasing levels of nitrogen.

2.9 1000 Grain weight

The observations on 1000 grain weight were recorded after harvest and analysed. The analysis of variance tables are presented in Appendix V. The mean grain weight corresponding to the different treatments are presented in Table 6.

Thousand grain weight was not significantly influenced by time of planting, but it slightly decreased with delay in planting time.

The varieties did not significantly differ in the 1000 grain weight. But Jaya had higher 1000 grain weight than Sabari.

The nitrogen levels did not significantly increase the 1000 grain weight. But 120 kg N/ha (n_3) gave higher grain weight than 60 kg N/ha (n_1).

2.10 Grain yield

The observations on grain yield were recorded after harvest and analysed. The analysis of variance tables are presented in Appendix VI. The mean grain yields corresponding to the different treatments are presented in Table 7 and Fig. 4.8.

As evident from the table, the time of planting significantly influenced the grain yield. The grain yield showed a decreasing trend with delay in planting time. The latest planting (T_4) recorded the lowest yield. Early planting (T_2) recorded the highest yield. Early plantings (T_1 and T_2) recorded significantly higher yield than late plantings (T_3 and T_4). But between the early plantings, T_1 and T_2 did not differ significantly in grain yield and so was the late plantings (T_3 and T_4).

The varieties did not differ signifiaantly in grain yield, though Jaya recorded slightly higher yield than Sabari.

Table 7 Effect of time of planting, varieties and levels of nitrogen on dry matter production and grain yield.

Treatments	Dry matter production g/m²			Grain yield
	30th day after planting	60th day after planting	Total dry matter at harvest	
Time of planting (T)				
T_1	158.46	505.32	1038.19	5085
T_2	133.89	467.19	1058.31	5128
T_3	122.53	422.83	791.19	4308
T_4	137.88	687.22	834.03	4273
F Test	N.S.	Sig.	Sig.	Sig.
C D at 5%	-	67.67	2[illegible]2.57	644
S E m	8.662	-	-	-
Varieties (V)				
(V_1) Jaya	141.71	504.03	954.76	4704
(V_2) Sabari	134.67	536.76	906.10	4693
F Test	N.S.	N.S.	N.S.	N.S.
C D at 5%	-	-	-	-
S E m	6.125	15.77	51.88	150.12
Nitrogen levels (N)				
N_1 (60 kg)	130.44	531.19	887.79	4427
N_2 (90 kg)	133.43	509.67	978.73	4854
N_3 (120 kg)	150.70	520.32	924.77	4814
F Test	Sig.	N.S.	N.S.	N.S.
C D at 5%	-	-	-	-
S E m	14.94	15.93	38.77	172.38

The grain yield was not significantly increased by nitrogen levels. But showed a slight increase in grain yield with higher levels of nitrogen. Nitrogen at 90 kg/ha had the highest yield.

2.11 Dry matter production

Observations on dry matter production at 30th day, 60th day and at harvest were taken and analysed separately and the analysis of variance is presented in Appendix VI. The mean values corresponding to different treatments are presented in Table 7 and Fig. 4 a.

As evident from the table, the dry matter production at 30th day after planting was not significantly affected by time of planting. But the dry matter production at 60th day after planting and at harvest was significantly affected by time of planting. At 30th day after planting, crop planted on 25th September recorded the highest dry matter accumulation and that planted on 9th November (T_4) showed a slight increase. At 60th day after planting, crop planted on 9th November recorded significantly higher dry matter production than that planted on all other dates. The dry matter production showed a decreasing trend with delay in planting but for the late planting T_4 which recorded the highest dry matter production. The lowest

Fig.4

4 A	Effect of time of planting on dry matter production at various stages of growth, viz. 30th day after planting, 60th day after planting and at harvest.
4 B	Effect of time of planting on total number of spikelets, number of filled grains and grain yield.
4 C	Effect of time of planting on tiller production at various stages of growth viz. 30th day after planting, 60th day after planting and at harvest, and productive tillers at harvest.
4 D	Effect of time of planting on nitrogen content of straw at various stages of growth viz. 30th day after planting, 60th day after planting and at harvest.

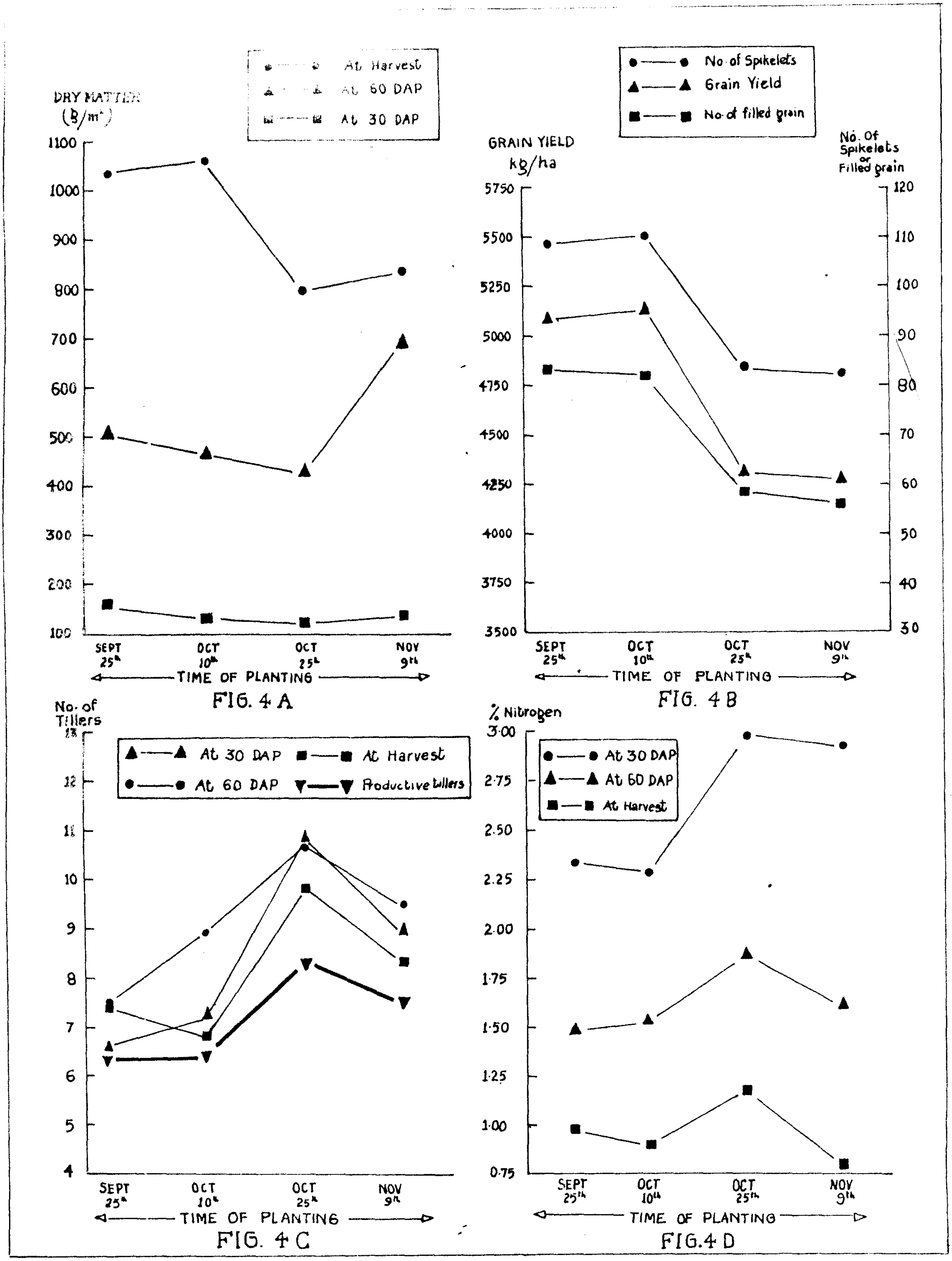
At Harvest
At 60 DAP
At 30 DAP
DRY MATTER (g/m²)
TIME OF PLANTING
SEPT 25th
OCT 10th
OCT 25th
NOV 9th
FIG. 4 A
No. of Spikelets
Grain Yield
No. of filled grain
GRAIN YIELD kg/ha
No. Of Spikelets or Filled grain
FIG. 4 B
No. of Tillers
At 30 DAP
At 60 DAP
At Harvest
Productive tillers
FIG. 4 C
% Nitrogen
At 30 DAP
At 60 DAP
At Harvest
FIG. 4 D

FIG. 4

dry matter production was recorded by 25th October planting. Twenty-fifth September planting (T_1) was significantly superior to 25th October planting (T_3). There was no significant difference in dry matter production between the crops planted on 25th September and 10th October. Similarly the crop planted on 10th October and 25th October were on par.

The dry matter production at harvest was significantly influenced by time of planting. The dry matter production was the highest in the crop planted on October 10th and was significantly higher to those planted on (T_3) 25th October and 9th November (T_4). The earlier planted crops had higher dry matter than the crop planted on 25th October. The dry matter production of the earlier planted crops were on par and so was that in late planted crops.

The varieties did not significantly differ in the dry matter production in any of the stages of growth. At 30th day after planting and at harvest Jaya had higher dry matter production than Sabari. But at 60th day after planting Sabari had more dry matter production than Jaya.

Nitrogen levels significantly increased the dry matter production at 30th day after planting. Dry matter production increased steadily with increasing levels of nitrogen. Nitrogen at 120 kg/ha had significantly higher dry matter production than nitrogen at 60 kg/ha and 90 kg/ha. Dry matter production at 60th day after planting and at harvest were not markedly affected by nitrogen levels. At 60th day after planting, n_2 (90 kg) had the lowest dry matter production. Dry matter production at n_2 and n_3 levels of nitrogen were lower than that at n_1 level. At harvest dry matter production increased with nitrogen application. Nitrogen at n_2 level had higher dry matter production than n_1 and n_3 levels and n_3 had more dry matter production than n_1.

The time of planting, variety and levels of nitrogen interaction significantly influenced the dry matter production.

2.12 Straw yield

Observations on straw yield were taken after harvest and analysed and analysis of variance table are given in Appendix VI. The mean straw yield corresponding to the different treatment are given in Table 8.

As observed from the table, the straw yield was not significantly influenced by the time of planting. But the early planting (T_2) had the highest straw yield and showed a decreasing trend with delay in planting.

Jaya had higher straw yield than Sabari. But the difference was not statistically significant.

Nitrogen levels had no significant effect on straw yield. Nitrogen at 60 kg/ha (n_1) had higher straw yield than 90 kg/ha (n_2) and 120 kg/ha (n_3).

2.13 Grain straw ratio

The grain straw ratio was computed after harvest and analysed and analysis of variance table are presented in Appendix V. The mean grain straw ratio corresponding to the different treatments are given in Table 8.

The data show that time of planting had no significant effect on grain straw ratio, but it showed a decreasing trend but for the late planting (T_4) which showed a slight increase.

The varieties also did not differ significantly in grain straw ratio. But Sabari had higher grain straw ratio than Jaya.

Table 8 Effect of time of planting, varieties and levels of nitrogen on straw yield, harvest index and grain straw ratio.

Treatments	Mean values		Grain straw ratio
	Straw yield kg/ha	Harvest index	
Time of planting (T)			
T_1	7353	42.42	0.723
T_2	7829	36.84	0.652
T_3	7244	39.36	0.623
T_4	6162	40.38	0.680
F Test	N.S.	Sig.	N.S.
C D at 5%	-	4.23	-
S E m	515.5	-	0.047
Varieties (V)			
(V_1) Jaya	7322	38.87	0.649
(V_2) Sabari	6972	39.62	0.690
F Test	N.S.	N.S.	N.S.
C.D at 5%	-	-	-
S E m	364.5	0.98	0.03
Nitrogen levels (N)			
N_1 (60 kg)	7203	37.66	0.629
N_2 (90 kg)	6752	41.69	0.748
N_3 (120 kg)	7187	38.39	0.632
F Test	N.S.	Sig.	Sig.
C D at 5%	-	3.11	0.089
S E m	241.9	-	-

The nitrogen level significantly affected the grain straw ratio. Nitrogen at 90 kg/ha (n_1) recorded significantly higher grain straw ratio than nitrogen at 60 kg/ha (n_1) and 120 kg/ha(n_3). But the grain straw ratio at 60 kg N/ha were on par.

2.14 Harvest index

Harvest index was computed and analysed and analysis of variance table are presented in Appendix V. The mean data on harvest index corresponding to the different treatments are given in Table 8.

It is evident from the table that harvest index was significantly influenced by the time of planting. The highest harvest index was noted in the crop planted on 25th September (T_1) and it showed a decreasing trend, but for the November 9th planting (T_4). Twenty-fifth September planting (T_1) and November 9th planting (T_4) were significantly superior to 25th October planting (T_3), whereas all planting times except 25th October planting (T_1, T_2 and T_4) were on par and 25th October planting and 10th October planting were also on par.

The harvest index was not significantly affected by the varieties tried. But Sabari had higher harvest index than Jaya.

The nitrogen levels were found to exert a significant influence on harvest index. Nitrogen at 90 kg/ha (n_2) significantly increased the harvest index over the other levels of nitrogen. But there was no significant difference between nitrogen at 60 kg/ha (n_1) and 120 kg/ha (n_3).

3 Chemical analysis

3.1 Total nitrogen content of plant parts

3.1.1 Nitrogen content of straw

The plant samples at 30th day, 60th day after planting and at harvest were taken and analysed separately. The analysis of variance table are presented in Appendix VII. The mean nitrogen content corresponding to the different treatment are given in Table 9 and Fig.5

The results show that the time of planting had significantly influenced the nitrogen content of plants in all stages of growth. The nitrogen content was highest at 30th day after planting and it gradually decreased with age of plant and was the least at harvest. October 25th planting (T_3) recorded the highest percentage of nitrogen in all stages of observation. At 30th day after planting, the late planted crops (T_3 and T_4) recorded significantly higher percentage

Table 9 Effect of time of planting, varieties and levels of nitrogen on nitrogen content of straw, grain and grain protein content.

Treatments	Percentage of nitrogen				
	Straw			Grain	Grain protein content
	30th day after planting	60th day after planting	At harvest		
Time of planting					
T_1	2.34	1.49	0.981	1.53	9.73
T_2	2.29	1.53	0.901	1.30	7.73
T_3	2.99	1.87	1.180	1.37	8.13
T_4	2.92	1.61	0.806	1.46	8.68
F Test	Sig	Sig	Sig	N.S	N.S.
C D at 5%	0.328	0.236	0.143	-	-
S E m	-	-	-	0.083	0.497
Varieties (V)					
(V_1) Jaya	2.67	1.61	0.95	1.44	8.56
(V_2) Sabari	2.61	1.63	0.98	1.39	8.27
F Test	N.S.	N.S.	N.S.	N.S.	N.S.
C D at 5%	-	-	-	-	-
S E m	0.076	0.055	0.033	0.003	2.84
Nitrogen levels (N)					
N_1 (60 kg)	2.60	1.59	0.951	1.36	8.10
N_2 (90 kg)	2.67	1.57	0.941	1.46	8.66
N_3 (120 kg)	2.65	1.72	1.010	1.43	8.49
F Test	N.S.	N.S.	N.S.	N.S.	N.S.
C D at 5%	-	-	-	-	-
S E m	0.076	0.058	0.044	0.042	0.249

of nitrogen than the early plantings (T_1 and T_2). The nitrogen content of the early planted crops T_1 and T_2 and the late planted crops T_3 and T_4 were on par. At 60th day after planting, 25th October planting (T_3) recorded significantly higher nitrogen content than all other planting dates. But the crops planted on October 10th and November 9th (T_2 and T_4) were on par and also the early planted crops (T_1 and T_2) were on par. The percentage of nitrogen at harvest in the crop planted on 25th October (T_3) was significantly higher to that of all other plantings. The nitrogen content of the crop planted on 25th September (T_1) was found to be significantly higher to that planted on on 9th November (T_4). But the early planting (T_1 and T_2) were on par, and so was 10th October and November 9th plantings (T_2 and T_4).

The nitrogen content of the plants did not differ significantly with varieties, in any of the stages of growth. But Jaya had higher percentage of nitrogen at 30th day and 60th day after planting. But at harvest Sabari had higher nitrogen content than Jaya.

The nitrogen levels did not significantly affect the nitrogen content of plant in any of the stages of growth. But the nitrogen content at 120 kg/ha(n_3)

was higher than that at 60 kg N/ha (n_1) and 90 kg N/ha (n_2).

3.1.2 Nitrogen content of grain

Samples were collected at harvest and analysed and the analysis of variance tables are presented in Appendix VII. The mean values corresponding treatments are given in Table 9 and Fig.5

The nitrogen content of grain was not significantly influenced by the time of planting, though September 25th planting (T_1) had slightly higher percentage of nitrogen than that of other plantings.

The varieties also did not vary significantly in the nitrogen content of grain. But Jaya had slightly higher nitrogen content than Sabari.

The nitrogen content of grain was not significantly influenced by the nitrogen levels. But the nitrogen at 90 kg/ha (n_2) had slightly higher nitrogen content than other levels of nitrogen.

3.1.3 Grain protein content

The data on grain protein content are presented in Table 9 and the analysis of variance in Appendix VII.

From the table it is evident that the time of planting had no significant influence on grain protein content.

The varieties also did not differ significantly in grain protein content.

The nitrogen levels also had not effected the grain protein content, though nitrogen at 90 kg/ha was noted to give a slightly higher percentage of grain protein compared to other levels of applied nitrogen.

3.2 Uptake of nitrogen by plant parts

3.2.1 Nitrogen uptake by straw

The data on nitrogen uptake by plants are presented in Table 10 and analysis of variance in Appendix VIII.

The uptake of nitrogen was not significantly influenced by the planting time at 30th day after planting and at harvest. But it was significantly influenced by time of planting at 60th day after planting. The November 9th planting (T_4) had significantly higher uptake of nitrogen compared to all other plantings. The other planting dates did not differ significantly in the uptake of nitrogen.

There was no significant difference in uptake of nitrogen between the varieties in any of the stages of growth. Jaya had higher nitrogen uptake at 30th day after planting than Sabari. At 60th day after planting and at harvest Sabari had more nitrogen uptake than Jaya. The interaction between time of planting and varieties was found to significantly affect the uptake of nitrogen at 60th day after planting (Table 14 b). In Jaya the nitrogen uptake increased progressively with delay in planting and the November 9th planting (T_4) recorded the highest nitrogen uptake. In Sabari no such a trend was seen, though the November 9th planting (T_4) had the highest uptake. The maximum nitrogen uptake was recorded by November 9th planting (T_4) of Jaya. It was significantly superior to all other dates of planting except the November 9th planting (T_4) of Sabari. The uptake values did not vary significantly in September 25th (T_1), October 25th (T_3) and November 9th (T_4) plantings of Sabari. The November 9th (T_4) planting of Sabari had more nitrogen uptake than the October 10th planting (T_2). Sabari planted on September 25th (T_1) and October 25th (T_3) had more nitrogen uptake than September 25th planting (T_1) of Jaya.

Table 10 Effect of time of planting, varieties and levels of nitrogen on nitrogen uptake by straw, grain and total nitrogen uptake at harvest.

Treatments	Nitrogen uptake in kg/ha				
	Uptake by straw			Uptake by grain	Total N uptake at harvest
	30th day after planting	60th day after planting	At harvest		
Time of planting (T)					
T_1	36.86	75.92	50.30	80.67	130.12
T_2	30.64	72.52	45.09	73.52	121.22
T_3	36.76	81.41	53.20	46.14	95.67
T_4	39.45	109.97	37.43	51.22	94.87
F Test	N.S.	Sig.	N.S.	Sig.	Sig.
C D at 5%	7.18	16.06	-	19.69	27.22
S E m	2.369	-	4.31	-	-
Varieties (V)					
(V_1) Jaya	37.17	81.92	46.46	65.57	115.90
(V_2) Sabari	34.68	87.99	46.54	60.20	105.04
F Test	N.S.	N.S.	N.S.	N.S.	N.S.
C D at 5%	-	-	-	-	-
S E m	1.67	3.7	3.05	4.59	6.34
Levels of nitrogen (N)					
N_1 (60 kg)	33.54	84.25	42.46	58.86	101.75
N_2 (90 kg)	34.91	79.69	48.60	68.40	116.35
N_3 (120 kg)	39.34	90.94	48.47	61.39	113.30
F Test	Sig.	N.S.	N.S.	N.S.	N.S.
C.D. at 5%	3.97	-	-	-	-
S E m	-	4.66	3.22	4.47	5.28

Table 10 (a) Combined effect of time of planting and varieties on nitrogen uptake by straw at 60th day after planting.

Varieties	Time of planting				Mean
	T_1	T_2	T_3	T_4	
V_1	59.59	75.62	76.30	116.17	81.92
V_2	92.23	69.41	86.52	103.78	87.98
Mean	75.91	72.51	81.30	109.97	

C D at 5% = 22.72

S E m = 7.49

The nitrogen levels significantly affected the nitrogen uptake at 30th day after planting, while it was unaffected at 60th day after planting and at harvest. The nitrogen uptake increased progressively with increase in the levels of nitrogen. Nitrogen at 120 kg/ha had significantly higher nitrogen uptake than that at 90 kg N/ha and 60 kg N/ha, which were on par. The time of planting variety and nitrogen interaction was found to significantly influence the nitrogen uptake at 30th day after planting, while no such interaction was found at 60th day after planting and at harvest.

3.2.2 Nitrogen uptake by grain

The data on nitrogen uptake by grain are presented in Table 10 and analysis of variance in Appendix VIII.

It is evident from the table, that the time of planting significantly affected the nitrogen uptake by grain. Nitrogen uptake progressively decreased with delay in planting, except the November 9th planting (T_4), where it showed a slight increase. Uptake of nitrogen was highest in September 25th planting (T_1) and the lowest was in October 25th planting (T_3). The nitrogen uptake by grain in early planting (T_1 and T_2) were significantly higher to the later plantings (T_3 and T_4). September 25th planting (T_1) and October 10th planting (T_2) did not vary significantly in nitrogen uptake by grain. October 25th and November 9th planting (T_3 and T_4) were also found to be on par.

The varieties did not differ significantly in nitrogen uptake by grain. But Jaya had slightly higher value than Sabari.

Nitrogen at 90 kg/ha was found to have higher nitrogen uptake compared to other levels, though the difference were not statistically significant. None of the interactions were found to have any influence on nitrogen uptake by grain.

3.2.3 Total uptake of nitrogen

The data on the total uptake of nitrogen at harvest are presented in Table 10 and analysis of variance in Appendix VIII.

The time of plantings significantly affected the total nitrogen uptake at harvest. The nitrogen uptake progressively decreased with delay in planting. The November 9th planting (T_4) recorded the lowest nitrogen uptake. Nitrogen uptake in September 25th planting (T_1) was the highest and it was significantly higher than that at October 25th and November 9th plantings (T_3 and T_4). The early plantings were on par in the total nitrogen uptake. The nitrogen uptake in October 10th (T_2) planting, October 25th (T_3) and November 9th (T_4) planting were also on par.

The total nitrogen uptake was not significantly influenced by varieties, though Jaya had more nitrogen uptake than Sabari.

The nitrogen levels did not significantly influence nitrogen uptake by the plant, though nitrogen at 90 kg/ha (n_2) had slightly higher uptake values than that at 60 kg N/ha (n_1) and 120 kg N/ha (n_3). The time of planting, nitrogen interaction significantly affected the total nitrogen uptake at harvest (Table 10 b). The highest nitrogen uptake was noted in September 25th planting (T_1) with 90 kg N/ha (n_2). It was significantly superior to the nitrogen uptake at October 25th (T_3) and November 9th plantings (T_4) at same level (n_2) of nitrogen application. Also it was significantly superior to the October 10th and November 9th planting (T_2 and T_4) at 120 kg N/ha. The total nitrogen uptake at September 25th planting (T_1)

Table 10 (b) Combined effect of time of planting and levels of nitrogen on total nitrogen uptake at harvest.

Nitrogen levels	Time of planting				Mean
	T_1	T_2	T_3	T_4	
n_1	110.48	119.46	77.21	99.86	101.75
n_2	151.57	123.67	87.41	102.77	116.35
n_3	128.31	120.51	122.38	82.00	113.30
Mean	130.12	121.21	95.67	94.87	

C D at 5% = 30.47

SE m = 10.57

at 90 kg N/ha and 120 kg N/ha (n_2 and n_3) and October 25th planting (T_3) at 120 kg N/ha (n_3) were on par.

3.3 Phosphorus content of plant parts

3.3.1 Phosphorus content of straw

The data on phosphorus content of straw at the various stages of crop growth are presented in Table 11 and Fig. 5 and the analysis of variance in Appendix IX.

The different time of planting did not significantly influence the phosphorus absorption by crop at 30th day after planting and at 60th day after planting. But the phosphorus content of straw at harvest was significantly influenced by time of planting. The phosphorus content of straw in October 25th planting (T_3) was significantly higher than that of November 9th planting (T_4), but was on par with September 25th and October 10th plantings (T_1 and T_2). The phosphorus content the early plantings (T_1 and T_2) were also significantly higher to November 9th planting (T_4).

Varieties significantly differed in phosphorus content at 30th day after planting while, there was

Table 11 Effect of time of planting, varieties and levels of nitrogen on phosphorus content of straw and grain.

Treatments	Percentage of phosphorus			
	30th day after planting	60th day after planting	Straw at harvest	Grain
Time of planting (T)				
T_1	0.349	0.301	0.184	0.281
T_2	0.339	0.282	0.180	0.249
T_3	0.350	0.293	0.137	0.254
T_4	0.368	0.237	0.134	0.240
F Test	N.S.	N.S.	Sig.	Sig.
C D at 5%	-	-	0.025	0.028
S E m	0.0082	0.0091	-	-
Varieties (V)				
(V_1) Jaya	0.363	0.289	0.179	0.258
(V_2) Sabari	0.340	0.292	0.168	0.254
F Test	Sig	N.S.	N.S.	N.S.
C D at 5%	0.018	-	-	-
S E m	-	0.0064	0.006	0.006
Levels of Nitrogen (N)				
N_1 (60 kg)	0.345	0.287	0.163	0.258
N_2 (90 kg)	0.353	0.289	0.173	0.258
N_3 (120 kg)	0.357	0.295	0.186	0.262
F Test	N.S.	N.S.	Sig.	N.S.
C.D at 5%	-	-	0.018	-
S E m	0.005	0.0056	-	0.004

no significant difference between varieties at 60th day after planting and at harvest. Jaya recorded significantly higher percentage of phosphorus than Sabari at 30th day after planting.

The nitrogen levels did not markedly influence the phosphorus content at 30th day and at 60th day after planting. But the nitrogen levels significantly influenced phosphorus content of straw at harvest. The phosphorus content of straw showed an increasing trend with increasing levels of applied nitrogen in all stages of growth. Phosphorus content of straw at 120 kg N/ha (n_3) was significantly superior to that at 60 kg N/ha (n_1). The phosphorus content of straw at 60 kg N/ha (n_1) and 90 kg N/ha (n_2) were on par and also the phosphorus content of straw at 90 kg N/ha (n_2) and 120 kg N/ha (n_3) were on par. None of the interactions were found to significantly affect the Phosphorus content of straw.

3.3.2 Phosphorus content of grain

The data on phosphorus content of grain are presented in Table 11 and Fig. [illegible] and analysis of variance in Appendix IX.

As evident from the table, phosphorus content of grain was significantly affected by the time of planting. The phosphorus content of grain showed a decreasing trend with delay in transplanting, but for the October 25th planting (T_3). The phosphorus content of grain in September 25th planting (T_1) was found to be significantly higher than that at October 10th and November 9th planting (T_2 and T_4). But the phosphorus content of grain in September 25th and October 25th planting (T_1 and T_3) were on par. The phosphorus content of grain in the later plantings (T_2, T_3 and T_4) were also on par.

The phosphorus content of grain was not significantly influenced by the varieties.

The nitrogen levels did not significantly influence the phosphorus content of grain. But there was a slight increase in phosphorus content with increase in nitrogen levels. None of the interactions were found to significantly affect the phosphorus content of grains.

3.4 Uptake of phosphorus by plant parts

3.4.1 Uptake of phosphorus by straw

The data on phosphorus uptake by plants at various stages of crop growth are presented in Table 12 and analysis of variance in Appendix X.

It is evident from the table, that the phosphorus uptake by straw at 30th day after planting and 60th day after planting were significantly affected by the time of planting. But, the phosphorus uptake by straw at harvest was not significantly affected by time of planting. The phosphorus uptake by straw showed a decreasing trend with delay in planting, but for the November 9th planting (T_4), at 30th day and 60th day after planting. The phosphorus uptake by straw in September 25th planting (T_1) was significantly higher to that in October 10th and October 25th plantings (T_2 and T_3) at 30th day after planting. The November 9th planting (T_4) had significantly higher phosphorus uptake than that in October 25th (T_3) planting. But, there was no marked difference in phosphorus uptake between September 25th planting and November 9th planting (T_1 and T_4). The phosphorus in October 10th planting (T_2) and November 9th planting (T_4) were on par and also in October 10th planting (T_2) and October 25th (T_3) planting. The phosphorus uptake, at 60th day after planting, was significantly higher in November 9th (T_4) planting compared to that in all other plantings. There was no significant difference in phosphorus uptake between the early plantings (T_1, T_2 and T_3).

Table 12 Effect of time of planting, varieties and levels of nitrogen on phosphorus uptake by straw, grain and total phosphorus uptake at harvest.

Treatments	Phosphorus uptake kg/ha				
	Phosphorus uptake by straw			Grain	Total at harvest
	30th day after planting	60th day after planting	At harvest		
Time of planting (T)					
T_1	5.43	15.08	9.34	14.34	23.69
T_2	4.53	12.94	9.01	13.87	22.88
T_3	4.26	12.65	8.76	8.66	17.43
T_4	5.04	19.76	6.26	8.84	15.11
F Test	Sig.	Sig.	N.S.	Sig.	Sig.
C D at 5%	0.77	2.438	-	3.69	5.55
S E m	-	-	0.77	-	-
Varieties (V)					
(V_1) Jaya	5.11	14.58	8.84	11.81	20.65
(V_2) Sabari	4.52	15.63	7.85	11.05	18.90
F Test	Sig.	N.S.	N.S.	N.S.	N.S.
C D at 5%	0.54	-	-	-	-
S E m	-	0.57	0.55	0.86	1.294
Levels of Nitrogen					
N_1 (60 kg)	4.46	15.30	7.42	10.99	18.41
N_2 (90 kg)	4.63	14.65	8.64	12.06	20.71
N_3 (120 kg)	5.35	15.38	8.96	11.25	20.22
F Test	Sig.	N.S.	N.S.	N.S.	N.S.
C D at 5%	0.50	-	-	-	-
S E m	-	0.61	0.45	0.62	0.83

The phosphorus uptake by straw was significantly influenced by varieties at 30th day after planting, whereas at 60th day after planting and at harvest no such influence was exerted by the varieties. Jaya recorded markedly higher phosphorus uptake at 30th day after planting.

The nitrogen levels were found to significantly affect the phosphorus uptake by straw at 30th day after planting. No significant influence of levels of applied nitrogen was noticed in phosphorus uptake at 60th day after planting and at harvest. The phosphorus uptake increased markedly with increase in levels of nitrogen at 30th day after planting. Phosphorus uptake at 30th day after planting was significantly higher at 120 kg N/ha (n_3) than that of 90 kg N/ha and 60 kg N/ha. But the phosphorus uptake at 60 kg N/ha and 90 kg N/ha were on par. The time of planting, variety and nitrogen interaction was found to significantly affect the phosphorus absorption at 30th day after planting and also at harvest.

3.4.2 Phosphorus uptake by grain

The data on phosphorus uptake by grain are presented in Table 12 and analysis of variance in Appendix X.

It is evident from the table that phosphorus uptake by grain is significantly influenced by the time of planting. The phosphorus uptake by grain progressively decreased with delay in planting, except the crop planted on 9th of November (T_4). Phosphorus uptake by grain in early plantings (T_1 and T_2) were significantly higher than that in late planted crops (T_3 and T_4). But, the phosphorus uptake in the early planted crops (T_1 and T_2) did not differ significantly and that in the late planted crops (T_3 and T_4) also did not differ significantly.

The varieties did not differ significantly in the phosphorus uptake by grain. But, the variety Jaya recorded more phosphorus uptake than Sabari in all the stages of growth.

The nitrogen levels had no significant influence on the phosphorus uptake by grain. But it increased slightly with 90 kg N/ha (n_2) than that in 60 kg N/ha (n_1). None of the interactions were found to have any significant influence on phosphorus uptake by grain.

3.4.3 Total uptake of phosphorus

The data on total phosphorus uptake are

presented in Table 12 and analysis of variance in Appendix X.

The total uptake of phosphorus was significantly influenced by the time of planting. The phosphorus uptake exhibited a decreasing trend with delay in planting time. The total phosphorus uptake in the early planted crop (T_1) was significantly higher than that in the late planted crops (T_3 and T_4). The crop planted on October 10th (T_2) had markedly higher phosphorus uptake than the late plant crop (T_4). But the phosphorus uptake in the early planted crops (T_1 and T_2) were on par and that in T_2 and T_3 were also on par. The late planted crops (T_3 and T_4) did not differ significantly.

The varieties did not differ significantly in the total phosphorus uptake. However, Jaya had more phosphorus uptake than Sabari.

The nitrogen levels had no marked effect on the total phosphorus uptake by rice at harvest. But the total phosphorus uptake increased with higher levels of applied nitrogen. Application of 90 kg N/ha (n_2) resulted in more phosphorus uptake tha
60 kg N/ha (n_1) and 120 kg N/ha (n_3).

3.5 Potassium content in plant parts

3.5.1 Potassium content of straw

The data on the potassium content of straw at different stages of growth are presented in Table 13 and Fig. The analysis of variance tables are presented in Appendix XI.

It is evident from the table, that the time of planting had no significant influence on potassium content of straw in any of the stages of growth. The potassium content of straw was the highest at early stages of growth and it gradually decreased with age of the plant, and at harvest the potassium content of straw was the lowest.

The varieties did not differ significantly in potassium content at 30th day after planting and at harvest. But, at 60th day after planting, the potassium content significantly varied with varieties. Sabari recorded higher potassium content than Jaya.

The potassium content of straw in all stages of growth was found to be unaffected by levels of applied nitrogen. None of the interactions were found to influence the potassium content of straw.

Table 13 Effect of time of planting, varieties and levels of nitrogen on potassium content of straw and grain.

Treatments	Percentage of potassium			
	Potassium content of straw			Grain
	30th day after planting	60th day after planting	At harvest	
Time of planting (T)				
T_1	1.77	1.59	1.60	0.280
T_2	1.60	1.46	1.43	0.320
T_3	1.71	1.60	1.41	0.320
T_4	1.73	1.59	1.48	0.300
F Test	N.S.	N.S.	N.S.	Sig.
C D at 5%	-	-	-	0.024
S E m	0.063	0.037	0.083	-
Varieties (V)				
(V_1) Jaya	1.70	1.52	1.46	0.30
(V_2) Sabari	1.71	1.60	1.50	0.31
F Test	N.S.	Sig.	N.S.	N.S.
C D at 5%	-	0.079	-	-
S E m	0.045	-	0.059	0.005
Nitrogen levels (N)				
N_1 (60 kg)	1.73	1.60	1.49	0.31
N_2 (90 kg)	1.67	1.55	1.46	0.30
N_3 (120 kg)	1.70	1.52	1.49	0.31
F Test	N.S.	N.S.	N.S.	N.S.
C D at 5%	-	-	-	-
S E m	0.020	0.024	0.047	0.0059

3.5.2 Potassium content of grain

The data on potassium content of grain are presented in Table 13 and Fig.6 The analysis of variance table are given in Appendix XI.

It is evident from the table, that the time of planting significantly affected the potassium content of grain. The crops planted on 10th October and 25th October (T_2 and T_3) had the highest percentage of potassium and were significantly superior to that planted on 25th September (T_1). There was no significant difference in potassium content of grain between the interplanted crops (T_2, T_3 and T_4). September 25th planting and November 9th planting were also on par.

The varieties did not differ significantly in the potassium content of grain. But, Sabari had higher potassium content than Jaya.

Levels of nitrogen had no influence on the potassium content of grain. None of the interactions were found to significantly influence the potassium content of grain.

Fig. 5 Effect of time of planting on N, P and K content of grain and straw.

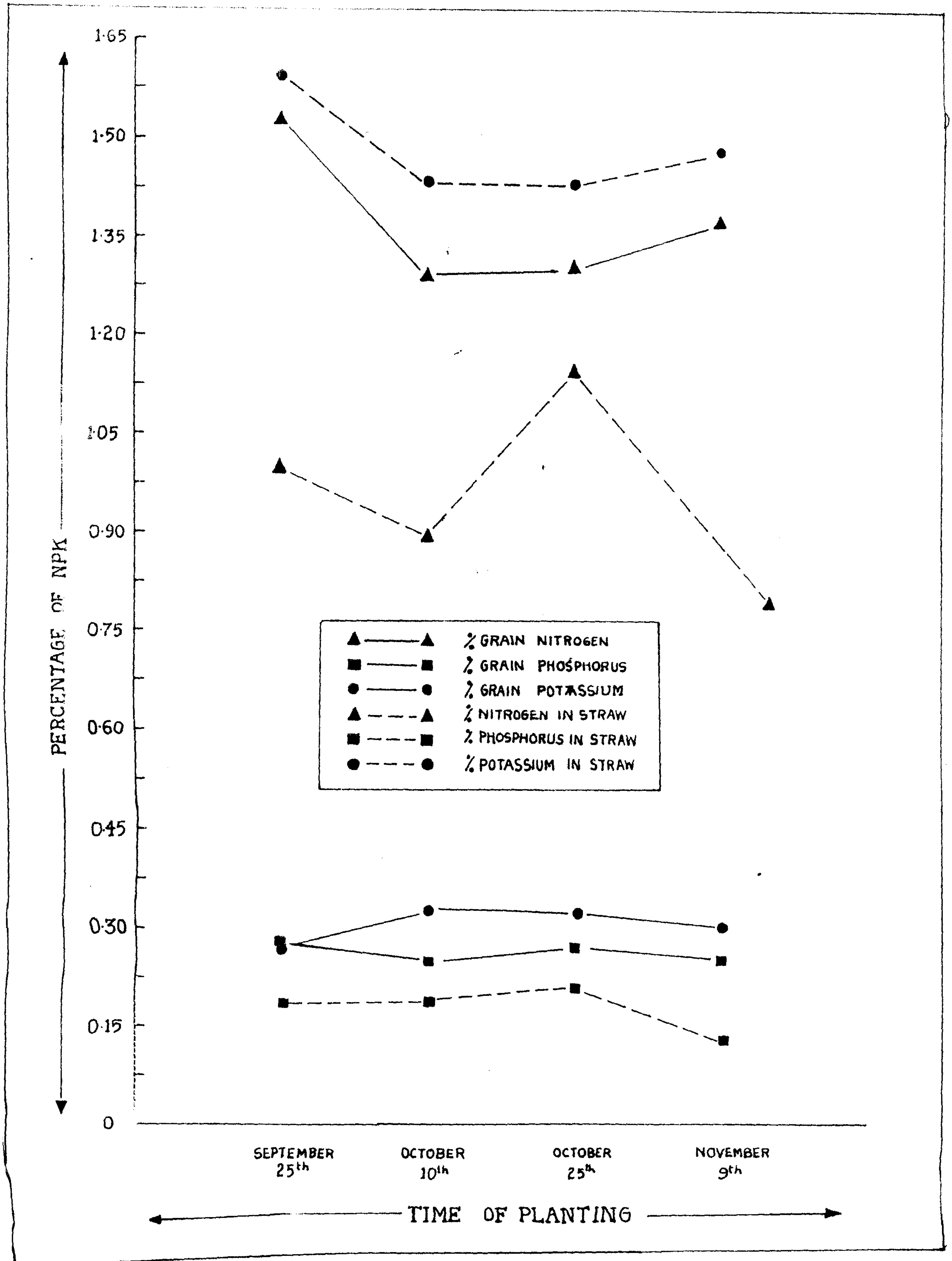
PERCENTAGE OF NPK
1·65
1·50
1·35
1·20
1·05
0·90
0·75
0·60
0·45
0·30
0·15
0
% GRAIN NITROGEN
% GRAIN PHOSPHORUS
% GRAIN POTASSIUM
% NITROGEN IN STRAW
% PHOSPHORUS IN STRAW
% POTASSIUM IN STRAW
SEPTEMBER 25th
OCTOBER 10th
OCTOBER 25th
NOVEMBER 9th
TIME OF PLANTING

FIG.5

3.6 Potassium uptake by plant parts

3.6.1 Potassium uptake by straw

The data on potassium uptake by straw are presented in Table 14 and analysis of variance in Appendix XII.

As evident from the table the time of planting had no influence on the potassium uptake at 30th day after planting and also at harvest. But potassium uptake at 60th day after planting was significantly influenced by the time of planting. The late planted crop (T_4) had the highest potassium uptake and was significantly superior to all other dates of planting. The early planted crop (T_1) had significantly higher uptake of potassium than the later planted crops (T_2 and T_3). The uptake of potassium in the October plantings (T_2 and T_3) did not differ significantly.

The varieties did not differ in potassium uptake at 30th day after planting and also at harvest. But the varieties significantly varied in potassium uptake at 60th day after planting. Sabari recorded higher potassium uptake than Jaya.

The uptake of potassium at 30th day after planting was significantly influenced by the level of

Table 14 Effect of time of planting, varieties and levels of nitrogen on potassium uptake by straw, grain and total potassium uptake.

Treatments	Potassium uptake kg/ha				
	Straw 30th day after planting	Straw 60th day after planting	Straw At harvest	Grain	Total uptake at harvest
Time of planting (T)					
T_1	27.01	83.68	81.33	14.90	96.23
T_2	20.73	68.31	70.89	17.75	88.69
T_3	20.59	68.14	61.95	11.20	73.10
T_4	23.59	108.89	69.09	11.02	80.11
F Test	N.S.	Sig.	N.S.	Sig.	N.S.
C.D at 5%	-	11.74	-	4.27	-
S E m	2.06	-	8.435	-	6.71
Varieties (V)					
(V_1) Jaya	23.56	76.61	71.95	13.97	85.89
(V_2) Sabari	22.41	87.90	69.68	13.47	83.47
F Test	N.S.	Sig.	N.S.	N.S.	N.S.
C D at 5%	-	8.30	-	-	-
SE m	1.458	-	4.22	1.00	4.75
Levels of Nitrogen					
N_1 (60 kg)	22.02	85.28	66.95	13.40	80.38
N_2 (90 kg)	21.93	81.90	75.36	14.15	89.48
N_3 (120 kg)	25.00	79.59	70.13	13.61	83.74
F Test	Sig.	N.S.	N.S.	N.S.	N.S.
C D at 5%	2.45	-	-	-	-
S E m	-	2.96	4.13	0.83	4.61

applied nitrogen. Nitrogen at 120 kg N/ha (n_3) significantly increased the potassium uptake compared to potassium uptake at 60 kg N/ha (n_1) and 90 kg N/ha (n_2). The potassium uptake at 60 kg N/ha and 90 kg N/ha did not vary significantly. The uptake of potassium at 60th day after planting and at harvest were not affected by the nitrogen levels. The time of planting, variety and nitrogen interaction was found to significantly influence the potassium uptake by straw at 60th day after planting.

3.6.2 Potassium uptake by paddy grain

The data on potassium uptake by grain are presented in Table 14 and analysis of variance in Appendix XII.

It is evident from the table, that the time of planting significantly influenced the uptake of potassium by paddy grain. The early planted crop (T_2) had the highest potassium uptake by grain and it was significantly higher to that in late planted crops (T_3 and T_4). The potassium uptake in early planted crops (T_1 and T_2) were on par. Also, potassium uptake in the late planted crops (T_3 and T_4) and the early planted crop (T_1) were on par.

The varieties did not differ significantly in the potassium uptake by grain. However, Jaya had slightly higher potassium uptake than Sabari.

The levels of nitrogen had no significant effect on potassium uptake by grain. But nitrogen at 90 kg/ha (n_2) had more potassium uptake than nitrogen at 60 kg/ha (n_1) and 120 kg/ha (n_3). None of the interaction were found to significantly influence the potassium uptake by paddy grain.

3.6.3 Total potassium uptake

The data on total potassium uptake are given in Table 14 and the analysis of variance in Appendix XII.

The data show that the total potassium uptake was not significantly affected by the time of planting but it showed a decreasing trend upto October 25th planting (T_3) and thereafter showed a slight increase. The varieties did not vary significantly in the potassium uptake, but Jaya had more potassium uptake than Sabari.

Levels of nitrogen had no significant effect on the total potassium uptake. But nitrogen at 90 kg/ha had more potassium uptake than 60 kg N/ha and 120 kg N/ha. None of the interactions were found to significantly influence the total potassium uptake.

Discussion

DISCUSSION

An experiment to study the differential response of two medium duration rice varieties, Jaya and Sabari to different time of planting and graded doses of nitrogen was conducted during the mundakan season of 1980-'81 at the Research Station and Instructional Farm, Mannuthy. The results of the experiment are discussed below.

1. Growth characters

1.1 Height of plants

Mean height of plant at 30th day, 60th day after planting and at harvest was significantly influenced by time of planting. Early planting had markedly higher plant height at all stages of plant growth and the mean plant height showed a decreasing trend with delay in planting. Majid and Ahmed (1975) had reported similar trend in plant height with delay in transplanting. The higher plant height observed in the early planting can be attributed to the comparatively lower temperature, as seen from meteorological data, during the early period of growth. Kang and Heu (1976) observed that lower temperature during nursery period of rice resulted in higher plant height. Also, the early planted crop had the highest number of rainy days and total rainfall as compared to the later plantings. Tanaka et al. (1964) observed that rice produced more height in wet season. The decreasing trend in plant height noted in the later planting can be due to the comparatively higher temperature during their growing period. This is in agreement with the findings of Lin (1976).

The varieties Jaya and Sabari did not differ significantly in plant height.

The nitrogen levels had no significant effect on plant height in any of the stages of growth. But during the active vegetative phase of the crop and at harvest the height of the plants showed an increasing tendency when the level of nitrogen was increased from 60 kg/ha to 120 kg/ha. This is in agreement with the findings of Kalyanikutty et al. (1969); Raju and Rao (1969); Koyama (1973) and Rego (1973). The lack of significant response to levels of applied nitrogen can be due to the masking effect of available soil nitrogen, whereby, there was no difference in the amount of nitrogen available for absorption by the plant with the different levels of applied nitrogen.

Though the varieties did not differ significantly in plant height, the interaction between varieties and nitrogen levels was found to be significant (Table 2a).

Plant height of Sabari showed an increasing trend with increasing levels of nitrogen. Nitrogen at 120 kg/ha increased plant height significantly over 60 kg/ha and 90 kg/ha. No increasing trend in plant height was observed with higher levels of nitrogen in Jaya. This differential response of rice varieties to increased levels of nitrogen can be due to the higher nitrogen utilisation efficiency of Sabari.

1.2 Number of tillers per plant

At all stages of growth, the tiller production per hill was significantly influenced by the time of planting. The late planted crops were found to have higher number of tillers per hill than the early planted crops. The crop planted on October 25th was found to have maximum number of tillers in all the stages of growth. The tiller production revealed a peak at 60th day after planting and thereafter it declined at harvest.

The increased production of tillers in the later plantings can be attributed to the higher temperature during their early growth period. The mateorological data (Appendix I) show that the crop planted on 25th October and 9th November had higher maximum temperature at early stages of growth than other planting dates. Oka (1959); Ghosh (1961); and Vergara et al. (1970) reported that high temperature at initial stages of growth increased the tillering rate. The decrease in the final number of tillers at harvest can be due to the mortality of late produced tillers due to mutual shading resulting from the increased leaf area index after maximum tillering stage.

The varieties did not significantly vary in tiller production at 30th day after planting and at harvest. But Sabari had more number of tillers than Jaya in both stages. At 60th day after planting, Sabari recorded significantly higher number of tillers than Jaya. This is due to the variation in the tillering habit of the varieties.

The nitrogen levels were not effective in significantly increasing the number of tillers per hill.

But the observation of number of tillers at the various stages revealed that the number of tillers increased with higher levels of applied nitrogen. In all the stages, nitrogen at 90 kg/ha increased the number of tillers over that of 60 kg/ha. Nitrogen at 120 kg/ha also had higher number of tillers than that at 60 kg/ha. This results are in agreement with the findings of Das Guptd (1969); Kalyanikutty *et al*. (1969); Tanaka (1972); and Rego (1973).

1.3 Days to 50 per cent flowering

Days to 50 per cent flowering was significantly influenced by time of planting. The earlier plantings (T_1 and T_2) took minimum number of days to flower. The crop planted on 25th October took the highest number of days to flower, followed by that planted on 9th November. The influence of time of planting on the number of days to 50 per cent flowering has been reported by many workers (Biswas *et al*., 1975 and Majid and Ahmed 1975). Ramdoss and Subramanian (1980) found that September sowing of Bhavani flowered earlier than other sowing dates. Palaniswamy *et al*.(1968) found that rice cultivar CO-30, when planted later than September resulted in delayed flowering compared to crop planted in August.

The result of the present study is in conformity with the above findings. The delay in flowering noticed with delay in transplanting may be due to the effect of prevailing weather conditions on the heat sum required for flowering, as suggested by Biswas *et al.* (1975).

The varieties differed significantly in the number of days to 50 per cent flowering. Sabari took higher number of days for flowering than Jaya. This may be due to varietal character. The time of planting variety interaction significantly influenced the days required for flowering (Table 4 a). In both Jaya and Sabari the number of days to flowering tended to increase with delay in planting. The crop planted on 25th October had the highest number of days to 50 per cent flowering for both varieties. The nitrogen levels had no significant effect on days to 50 per cent flowering.

1.4 Days to maturity

The days to maturity was significantly affected by time of planting. Early planted crop had the shortest duration and it tended to increase with delay in planting. The influence of planting time on crop duration has been reported by many workers (Mahapathra *et al.*, 1973 and Lozano and Abruna 1975). Mahapathra *et al.* (1973) were of opinion that duration of the crop depended on the temperature summation. The temperature summation for short and medium duration variety varied from 3000 degree centigrade to 3300 degree centigrade. The variation in the duration of the crop planted at different dates can be attributed to the then prevailing weather condition at the growing period. The days to maturity is positively correlated to the number of days to flowering. Since the late planted crops took more number of days to flower, their days to maturity also increased.

Sabari took more number of days to mature than Jaya. This can be due to the varietal character. The interaction between the time of planting and varieties was significant (Table 4 a). In both varieties, days to maturity showed an increasing trend with delay in planting time. The earlier planted crops (T_1 and T_2) of Jaya did not differ significantly in duration.

2. Yield and yield attributes

2.1 Productive tillers

Productive tillers per square meter varied significantly with time of planting. Later plantings had higher number of productive tillers per square meter than the early plantings. The crop planted on 25th October had significantly higher number of productive tillers than all other dates of planting. Halappa *et al*. (1974) and Ramdoss and Subramonian (1980) found that time of planting significantly influenced the production of effective tillers. They observed significant reduction in productive tillers in September sown crop as compared to the earlier sown crop during *kharif* season. The results of the present study also show that September planting significantly reduced the number of productive tillers and is in agreement with their findings. Nel and Small (1969) opined that low night temperature increased ear number. The mateorological data (Appendix I) revealed that the night temperature was comparatively lower during the flowering period to harvest in the late planted crops.

Sabari recorded significantly higher number of productive tillers than Jaya. This can be a varietal character.

The nitrogen levels did not significantly influence the number of productive tillers produced. But the number of productive tillers increased with increase in levels of applied nitrogen. Nitrogen at 90 kg per hectare resulted in higher number of productive tillers than 60 kg per hectare and 120 kg per hectare. This is in agreement with the findings of Choudhary _et al_. (1969); Pande and Singh, 1970; Ishizuka, 1971; Koyama _et al_. (1973); Nair _et al_. (1973) Eunus and Sadeque (1974). The lack of significant response may be due to the fact that difference in levels of applied nitrogen was masked by the higher amount of available soil nitrogen, whereby, the net amount of available nitrogen for plant absorption was not limiting.

2.2 Percentage of productive tillers

The time of planting had no significant

influence on the percentage of productive tillers. As discussed in 1.2 and 2.1 above, time of planting significantly affected the total number of tillers at harvest and also the number of productive tillers. Percentage of productive tillers being a relative expression of these two factors, their proportionate change did not reflect in the percentage of productive tillers.

Though the varieties did not significantly differ in the percentage of productive tillers, Jaya had higher percentage of productive tillers than Sabari. This can be a varietal character.

Levels of nitrogen did not significantly increase the percentage of productive tillers. But the percentage of productive tillers increased when the level of nitrogen was increased from 60 kg/ha to 90 kg/ha and to 120 kg/ha. This is in agreement with the findings of Nair et al., 1973 and Padmaja (1976).

2.3 Length of panicle

The earlier plantings (T_1 and T_2) resulted in significantly lower panicles than that in later plantings (T_3 and T_4). Similar results were obtained by Mahapathra and Badekar (1968) and Ramdoss and Subramanian (1980).

The panicle length of varieties did not show significant differences. Levels of nitrogen had no significant effect on panicle length. But the panicle length showed an increasing trend with increasing levels of applied nitrogen. This is in agreement with the findings of Kalyanikutty __et al__., 1969 and Chaudhary __et al__., 1969. The lack of significant response to nitrogen levels may be due to the higher available soil nitrogen content of the soil.

2.4 Number of spikelets per panicle

The total number of spikelets was significantly higher in earlier planted crops (T_1 and T_2) than in late planted crops (T_3 and T_4). Similar results were obtained by Mahapathra and Badeker (1968) and Ramdoss and Subramanian (1980). The probable reason for the decrease in the number of spikelets per panicle with late planting can be that source was limiting the spikelet production compared to the higher sink capacity of the late planted crop. This is evident from the production of significantly higher number of productive tillers in the late planted crop.

Varieties did not differ significantly in the number of total spikelets per panicle. But Jaya had more number of spikelets than Sabari. This indicates the production potential of Jaya over Sabari.

Nitrogen levels significantly influenced the total number of spikelets per panicle. The number of spikelets per panicle increased steadily with increase in level of nitrogen. Nitrogen at 120 kg/ha had significantly more number of spikelets than 60 kg/ha. Tanaka (1972) opined that heavy nitrogen application decreased the number of spikelets per panicle due to the increase in sink capacity resulting from higher production of effective tillers. But in the present study, the higher level of nitrogen at 120 kg/ha did not significantly increase the number of productive tillers. Hence the higher sink capacity resulting from higher level of nitrogen was reflected through the production of significantly higher number of spikelets per panicle.

2.5 Filled grains per panicle and percentage of filled grains

The number of filled grains per panicle showed a decreasing trend with delay in transplanting. The early plantings (T_1 and T_2) recorded significantly higher number of grains per panicle compared to the later plantings (T_3 and T_4). Palaniswamy **et al.** (1968) found that the number of filled grains varied significantly with time of planting. Majid and Ahmed (1975) and Nho **et al.** (1976) observed a marked decrease in the number of filled grains when planting time was delayed. The results of the present study is also in confirmation to the above findings. The reason for the significantly lower number of filled grains per panicle in the later plantings is that source was a limiting factor compared to the higher sink in the late planted crops. This is evident from the significantly higher number of productive tillers per square metre produced in the late planted crops compared to the early planted crops. The percentage of filled grains also was found to be significantly higher in early planted crop and it showed a decreasing trend with delay in planting. The results of the present study is in agreement with findings of Liou (1975) and Nho et al. (1976). The higher wind velocity and higher air temperature between heading and ripening phase of late planted cropsincreased the spikelet sterility through higher evaporating rate and desication of the spikelets. This decreased the percentage of filled grains in late planted crop.

The varieties did not differ significantly in the number of filled grains or in the percentage of filled grains. But the time of planting variety interaction was found to influence the percentage of filled grains significantly (Table 6a). In Sabari, the percentage of fertile grains decreased markedly, with delay in planting time thereby indicating that it is more sensitive to planting time. But no such trend was noted in Jaya.

The levels of nitrogen were found to increase the number of grains per panicle. However it was not statistically significant. Chaudhary et al.(1969) observed a positive correlation between the number of fertile grains per panicle and nitrogen levels in $T (N)_1$ and IR-8. Similar results were obtained by

Kalyanikutty *et al.* (1969), Pande and Singh (1970); Izhizuka (1971) and Nair *et al.* (1973). The result of the present study also is in confirmation with the above findings.

Increasing levels of nitrogen were found to decrease the percentage of fertile grains, though it was not statistically significant. This is in agreement with the findings of Tanaka *et al.* (1964). Since the higher nitrogen levels tend to decrease the percentage of fertile grains it can be inferred that increased nitrogen levels had more pronounced effect in increasing the total number of spikelets than the number of filled grains. The percentage of filled grains and the percentage of spikelet sterility were found to have negative correlation.

2.6 1000 Grain weight

The 1000 grain weight was found to show a decreasing trend with delay in planting time. However it was not statistically significant. This is in agreement with the findings of Liou (1975) K.A.U. 1980, Annual Report 1979-80. The probable reason for this decreased trend can be the unbalanced source sink relation in the late planted crops. The higher air temperature was reported to accelerate the development of kernal in early stage of ripening period but depressed them at later stages. This hastened the ripening process and reduced the grain weight (Nagato *et al.* 1966). The mateorological data shows that maximum air temperature increased in the ripening phase of the late planted crops.

The varieties did not differ significantly in 1000 grain weight.

The nitrogen levels had no significant effect on 1000 grain weight. But 1000 grain weight showed a slight increase when nitrogen level was increased from 60 kg/ha to 120 kg/ha. This is in agreement with the findings of Kalyanikutty *et al.* (1969); Pandey and Singh (1970) and Padmaja (1976).

2.7 Grain yield

Early planted crops (T_1 and T_2) recorded significantly higher grain yield than the late planted crops (T_3 and T_4). The grain yield showed a decreasing trend with delay in planting time, but the crop planted on 10th October (T_2) recorded the highest grain yield. The influence of time of planting on grain yield has been reported by many workers. Palaniswamy et al. (1968) observed significant yield reduction when CO-30 rice variety was sown later than September. Nanda et al. (1976) also found September sowing to be the best for obtaining higher grain yield with rice varieties Ratna, Vijaya, Jayanthi and Bala. Rajagopalan et al. (1973); Halappa et al. (1974); Liou (1975) and Balasubramanian et al. (1978) also got similar results. The results of the present study are in confirmity with the above findings. The significantly higher panicle length, higher number of total spikelets per panicle, higher number of filled grains per panicle, higher percentage of filled grains and the comparatively higher 1000 grain weight contributed to the markedly higher grain yield in the early planted crop than late planted crop. Though all the yield attributes in the early planted crops (T_1 and T_2) were on par, the crop planted on 10th October (T_2) had slightly higher grain yield than the crop planted on 25th September (T_1). The reason for this increased yield is the optimum source sink relation observed in 10th October planting (T_2). The slightly longer panicles, higher number of total spikelets and higher number of productive tillers, observed in 10th October planting over that observed in 25th September planting, coupled with the almost same number of filled grains per panicle in both 25th September and 10th October plantings (T_1 and T_2) is indicative of better source sink relation in crop planted on 10th October (T_2). The final contributing factor for the yield increase in the crop planted on 10th October (T_2) was the increase in number of grains per unit area.

The varieties did not differ significantly in grain yield. But Jaya recorded higher yield than Sabari. The higher grain yield of Jaya over Sabari can be attributed to the higher values of all the yield contributing factors, except the number of productive tillers.

The grain yield was not significantly affected by fertilizer levels. But grain yield increased with higher levels of applied nitrogen. Nitrogen at 90 kg/ha increased grain yield from that at 60 kg/ha and at 120 kg/ha. Positive influence of higher levels of applied nitrogen on grain yield has been reported by many workers. Sreedharan and George (1968) obtained progressive increase in yield with increased levels of nitrogen upto 160 kg N/ha in rice variety IR-8. Similar results were obtained by Kalyanikutty et al. (1969); Mahatim Singh and Singh (1972); Kadrekar and Mehta (1975); Varma et al. (1975); Lerch (1976) and Singh et al. (1977). However, heavy application of nitrogen beyond an optimum level has been reported to induce a negative response (IRRI, 1963; Tanaka, 1966 and Padmaja, 1976). The results of the present study showed an increase in grain yield with higher levels of applied nitrogen. However application of 120 kg N/ha slightly decreased the yield compared to the grain yield with 90 kg N/ha. However the increase in grain yield was not statistically significant. This is in confirmity with the above findings.

2.8 Dry matter production

The dry matter production at 30th day after planting was not significantly affected by time of planting. But dry matter production at 60th day after planting and at harvest were, markedly affected by the time of planting. The dry matter production at 60th day after planting showed a decreasing trend upto the crop planted on October 25th (T_3), but increased in the crop planted on 9th November, and it recorded the highest dry matter production. The increase in dry matter production can be due to higher nutrient absorption efficiency of the crop planted on 9th November. Kang and Hsu (1976) observed that lower daily average temperature and longer period daily sunshine from transplanting to panicle initiation gave greater total dry weight. At harvest the crop planted on 10th October had significantly higher dry matter accumulation than the late planted crops. The dry matter production in the early plantings were on par, and so was in the later plantings. The crop planted on 25th October had the lowest dry matter production at all stages of growth. The comparatively lower temperature during the flowering and grain filling stage coupled with high light intensity resulted in higher net photosynthetic production in the earlier planted crop (Lin, 1976). This was exhibited through the production of lengthy panicles and higher number of filled grains, per panicle.

The influence of time of planting on dry matter production has been reported by many workers. (Faw and Johnson, 1975 and Lerch, 1976). Faw and Johnson (1975) found that late sowing reduced dry matter production. The increased dry matter production can be attributed to the then prevailing weather condition during the growth period of early planted crop.

The varieties did not differ significantly in the dry matter accumulation in any of the stages of growth. But Jaya had more dry matter production than Sabari in all stages of growth and it indicates that Jaya has high growth, vigour and high yield potential.

The nitrogen levels significantly affected the dry matter production at 30th day after planting. The dry matter production increased with levels of nitrogen. Nitrogen at 120 kg/ha increased the dry matter production significantly over that at 60 kg/ha. Increased dry matter production with nitrogen application has been reported by many workers. Das Gupta (1969) obtained increased dry matter production by nitrogen application with two varieties of swamp rice.

Similar results have been obtained by Varma (1972); Beye (1977); Haque (1977) and Chinnaswamy and Chandrasekharan (1977). The dry matter production at 30th day after planting is in confirmity with the above findings. Dry matter production at 60th day after planting was not affected by nitrogen levels. This may be due to the masking effect of the available soil nitrogen, whereby the differences in the levels of applied nitrogen was nullified, and available nitrogen for absorption by the crop was not limiting. But at 30th day after planting the effect of soil nitrogen might not have started to exercise as the root system was not well developed at the early stages. But the demand for nitrogen is higher at the early stage. Also the relative proportion of applied nutrients nitrogen, phosphorus and potash at early stages might have been in the optimum ratio which facilitated rapid absorption of the nutrients. Migel (1978) found the optimum ratio of nutrients were 4 nitrogen + 4 phosphorus + 2 potash for increased absorption by plant. Sadanandan et al. (1969) reported that maximum utilization of nitrogen occurs during tillering and flowering phases. Hence, the significant response to applied nitrogen was obtained at 30th day after planting. At harvest, nitrogen at 90 kg/ha resulted in higher dry matter production than nitrogen at 60 kg/ha but the increase was not significant. Dry matter production at 120 kg N/ha was also higher than that in 60 kg N/ha, but was less than that at 90 kg N/ha. But the differences were not statistically significant. This is in agreement with the results discussed earlier.

2.9 Straw yield

The straw yield was not significantly influenced by time of planting. The highest straw yield was recorded by the crop planted on 10th October (T_2) and thereafter straw yield showed a decreasing trend with delay in planting. Palaniswamy et al. (1968) obtained more straw yields with late September - early October planting and early - mid October planting, than earlier plantings. The present study also showed higher straw yield with late September planting and early October plantings and this is in confirmity to their findings.

The varieties did not differ significantly in straw yield. But Jaya recorded higher straw yield than Sabari. This can be a varietal character.

The levels of nitrogen were not effective in significantly increasing the straw yield.

2.10 Grain straw ratio

Time of planting had no significant effect on grain straw ratio. But it showed a decreasing trend with delay in planting time. This decreasing trend indicates that the translocation of stored photosynthates in the straw before flowering decreased with delayed planting and also that net photosynthetic production was higher in earlier planted crops.

The varieties did not significantly vary in the grain straw ratio. But nitrogen levels significantly affected the grain straw ratio. Nitrogen at 90 kg/ha significantly increased the grain straw ratio. But higher levels of nitrogen has been reported to decrease the translocation of photosynthetes stored in straw to the grain and thereby decrease the grain straw ratio.(Murayama <u>et al</u>., 1955; Tanaka <u>et al</u>., 1964; Osada, 1967 and Yoshida, 1972). But in the present study no such trend was noticed. However, Sandchez <u>et al</u>. (1973) got high grain straw ratio with higher levels of nitrogen. The results of the present study is in agreement with the above finding. It can be inferred that nitrogen at 90 kg/ha enhanced the photosynthetic production.

2.11 Harvest index

The harvest index was significantly influenced by the time of planting. Earlier planting (T_1) had significantly higher harvest index than the late plantings. It showed a decreasing trend with delay in transplanting. Harvest index followed the same trend as grain straw ratio. The higher harvest index in the early planting indicate that a higher portion of photosynthate was translocated to sink.

The varieties did not vary significantly in the harvest index. But Sabari had higher harvest index than Jaya. This can be a varietal character.

The nitrogen levels significantly influenced the harvest index. Nitrogen at 90 kg/ha gave significantly higher harvest index than that at 60 kg/ha and 120 kg/ha. It indicates that nitrogen application at 90 kg/ha increased the proportion of total photosynthate translocated to the sink.

3. Chemical analysis

3.1 Nitrogen content of plant parts

3.1.1 Nitrogen content of straw

The nitrogen content was highest at 30th day after planting and it gradually decreased with age (Fig.7). This observation is in accordance with the findings of Sadanandan et al. (1969). In all stages of growth, the crop planted on 25th October (T_3) recorded markedly higher percentage of nitrogen. At 30th day after planting and 60th day after planting, the late planted crops had significantly higher percentage of nitrogen than the early planted crop. It seems that the comparatively higher air temperature during the early stages of late planted crop enhanced the nitrogen absorption at 30th day and 60th day after planting. It also appears that nitrogen content at these stages are closely related to the corresponding dry matter production, the relation being inverse. The crop planted on 25th October (T_3) recorded the highest nitrogen content and also the lowest dry matter production in all the stages of growth. This indicates that the time of planting had more pronounced effect on dry matter production rather than the amount of nitrogen absorbed by the plants. Chiu et al. (1961)

opined that high temperature increased nitrogen absorption. The higher nitrogen content in straw at harvest, observed in the crop planted on 25th October indicates a reduction in translocation of absorbed nitrogen to grain.

There was no marked difference in the nitrogen content of the varieties, in any of the stages of growth.

The levels of nitrogen did not impart any significant effect on the nitrogen content of straw at any of the stages of growth. But higher levels of nitrogen were noted to increase the nitrogen content of straw. This is in agreement with the findings of Sadanandan *et al.* (1969); Varma (1972); Khan and Pathak (1976) and Thiruvakkarasu (1978). The lack of significant response to higher levels of nitrogen can be due to the presence of sufficient quantity of available soil nitrogen for plant absorption. Bredero (1965) observed that nitrogen was absorbed independently of the pattern and rate of nitrogen application, provided sufficient soil nitrogen was available for uptake.

The different planting times did not significantly influence the nitrogen content of grain. But the nitrogen content of grain was observed to decrease with delay in planting (Fig.5). This can be due to the decrease in nitrogen translocation to grain.

The grain nitrogen content of the varieties did not vary significantly. But Jaya had higher grain nitrogen content. This can be due to the higher translocation of stored nitrogen to grain, and may be a varietal character.

The nitrogen levels did not significantly increase the grain nitrogen content. But nitrogen content of grain was found to increase with higher levels of nitrogen application. Increase in nitrogen level from 60 kg/ha to 90 kg/ha increased the grain nitrogen content. This is in agreement with the findings of Varma (1972) and Khan and Pathak (1976).

3.1.3 Protein content of grain

The grain protein content was not significantly affected by time of planting. But the early planted crop (T_1) was found to have higher protein content than other dates of planting. The crop planted on 10th October (T_2) had the lowest protein content and thereafter showed an increasing trend with delay in planting. The influence of weather conditions on grain protein content was reported by many workers (Honsu, 1971; Denium, 1971; De Datta, 1972 and Nanda et al., 1976). De Datta et al. (1972) opined that grain protein content was higher in wet season than in dry season. The early planted crop had the maximum number of rainy days and total rainfall. Denium (1971) opined that the high light intensity exhausted the nitrogen reserve and diminish the crude protein content. The later planting had higher number of sunny days and lower protein content. The results of the present study agree with the above findings.

The varieties did not differ significantly in the grain protein content. But Jaya had higher grain protein content than Sabari. Probably, this is a varietal character.

Nitrogen content with 90 kg/ha was noted to give higher grain protein content than that at 60 kg/ha and 120 kg/ha. But the increase was not statistically significant. Influence of applied nitrogen on grain protein content was found to increase with increasing levels of applied nitrogen (Ramanujam and Rao, 1970; Rego, 1973; Kadrekar et al., 1975; Kothandaraman, 1975;

Pisharady, 1976; Rabindra **et al.**, 1977 and Sidayappan and Kolandaiswamy, 1978). However, Muthuswamy **et al.** (1973) could not get any increase in protein content by different levels of nitrogen. The present study showed that the grain protein content increased with higher levels of nitrogen. The protein content with 90 kg N/ha and 120 kg N/ha was higher than that with 60 kg N/ha. The results of the present study is in agreement with the findings of the above workers.

3.2 Uptake of nitrogen by plant parts

3.2.1 Uptake of nitrogen by straw

Uptake of nitrogen at 60th day after planting was significantly influenced by time of planting, while that at 30th day after planting and at harvest were unaffected. The late planted crop (T_4) had significantly higher nitrogen uptake than all other dates of planting. This can be ascribed to the higher dry matter production observed at corresponding stage of growth. Uptake of nitrogen increased considerably during the period from 30th day after planting to 60th day after planting. This indicate that major part of nitrogen absorption takes place during this period. Nitrogen uptake at harvest was found to decrease, probably due to the translocation of nitrogen to grain.

The varieties did not differ significantly in nitrogen uptake. But the nitrogen uptake was higher in Jaya at 30th day after planting and it was just the reverse at later stages. This is due to the difference in dry matter production of the varieties at the corresponding stages of growth.

The nitrogen levels did not markedly influence the uptake of nitrogen. But nitrogen content of straw increased when nitrogen level was increased from 90 kg/ha to 120 kg/ha. The uptake of nitrogen followed the pattern of dry matter production at corresponding levels of nitrogen application. The results of the present study is in agreement with the findings of Sadanandan et al. (1969). However, Loganathan and Raj (1972) reported that the nitrogen uptake was not affected by variation in dosage of nitrogen supplied to the soil even with 160 kg/ha. This may be due to the variation in fertility status of soil.

3.2.2 Uptake of nitrogen by grain

The time of planting significantly affected uptake of nitrogen by grain. The earlier planted crops had significantly higher uptake values than that of late planted crops. Uptake of nitrogen progressively decreased with delay in planting time. The higher nitrogen uptake by grain in early planted crops can be attributed to higher panicle weight of early planted crops.

The varieties did not differ markedly in nitrogen uptake by grain. But Jaya recorded higher nitrogen uptake than Sabari. This can be attributed to the higher nitrogen content of grain and higher grain dry matter production observed in Jaya.

The nitrogen levels were not effective in increasing grain uptake of nitrogen. This is because the dry weight of panicle was not significantly affected by nitrogen levels.

3.2.3 Total nitrogen uptake

The early planted crops had significantly higher total nitrogen uptake than late planted crops. The uptake pattern exhibited a decreasing trend with delay in planting. This can be attributed to the pattern of straw and grain dry matter accumulation.

The varieties did not significantly vary in total uptake of nitrogen. But Jaya had more nitrogen uptake than Sabari and followed the pattern of dry matter accumulation of the varieties.

The nitrogen levels did not significantly affect the total nitrogen uptake. But higher levels of nitrogen increased total nitrogen uptake. This is in agreement with the findings of Varma (1972) and Khan <u>et al</u>. (1976).

3.3 Phosphorus content of plant parts

3.3.1 Phosphorus content of straw

Phosphorus contents of straw at 30th day after planting and 60th day after planting were unaffected by time of planting. But at harvest, the late planted crop (T_4) recorded significantly lower phosphorus content than that of other planting dates. The pattern of phosphorus content at harvest was found to be similar to that of nitrogen content at harvest. The late planted crop(T_4) had the lowest nitrogen content at harvest. Sadanandan <u>et al</u>.(1969) found that uptake of nitrogen and phosphorus are significantly corralated. Varma (1972) observed that percentage of phosphorus translocated to the grain decreased with increase in nitrogen content of straw. The observed low phosphorus content of straw at harvest in the late planted crop (T_4) can be due to translocation of increased proportion of phosphorus to the grains, which was facilitated by the low nitrogen content of straw.

The varieties significantly differed in phosphorus content of straw at 30th day after planting. Jaya had higher phosphorus content than Sabari. The higher nitrogen content in straw at the corresponding stage of growth would have increased the phosphorus absorption due to the significant positive correlation observed between them.

The nitrogen levels did not affect the phosphorus content of straw at 30th day after planting and 60th day after planting. But the nitrogen levels significantly influenced the phosphorus content of straw at harvest. The phosphorus content increased with the levels of nitrogen. The phosphorus content of straw at 120 kg N/ha was significantly higher than that at 60 kg N/ha. This is in accordance with the findings of Sadanandan et al. (1969). Due to the significant correlation observed in uptake of nitrogen and phosphorus absorption of higher amount of phosphorus was recorded with higher levels of applied nitrogen. Application of higher levels of nitrogen increased initrogen uptake by straw which in turn increased the phosphorus uptake.

3.3.2 Phosphorus content of grain

Time of planting influenced phosphorus content of grain significantly. A progressive reduction in phosphorus content of grain was observed with delay in planting time. The effect of time of planting on phosphorus content of grain is rather indirect. As evident from fig. the phosphorus content of straw at harvest is rather high except in the late planted crop (T_4). So it can be presumed that the variation in grain phosphorus content is not the direct effect of difference in absorption of the nutrient, but is the result of the difference in the proportion of absorbed nutrient translocated to the grain. It is seen from the Table 10 and 11 that nitrogen phosphorus ratio of grain is almost same in all the planting times except the late planting (T_4), where it was higher. Hence the difference in the phosphorus content of grain in all the planting times except T_4 was determined by the nitrogen content of grain and lower nitrogen content of grain limited the phosphorus content of grain. But in the late planted crop (T_4), the nitrogen content of grain was not a limiting factor as the nitrogen phosphorus ratio was higher. The phosphorus content of straw in (T_4) the late planted crop at harvest was the lowest and as such a higher proportion of absorbed phosphorus would have been translocated to grain, since the nitrogen content of grain was not limiting (Fig.5). The limiting factor of low phosphorus content of grain in the late planted crop (T_4) is the low amount of phosphorus absorbed by the plant.

The varieties did not differ in phosphorus content of grain. But Jaya had higher phosphorus content. This was so because of Jaya had higher grain nitrogen content.

The applied nitrogen levels had no significant effect on grain phosphorus content. But the phosphorus uptake by grain was found to increase with higher levels of nitrogen (Fig.5). Nitrogen at 90 kg/ha and 120 kg/ha had higher phosphorus uptake than at 60 kg/ha. This is in agreement with the findings of Kanwar and Seghal (1962); Bredero (1965) and Sadayappan and Kolandaiswamy (1978).

3.4 Uptake of phosphorus by plant parts

3.4.1 Uptake of phosphorus by straw

The time of planting significantly affected the phosphorus uptake by crop at 30th day and 60th day after planting, but not at harvest. At 30th day after planting the phosphorus content of straw showed a decreasing trend with delay in planting time. At 60th day after planting the late planted crop (T_4) had the highest phosphorus uptake. Phosphorus uptake showed a decreasing trend with delay in planting time, but for the late planted crop (T_4). At harvest, phosphorus uptake progressively decreased with delay in planting time. This trend can be attributed to the effect of time of planting on dry matter production and phosphorus content of straw.

The varieties significantly differed in the phosphorus uptake at 30th day after planting, but not in other stages. Jaya recorded higher phosphorus uptake than Sabari. Probably this is because of the observed positive correlation between nitrogen uptake and phosphorus uptake. Jaya had higher nitrogen uptake, and it influenced the phosphorus uptake.

The nitrogen levels significantly increased phosphorus uptake at 30th day after planting and at harvest, but it was unaffected at 60th day after planting. But at all stages the phosphorus uptake was found to increase with higher levels of nitrogen. This result is in confirmity with the findings of Bredero (1965); Sadanandan *et al.* (1969); Sadayappan and Kolandaiswamy (1978). The phosphorus uptake increased considerably during the period from 30th day after planting to 60th day of planting, indicating that phosphorus is absorbed continuously upto 60th day after planting.

3.4.2 Phosphorus uptake by grain

The uptake of phosphorus by grain steadily decreased with delay in planting time. Early planting (T_1 and T_2) recorded significantly higher phosphorus uptake than late planting. This trend in phosphorus uptake can be ascribed to the effect of time of planting on the grain dry matter production. Phosphorus uptake was observed to closely follow the nitrogen uptake pattern. The varieties did not differ significantly in phosphorus uptake by grain.

The nitrogen levels had no significant effect on phosphorus uptake by grain. But the higher levels of nitrogen were noted to increase phosphorus uptake by grain. The phosphorus uptake by grain increased with higher levels of nitrogen. Nitrogen at 90 kg/ha recorded higher phosphorus uptake than that at 120 kg/ha. This is in agreement with the findings of Bredero (1965); Sadanandan et al. (1969) and Sadayappan and Kolandaiswamy (1978).

3.4.3 Total phosphorus uptake

The total phosphorus uptake in the early planting was significantly higher than that of late planting. The total phosphorus uptake steadily decreased with delay in time of planting. The observed trend in total phosphorus uptake can be ascribed to the influence of the time of planting on dry matter production.

The varieties did not differ significantly in total phosphorus uptake. But Jaya had more total phosphorus uptake than Sabari. This is discussed in 3.4.2 above.

Nitrogen levels did not increase the total phosphorus uptake significantly. But uptake of total phosphorus increased with higher levels of applied nitrogen. This is in accordance with the findings of Bredero (1965); Sadanandan et al. (1969) and Sadayappan and Kolandaiswamy (1978).

3.5 Potassium content of plant parts

3.5.1 Potassium content of straw

Planting times had no significant effect in the potassium content of straw in any of the stages of growth. The potassium content during early stages of growth was noted to be higher and it slowly decreased with age of the plant, recording the lowest potassium content at harvest (Fig.5).

Sabari recorded significantly higher percentage of potassium than Jaya at 60th day of sowing. In other stages also Sabari had higher potassium content. This can be due to the luxury consumption of potassium by Sabari.

The nitrogen levels had no significant effect on the potassium content in any of the stages of growth. Loganathan and Raj (1972) reported that potassium uptake was not affected by variation in dosage of nitrogen supplied to soil.

3.5.2 Potassium content of grain

The crops planted on 10th October (T_2) and 25th October (T_3) had significantly higher grain potassium content than the early planted crop (T_1). The effect of time of planting on potassium content of grain seems to be indirect; by affecting the nitrogen content of grain. There appears to be a negative relation between nitrogen content of grain and potassium content of grain (Fig.5). In crops planted on 10th (T_2) October and 25th October (T_3) the grain nitrogen content was lowest and the potassium content of grain was highest. In crop planted on 25th September (T_1) the grain nitrogen content was highest. This relationship was noted in the late planted crop (T_4)also. This negative relationship between grain nitrogen content and potassium content becomes all the more clear from the fact that at harvest the potassium content of straw in the crop planted on 25th September (T_1) was highest, but the grain potassium at T_1 was the lowest, while that in 10th October and 25th October planting (T_2 and T_3) were lowest and corresponding potassium content of grain was highest; thereby indicating that the translocation of absorbed potassium to grain was not decided by the amount of potassium available, but by the amount of nitrogen translocated to the grain. In crops planted on 25th September and 9th November (T_1 and T_4) the limiting factor for low grain potassium content was the high nitrogen content of grain.

The varieties did not differ significantly in grain potassium content. But Sabari had higher grain potassium content than Jaya. Here also the negative relation of grain nitrogen on grain potassium was evident.

The nitrogen levels had no significant effect on grain potassium content. But with 90 kg N/ha the grain potassium content decreased. This was due to the higher grain nitrogen content at 90 kg N/ha.

3.6 Potassium uptake by plant parts

3.6.1 Potassium uptake by straw

The time of planting significantly increased the potassium uptake by straw at 60th day after planting, while potassium uptake at 30th day after planting and at harvest was unaffected. The potassium uptake by the crops planted on 25th September and 9th November (T_1 and T_4) were significantly higher than the crop planted on 10th October and 25th October (T_2 and T_3). The late planted crop (T_4) recorded the highest potassium uptake. This is attributed to the influence of planting time on dry matter accumulation. The potassium uptake was the lowest at early stages and reached the maximum at 60th day of planting and continued absorption upto harvest, indicating high luxury consumption of the nutrient.

Sabari had significantly higher potassium uptake than Jaya at 60th day after planting. This can be due to the higher luxury consumption of this nutrient by Sabari. The potassium uptake at 30th day after planting was significantly increased by nitrogen levels. Nitrogen at 120 kg/ha significantly increased potassium uptake over 60 kg/ha and 90 kg/ha. But nitrogen levels had no effect at 60th day after planting and at harvest. The increase in potassium uptake at 30th day after planting can be ascribed to the combined effect of dry matter accumulation and its potassium content.

3.6.2 Potassium uptake by grain

Time of planting significantly influenced the grain uptake of potassium. The crop planted on 10th October (T_2) recorded markedly higher uptake of potassium in grain than all other planting times. This can be attributed to the higher panicle weight of the crop planted on 10th October.

The potassium uptake by varieties did not differ significantly. But Jaya had more potassium uptake than Sabari.

The nitrogen levels were not found to influence potassium uptake by grain significantly. But the grain potassium uptake slightly increased with higher levels of applied nitrogen. This is in agreement with the findings of Bredero (1965); Ramanajuam (1967); Sadayappan and Kulandaiswami (1978). The effect of time of planting on uptake of grain potassium was by influencing the dry matter accumulation and potassium content of grain.

3.6.3 Total potassium uptake

The total uptake of potassium was not significantly influenced by the time of planting. The early planting (T_1) had higher potassium uptake but showed a decreasing trend with delay in planting time.

Jaya had higher total potassium uptake than Sabari, though the difference was not statistically significant.

Nitrogen levels had no significant effect on total potassium uptake. But the total potassium uptake at 90 kg N/ha was found to be higher than other levels of nitrogen. The observed trends can be ascribed to the effect on dry matter accumulation and potassium content of plant parts.

Summary

SUMMARY

An experiment to study the differential response of two medium duration rice varieties, Jaya and Sabari, to time of planting and graded doses of nitrogen was under taken during the *mundakan* season of 1980-'81, at the Research Station and Instructional Farm, Mannuthy. The experiment was laid out in split plot design. The treatments consisted of combination of four time of planting (September 25th, October 10th, October 25th and November 9th) and two varieties in the main plot and 3 levels of nitrogen (60 kg, 90 kg and 120 kg/ha) in the sub plots.

Observations on the growth characters were taken on 30th day, 60th day after planting and at harvest. The chemical composition of the plant at these stages were also determined. At harvest the grain and straw were chemically analysed separately. The crop was harvested when 85 per cent of the panicles in the plot matured. The results of the study are summarised below.

The time of planting significantly influenced the growth of the crop at all stages of growth. Delay in planting time significantly reduced the plant height and

tiller production at all stages of growth. Early planting (September 25th) of the crop significantly decreased the number of days to 50 per cent flowering and maturity and showed an increasing trend with delay in planting time. Early planting had a positive influence on the yield attributes of rice. Delayed planting exhibited a decreasing trend on the number of total spikelets, filled grains, percentage of 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.

The nitrogen content of straw at all stages of growth and phosphorus content of straw at early stages significantly decreased with delayed planting. November 9th planting (T4) increased the phosphorus content of straw at harvest. Nitrogen uptake by grain and total nitrogen, phosphorus and potassium uptake at harvest showed a decreasing trend with delay in planting time.

The optimum time of planting rice in mundakan season under the agroclimatic conditions of Mannuthy is late September to early October.

Sabari took more number of days to flowering and to maturity and produced significantly higher number of productive tillers and number of branches per panicle than Jaya. Early planted crop (September 25th) recorded significantly higher percentage of grains than other planting dates. Sabari planted on October 25th took the longest period for earing.

Total dry matter production and total number of spikelets per panicle increased significantly with 120 kg N/ha. Application of 90 kg N/ha significantly increased the harvest index and grain straw ratio. At early stages of growth, nitrogen at 120 kg/ha increased the content of nitrogen, phosphorus and potassium in straw. The 1000 grain weight and the protein content of grain were not found to be affected by levels of nitrogen.

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*Originals not seen

Appendices

APPENDIX I

Weather data - Weekly averages, from 1st of September 1980 to 24th February 1981

Date	Week	Temperature C°		R.H.%	Total rainfall m.m.	No. of rainy days	Wind speed km/h.	Evaporation m.m.	Sunshine* hrs.
		Maximum	Minimum						
1--9--80 to 7--9--80	1	29.75	23.6	83.64	1.42	5/7	5.71	3.24	
8--9--80 to 14-9--80	2	30.71	23.81	79.07	-	-	4.67	3.66	
15-9--80 to 21-9--80	3	30.98	23.44	79.07	0.14	1/7	4.20	3.50	
22-9--80 to 28-9--80	4	31.31	23.38	82.07	12.84	7/7	3.26	2.41	
29-9--80 to 5-10--80	5	30.55	23.73	81.86	8.24	5/7	2.97	2.28	
6--10-80 to 12-10-80	6	32.10	23.61	81.00	28.87	4/7	2.63	2.01	
13-10-80 to 19-10-80	7	30.15	22.85	84.57	11.88	6/7	2.23	2.06	
20-10-80 to 26-10-80	8	30.61	23.81	84.07	4.14	5/7	2.23	2.50	
27-10-80 to 2--11-80	9	32.47	22.50	65.5	-	-	3.51	3.66	
3--11-80 to 9--11-80	10	32.51	23.34	72.28	6.16	2/7	3.20	3.20	

(Contd.)

APPENDIX-I (Contd.)

Date	Week	Temperature °C Maximum	Temperature °C Minimum	R.H.%	Total rainfall m.m.	No.of rainy days	Wind speed km/ha	Evapo-ration m.m.	Sun-shine hrs*
10-11-80 to 16-11-80	11	31.73	23.64	72.64	8.12	3/7	4.94	3.61	
17-11-80 to 23-11-80	12	31.18	23.40	78.07	17.50	4/7	3.78	2.16	
24-11-80 to 30-11-80	13	31.73	22.68	66.21	-	-	4.07	3.81	
1--12-80 to 7--12-80	14	31.34	21.84	69.20	-	-	5.0	4.50	
8--12-80 to 14-12-80	15	32.30	23.20	74.36	-	-	3.01	3.71	
15-12-80 to 21-12-80	16	31.14	22.70	63.00	-	-	8.58	6.50	
22-12-80 to 28-12-80	17	31.00	21.77	72.07	0.36	2/7	4.10	3.54	
29-12-80 to 4--1--81	18	31.70	22.94	61.00	-	-	10.01	6.91	
5--1--81 to 11-1--81	19	31.90	20.27	69.70	-	-	4.41	4.60	
12-1--81 to 18-1--81	20	31.97	21.55	66.00	-	-	9.25	6.45	

(Contd.)

APPENDIX-I (Contd.)

Date	Week	Temperature °C		R.H.%	Total rainfall m.m.	No. of rainy days	Wind speed km/ha	Evaporation m.m.	Sunshine hrs*
		Maximum	Minimum						
19-1--81 to 25-1--81	21	32.87	21.95	64.93	-	-	6.5	5.47	
26-1--81 to 1--2--81	22	32.91	21.18	55.85	-	-	8.4	7.37	
2--2--81 to 8--2--81	23	34.05	19.12	61.20	-	-	4.95	6.54	
9--2--81 to 15-2--81	24	33.60	22.80	75.64	0.8	1/7	2.95	4.28	
16-2--81 to 22-2--81	25	35.45	19.80	46.21	-	-	7.33	9.44	
23-2--81 to 1--3--81	26	36.77	21.50	53.00	-	-	5.05	7.57	

* Data not available

APPENDIX - II

Analysis of variance for plant height, days to 50 per cent flowering and days to maturity.

Source	df	Mean squares				
		30th day after planting	60th day after planting	At harvest	Days to 50% flowering	Days to maturity
Block	2	325.09**	189.03*	204.30**	0.29	0.26
Time of planting (T)	3	230.30**	558.07**	378.60**	1049.97**	275.79**
Varieties (V)	1	156.05	86.88	52.02	975.34**	847.35**
T x V	3	3.86	5.97	13.25	71.27**	30.93**
Error (1)	14	34.62	33.60	14.79	0.75	0.517
Nitrogen (N)	2	25.34	13.11	2.21	1.54	0.013
T x N	6	10.88	1.95	1.10	1.004	0.85
V x N	2	6.06	32.05*	0.79	0.51	1.09
T x V x N	6	7.70	17.37	9.82	3.16**	0.41
Error (2)	32	9.74	8.85	9.15	0.67	0.36

* Significant at 5% level
** Significant at 1% level

APPENDIX - III

Analysis of variance for tillers/hill, productive tillers and percentage production tillers.

Source	df	Mean squares				
		30th day after planting	60th day after planting	Harvest	Productive tillers/m2	Percentage of productive tillers
Block	2	2.33	0.57	1.12	5279.17	290.1
Time of planting (T)	3	63.36**	32.61**	30.53**	42732.75**	264.35
Varieties (V)	1	3.47	35.7**	9.97	18208.68*	108.88
T x V	3	1.63	2.20	0.23	1270.72	135.21
Error (1)	14	2.86	2.93	2.91	2872.82	112.54
Nitrogen (N)	2	0.24	0.22	1.14	4246.87	61.83
T x N	6	1. 29	1.07	0.55	2440.39	24.47
V x N	2	2.03	2.39	1.25	4285.76	40.63
T x V x N	6	2.78	2.60	2.46*	5603.91*	37.90
Error (2)	32	1.45	1.22	0.996	2091.84	51.43

* Significant at 5% level
** Significant at 1% level

APPENDIX - IV

Analysis of variance for total number of spikelets, filled grains, percentage of filled grains and percentage of sterility.

Source	df	Mean square			
		Total No. of spikelets per panicle	Filled grain	Percentage of filled grains	Percentage of sterility
Block	2	701.54*	524.69*	18.77	18.77
Time of planting (T)	3	4284.09**	3783.22**	228.90*	228.90*
Varieties (V)	1	114.33	40.95	2.72	2.72
T x V	3	312.02	64.78	175.51*	175.51*
Error (1)	14	150.67	93.90	47.26	47.26
Nitrogen (N)	2	885.56	306.61	51.00	51.00
T x N	6	56.15	56.49	24.15	24.15
V x N	2	151.73	53.80	10.06	10.06
T x V x N	6	95.62	119.04	31.87	31.87
Error (2)	32	335.90	182.03	53.72	53.72

* Significant at 5% level
** Significant at 1% level

APPENDIX - V

Analysis of variance for panicle length, branchlets/panicle, 1000 grain weight, grain straw ratio and harvest index.

Source	df	Mean squares				
		Panicle length	Branchlets per panicle	1000 grain weight	Grain straw ratio	Harvest index
Block	2	9.26**	1.11*	8.134	0.097	18.39
Time of planting (T)	3	31.08**	5.59**	6.137	0.033	159.58*
Varieties (V)	1	1.32	12.41**	0.464	0.030	10.18
T x V	3	1.81	0.308	5.809	0.0079	19.37
Error (1)	14	0.803	0.287	2.239	0.04	34.96
Nitrogen (N)	2	2.64	0.104	0.732	0.011*	110.92*
T x N	6	0.22	0.245	0.432	0.0076	21.10
V x N	2	0.21	0.175	0.456	0.020	3.96
T x V x N	6	0.73	0.237	1.057	0.028	41.00
Error (2)	32	1.20	0.398	1.108	0.0023	27.96

* Significant at 5% level
** Significant at 1% level

APPENDIX - VI

Analysis of variance for dry matter production grain yield and straw yield

Source	df	Mean squares				
		Dry matter production			Grain yield	Straw yield
		30th day after planting	60th day after planting	At harvest		
Block	2	21738.00**	178582.8**	353858	1551628.7	165899.08*
Time of planting (T)	3	4046.23	240447.61**	339871.57*	4005732.5*	8928286.00
Varieties (V)	1	892.53	19279.90	42632	2061.13	2205700.00
T x V	3	440.37	28500.96	105193.1	25125.9	2321063.20
Error (1)	14	1350.60	8958.12	96898.5	811273.1	1563.80
Nitrogen (N)	2	2872.45*	2778.96	50194.4	1338745.5	3297183.58
T x N	6	1235.97	4402.3	65406.9	479840.3	558892.80
V x N	2	949.14	5560.95	18416.38	1482986.2	62549.30
T x V x N	6	1540.4*	7831.55	101797.7	959045.3	1667706.80
Error (2)	32	582.29	6095.44	36078.9	713141.2	1403968.50

* Significant at 5% level
** Significant at 1% level

APPENDIX -VII

Analysis of variance for nitrogen content of straw grain and grain protein content

Source	df	Mean squares				
		Straw			Grain	Grain protein content
		30th day	60th day	At harvest		
Block	2	0.720	1.016**	0.047	0.210	6.92
Time of planting (T)	3	2.48*	0.518*	0.444**	0.183	6.76
Varieties (V)	1	0.06	0.007	0.018	0.049	1.55
T x V	3	0.64	0.130	0.015	0.021	0.748
Error (1)	14	0.211	0.109	0.400	0.124	4.45
Nitrogen (N)	2	0.033	0.165	0.029	0.059	1.95
T x N	6	0.16	0.055	0.016	0.024	0.848
V x N	2	0.12	0.045	0.076	0.020	0.786
T x V x N	6	0.22	0.112	0.012	0.081	2.91
Error (2)	32	0.139	0.081	0.046	0.041	1.49

* Significant at 5% level
** Significant at 1% level

APPENDIX - VIII

Analysis of variance for nitrogen uptake by straw, grain and total uptake of nitrogen at harvest.

Source	df	Mean squares				
		Straw			Grain	Total uptake
		30th day after planting	60th day after planting	At harvest		
Block	2	1059.66**	10354.4**	720.43	2724.88	7418.68*
Time of planting (T)	3	251.41	5249.65**	861.30	5074.98**	5784.81*
Varieties (V)	1	111.70	662.78	0.16	517.83	2120.10
T x V	3	195.83	1822.37*	423.50	238.94	1231.36
Error (1)	14	101.01	504.70	334.55	758.61	1449.27
Nitrogen (N)	2	221.22*	770.35	295.46	585.98	1423.15
T x N	6	97.09	441.21	355.82	385.41	1760.16*
V x N	2	101.14	200.65	276.39	36.44	77.45
T x V x N	6	139.00*	315.59	376.61	901.27	1008.56
Error (2)	32	45.58	390.89	248.35	480.14	670.58

* Significant at 5% level
** Significant at 1% level

APPENDIX - IX

Analysis of variance for phosphorus content of straw and grain

Source	df	Mean squares			
		Straw			Grain
		30th day after planting	60th day after planting	At harvest	
Block	2	0.012**	0.003	0.006*	0.00067
Time of planting (T)	3	0.002	0.001	0.013**	0.0055*
Varieties (V)	1	0.010*	0.0002	0.002	0.0004
T x V	3	0.0009	0.0005	0.001	0.0014
Error (1)	14	0.0012	0.001	0.001	0.00156
Nitrogen (N)	2	0.0009	0.0004	0.003*	0.000272
T x N	6	0.00006	0.0006	0.0002	0.00033
V x N	2	0.0007	0.0001	0.001	0.00028
T x V x N	6	0.0002	0.0004	0.001	0.00028
Error (2)	32	0.0007	0.0007	0.0009	0.00041

* Significant at 5% level
** Significant at 1% level

APPENDIX - X

Analysis of variance for phosphorus uptake by straw, grain and total phosphorus uptake at harvest.

Source	df	Mean squares				
		Straw			Grain	Total phosphorus uptake
		30th day after planting	60th day after planting	At harvest		
Block	2	16.2**	139.31**	12.08	60.84	97.06
Time of planting (T)	3	4.87*	193.99**	35.63	172.61*	312.95*
Varieties (V)	1	6.15*	19.88	17.51	10.47	54.86
T x V	3	0.77	29.87	16.20	16.82	52.42
Error (1)	14	1.16	11.63	10.75	26.65	60.29
Nitrogen (N)	2	5.36**	3.80	15.88	7.49	35.09
T x N	6	1.61	2.87	4.33	10.00	24.95
V x N	2	1.17	3.58	5.55	1.60	3.93
T x VxN	6	1.85*	3.76	13.64*	14.66	43.63*
Error (2)	32	0.722	8.97	5.05	9.14	16.47

* Significant at 5% level
** Significant at 1% level

APPENDIX - XI

Analysis of variance for potassium content of straw and grain

Source	df	Mean squares			
		Straw			Grain
		30th day after planting	60th day after planting	At harvest	
Block	2	3.22**	0.007	0.129	0.0016
Time of planting (T)	3	0.092	0.081	0.129	0.0067**
Varieties (V)	1	0.003	0.127*	0.023	0.00055
T x V	3	0.004	0.003	0.088	0.0011
Error (1)	14	0.0726	0.025	0.125	0.0011
Nitrogen (N)	2	0.029	0.029	0.006	0.0004
T x N	6	0.005	0.009	0.023	0.0002
V x N	2	0.027	0.036	0.131	0.0019
T x V x N	6	0.003	0.024	0.075	0.0004
Error (2)	32	0.0008	0.014	0.054	0.0008

* Significant at 5% level
** Significant at 1% level

APPENDIX - XII

Analysis of variance for potassium uptake by straw, grain and total potassium uptake at harvest.

Source	df	Mean squares				
		Straw			Grain	Total uptake
		30th day after planting	60th day after planting	At harvest		
Block	2	143.83	4035.75**	409.32	91.91	895.41
Time of planting (T)	3	164.33	6631.78**	1153.36	187.67*	1826.77
Varieties (V)	1	23.77	2294.09**	92.26	4.45	132.75
T x V	3	21.21	791.96	1480.11	21.02	1741.24
Error (1)	14	76.58	269.76	640.36	35.76	881.08
Nitrogen (N)	2	73.18*	196.96	432.09	3.65	507.41
T x N	6	34.70	189.75	577.23	17.40	755.52
V x N	2	14.57	533.94	70.04	0.04	67.35
T x V x N	6	35.16	640.50*	769.27	32.20	977.27
Error (2)	32	17.48	210.09	410.25	16.42	510.38

* Significant at 5% level
** Significant at 1% level

DIFFERENTIAL RESPONSE OF TWO MEDIUM DURATION RICE VARIETIES TO TIME OF PLANTING AND GRADED DOSES OF NITROGEN

By

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ABSTRACT OF A THESIS

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ABSTRACT

An experiment to study the differential response of two medium duration rice varieties to time of planting and graded doses of nitrogen was conducted during the *mundakan* season of 1980-81, at the Research Station and Instructional Farm, Mannuthy. The experiment was laid out in split plot design, with combinations of four time of planting (September 25^{th}, October 10^{th}, October 25^{th} and November 9^{th}) and 2 varieties (Jaya and Sabari) in the main plot and 3 levels of nitrogen (60, 90, 120 kg/ha) in subplots.

Observations on the plant growth characters were recorded at 30^{th} day, 60^{th} day after planting and at harvest. Chemical analysis of plants at these stages were also done.

Time of planting significantly influenced the growth characters as well as the yield and yield attributes. Plant height, panicle length, number of spikelets, number of filled grains, percentage of filled grains, dry matter production, grain yield, straw yield, harvest index, grain straw ratio, total nitrogen uptake at harvest, nitrogen uptake by grain, content of phosphorus in straw and grain

and the total uptake of phosphorus at harvest and potassium uptake by grain were significantly higher in the early planted crop, than in later planted crops. However, number of days taken to 50 per cent flowering, and to maturity, production of tillers and productive tillers, phosphorus content of straw and potassium content of grain were positively influenced by delayed planting.

Sabari recorded significantly higher number of days to flowering and maturity than Jaya. Higher levels of nitrogen were found to increase the dry matter production and nitrogen, phosphorus and potassium content of straw.