STANDARDIZATION OF PLANTING TECHNIQUES IN RICE

BY

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THESIS

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D E C L A R A T I O N

I hereby declare that this thesis entitled "Standardization of planting Techniques in Rice" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellayani,
15th June 1986.

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CERTIFICATE

Certified that this thesis entitled "Standardization of planting Techniques in rice" is a record of research work done independently by Sri.Thankappan, G. 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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G.THANKAPPAN

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LIST OF ABBREVIATIONS

a - Age of seedling

A - Age of seedling under interaction

AICRIP - All India Co-ordinated Rice Improvement Project.

@ - At the rate of

cm - Centimetre

CSRC - Cropping Systems Research Centre

cv - Cultivar

d - Depth of planting

D - Depth of planting under interaction

DAT - Days after transplanting

g - gram

HI - Harvest Index

LAI - Leaf area index

M - Medium

m^2 - Square metre

mm - Millimetre

n - No. of seedlings per hill

N - No. of seedlings per hill under interaction

RH - Relative humidity

s - spacing

S - Spacing under interaction.

INTRODUCTION

INTRODUCTION

The importance of rice in Indian agriculture needs no emphasis. It is the staple food of more than half the world's population. Demands for rice are ever increasing and hence farmers and agricultural experts are earnestly searching for ways and means to increase production, to meet the demand of the teeming population of the world.

Perhaps the most significant development in agriculture during the past decade has been the shift from traditional agriculture to modern agriculture using science based technologies. Most of the modern techniques, unfortunately, are high-cost technologies which escalate the cost of cultivation of rice, making rice farming less remunerative. This may perhaps be one of the main reasons for the observed reduction in rice area of the country in the recent past. The poor socioeconomic conditions of the farmers of Asia, the rice bowl of the world, make it difficult to absorb the highcost technology. Considering the above facts efforts are being made by the researchers, to evolve suitable low cost technologies appropriate to every specific situation which can not only boost up production but also make rice farming more remunerative.

Although there are recommendations for the low cost technologies such as selection of varieties, optimum fertilization, plant population, planting depth, seedling age etc, which play vital role for increased productivity, adoption of these under farmers conditions has not been consistent due to obvious reasons. Diversities in the agroclimatic conditions of the rice growing regions warrant standardization of these techniques for every specific region. Hence it has been felt necessary to develop low cost technology such as optimum seedling age, planting depth, seedling number per hill, and spacing for rice for the rice growers of southern Kerala. Thus the present study was undertaken with the following objectives.

1. To fix the optimum spacing, number of seedlings/hill, seedling age, and planting depth of rice.

2. To study the interaction effect between plant spacing seedling age, planting depth, and seedling number per hill on growth and yield of rice.

3. To assess the uptake of fertilizer nutrients as influenced by plant population, seedling age, planting depth and their interactions.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

High productivity in rice has been associated not only with the use of improved plant types, but also with the adoption of scientific management practices. Adoption of suitable agronomic practices such as maintenance of optimum plant population, use of seedlings of optimum age, and planting of seedlings at optimum depth enabled the high yielding rice varieties to express their production potential to a greater extent. A brief review of the work done on the influence of seedling age, plant population, and planting depth on the growth and yield of rice is presented below.

I <u>Effect of spacing on</u>

A. <u>Growth characters</u>

Change in plant spacings did not change the plant height according to Seva Ram et al (1973) and Shahi et al (1976). But Fagundo et al (1978) and Ibrahim et al (1980) observed increase in plant height with increased spacings.

Seva Ram et al (1973) obtained maximum tiller number with wider spacing of 20 x 15 cm as compared to 10 x 10 cm. Similar observations were made by Chang and Su (1977), Fagundo et al (1978) and Ibrahim et al (1980).

In trials conducted by Chang (1968) on japonica rice cv Chianung-242 and Tainan-3 with four spacings, viz. 30 x 20 cm, 30 x 15 cm, 30 x 10 cm and 30 x 5 cm, it was found that leaf area index in both the cultivars increased with decrease in spacing. Golingai and Mabbayad (1969) observed that leaf area index increased with increase in the number of plants per ha. Fagade and Datta (1971) and Chang and Su (1977) have also recorded similar results. Investigations undertaken by Murty and Murty (1980) revealed that the values for LAI were the highest at a spacing of 10 x 10 cm and the LAI progressively decreased with increased spacings.

Ibrahim (1980) also reported increased leaf number per hill with increased spacing. But Sobhana (1983) recorded the highest leaf number per hill at a spacing of 10 x 10 cm compared to 15 x 10 cm, 10 x 5 cm and 20 x 10 cm at different stages of plant growth.

B. <u>Nutrient Uptake</u>

Sahu and Lenka (1966) found that wider spacing of 25 x 25 cm decreased the uptake of nitrogen. But Sankara Panickar (1975) reported that change in plant spacings from 15 x 10 cm to 20 x 10 cm did not influence the nitrogen uptake.

C. Yield Attributes

Chang (1968) observed that the number of panicles per hill decreased with decrease in spacing from 30 x 20 cm to 30 x 5 cm. Chang and Su (1977) from their field trials noticed that the number of panicles per hill increases with increase in spacing upto 25 x 50 cm.

Panicle length increases with increase in spacing Mohammed Khurshid et al (1966) and Chang and Su (1977).

Chang (1968) recorded decrease in grain number per panicle with decrease in spacing. Number of grains per panicle increased with increased spacing from 25 x 12.5 cm to 25 x 50 cm. Chang and Su (1977), Murty and Murty (1980) observed highest spikelet number per m^2 at a spacing of 10 x 10 cm as compared to 30 x 25 cm or 50 x 15 cm spacings. Sobhana (1983) obtained similar results.

Chang (1968) reported that reducing spacing from 30 x 20 cm to 30 x 5 cm increased the test weight of japonica rice cv Chianung-242 and Tainan-3, while Pillai and George (1973) and Shahi et al (1976) observed that the 1000 grain weight remained unaffected due to spacing.

Pillai and George (1973) did not find any difference in the production of effective tillers due to spacing. But Venkateswaralu and Singh (1980) noticed a decrease in the number of productive tillers at wider spacing.

D. Effect of spacing on yield

A trial conducted at Hyderabad during two successive seasons with two varieties at spacings of 15 x 10 cm, 15 x 15 cm and 15 x 20 cm revealed that closer spacing increased the grain yield of a short duration variety, which was a hybrid. Hussain (1967), and Chang (1968) observed that grain yields increased with decrease in spacing from 30 x 20 cm to 30 x 5 cm. Mandal and Mahapatra (1968) obtained higher grain yields at a spacing of 15 x 15 cm than 22.5 x 15 cm or 7.5 x 15 cm. Rice cv culture 120-35 when transplanted at spacings of 15 x 15 cm and 10 x 10 cm gave paddy yields of 4.92 and 5.64 t/ha, respectively. Pillai and George (1973), Singh and Singh (1973) recorded 11.1 per cent higher grain yield with spacing 15 x 10 cm compared to 20 x 10 cm. Chang and Su (1977) reported increased grain yield with increased spacing. Ghosh et al (1979) observed a decline in yield with a closer spacing of 10 x 10 cm and the highest grain yield of 6.6 t/ ha was obtained at a spacing of 20 x 20 cm. Chandrakar and Khan (1981), in trials with medium duration variety noted optimum grain yield at 15 x 10 cm or 20 x 10 cm as compared to 10 x 10 cm spacing. Kulandaivelu and

Kaliappa (1971), Yadava et al (1976) and Venkateswaralu and Singh (1980) reported nonsignificant effect of spacing on grain yield.

Lal and Singh (1967) obtained higher straw yields under wider spacings of 25 x 25 cm and 30 x 30 cm compared to 20 x 20 cm.

The review of work presented in the foregoing section reveals the superiority of closer spacing for increased rice production. However, better performance of medium duration rice under wider spacing (20 x 10 cm or 20 x 20 cm) is also indicated. Nonsignificant effect of spacing on grain yield was also reported by a few researchers.

II Effect of Seedling Age on

A. Growth characters

Enyi (1963) noted decrease in plant height at harvest when 60 day old seedlings were transplanted compared to 30 day old ones. Barthakur and Gogoi (1974), Murty and Sahu (1979) also recorded similar results.

Tiller number at harvest was high with 30 and 40 day old seedlings compared to 60 day old ones (Enyi 1963). Similar observations were made by Prasad Rao (1970). But Murty and Sahu (1979) obtained no reduction in tiller number at flowering with 40 and 60 day old seedlings of medium and late duration varieties as compared to 20 day old seedlings.

Singh and Tarat (1978) reported higher leaf number with seedlings transplanted at 29th day as compared to 24, 34,44 and 49 day old ones.

The leaf area index (LAI) was higher when 30 day old seedlings were transplanted compared to 45 and 60 day old ones (Enyi 1963). Murty and Sahu (1979) observed low leaf area index when 60 day old seedlings of short duration variety of rice was transplanted compared to 20 day old ones. But they did not observe such a reduction in LAI with medium duration and late maturing varieties.

B. <u>Nutrient uptake</u>

Transplanting seedlings of varying age did not influence the amount of nutrients absorbed by rice variety Jaya (Sankara Panicker, 1975). Sadayappan (1977) in his studies on the management of aged seedlings with the variety ADT-31 observed higher nitrogen uptake when 30 and 40 day old seedlings were transplanted compared to 50 and 20 day old ones. Fujiwara et al (1980) observed higher nitrogen uptake when younger seedlings were transplanted compared to older ones.

C. Yield attributes

Kawashima and Tanabe (1970) reported increase in panicle weight, spikelet number and number of grains per panicle by transplanting 40 day old seedlings as compared to 30 day old ones. Panicle number per hill and 1000 grain weight decreased when aged seedlings were transplanted (Sanches and Larrea (1972). Sankara Panicker (1975) observed higher percentage of filled grains in the crop raised by 35 and 28 day old seedlings compared to 21 day old ones. Nho (1976) observed that increasing the period in the nursery decreased panicle number and percentage of ripened grains. Fujiwara et al (1980) obtained more panicle per unit area when young seedlings were transplanted compared to old ones.

D. Grain yield

Ma and Kao (1940) reported that seedlings transplanted at the age of 30 days outyielded those transplanted at the age of 45 days. Annappan and Vaisavan (1973) reported that 25 day old seedlings gave the highest grain yield compared to older ones. Sankara Panicker (1975) did not observe any change in grain yield when the seedling age was changed from 21 to 35 days. In trials conducted over 6 locations by AICRIP, Hyderabad it was indicated that the age of seedlings did not exert much influence on grain yield (Anon 1976). Similar observations were made by Lal et al (1981) and Sahani et al (1984).

III <u>Effect of depth of planting on growth and yield</u>

Orsi (1960) found increased plant height, when seedlings were transplanted at a depth of 3 cm compared to 6 cm and 10 cm depths. But Mahapatra and Padalia (1971) observed increasedplant height with increasing depth of planting from 1 to 7 cm.

Orsi (1960) observed higher tillering with 3 cm depth of planting as compared to 6 and 10 cm depths. Similar observation was made by Enyi (1963). Leaf production was less when seedlings were transplanted deep compared to shallow planting (Enyi 1963, and Padalia and Mahapatra 1965).

Enyi (1963) observed nonsignificant difference in LAI due to planting depth. Orsi (1960) observed more number of spikelets per ear and length of ear with 3 cm depth of planting compared to 6 or 10 cm depths of planting. Padalia and Mahapatra (1971) observed decrease in effective tillers and panicle length with increase in depth of planting from 1 to 15 cm.

Shallow transplanting gave higher yield compared to deep planting (Muhandiran Peiris 1965). Enyi (1963) obtained increase in yield with shallow transplanting at 1 to 3 cm depth compared to 9 cm depth. Mahapatra and Padalia (1971) obtained increase in grain and straw yields with shallow transplanting compared to deep planting. Patel and Patel (1983) also recorded higher paddy yields when seedlings were transplanted at a depth of 3 to 4 cm compared to 5 to 7 cm depths.

The review of literature on the effect of planting depth on grain yield, presented in the foregoing sections clearly indicates the superiority of shallow planting (about 3 cm depth) compared to deep planting to obtain higher grain yields in rice.

IV. Effect of Seedling number per hill on

A. Growth characters

Transplanting more number of seedlings per hill resulted in higher plant height (according to Tanaka (1964) Sreenivas and Khuspa (1965). But Sahu and Lenka (1966) observed decrease in plant height as the number of seedlings increased from 2 to 4 per hill. Shahi et al (1976) observed no consistent variation in plant height due to change in number of seedlings per hill. Sedeno et al (1980) in pot trials with 4,6,8 or 10 seedlings per pot, also observed no difference in plant height due to variation in plant density.

Shahi et al (1976) noticed more tiller production with increase in number of seedlings per hill from 1 to 4. But Sedino et al (1980) observed decreased tiller production with increase in plant density.

B. Yield attributes and yield

Increase in seedling number per hill resulted in an increase in productive tillers (Khan and Shahi (1956). Shahi et al (1976) in trials with 1 to 4 seedlings per hill found no consistent change in the number of productive tillers.

Panicle length decreased with increase in the number of seedlings per hill (Mahapatra et al 1963). But Mohammed Khursheed et al (1966) observed no change in panicle length and number of grains per panicle due to variation in number of seedlings per hill.

Increase in the number of seedlings per hill from one to three increased the test weight of grains (Hukkeri et (1968). But Shahi et al (1976) reported that 1000 grain wieght was not affected by changing the number of seedlings per hill from one to four.

Bains and Singh (1967) obtained highest grain yield by transplanting 2 seedlings per hill compared to 3 and 4 seedlings per hill. Shahi et al (1976) observed no significant difference in yield of cv Jaya by changing the seedling number per hill from 1 to 4. Reddy and Mittra (1984) also reported similar results.

MATERIALS AND METHODS

MATERIALS AND METHODS

A field experiment was conducted during 1984-85 to find out the optimum spacing, seedling age, planting depth and the number of seedlings to be transplanted per hill for rice variety Jaya during second crop (Mundakan) season. The materials used and the methods followed for the experiment are given below.

1. Materials

1.1. Experimental site

The experiment was conducted at the cropping systems Research Centre, Karamana-Trivandrum. The experimental site is situated at 8.5^{o} North latitude and 76.9^{o} East longitude with an altitude of 29 metres above mean seal level. The experimental area was under bulk crop of rice during the previous seasons.

1.2 Soil and climate

The soil of the experimental area is sandy loam. The physico-chemical properties of the soil are presented in Table 1.

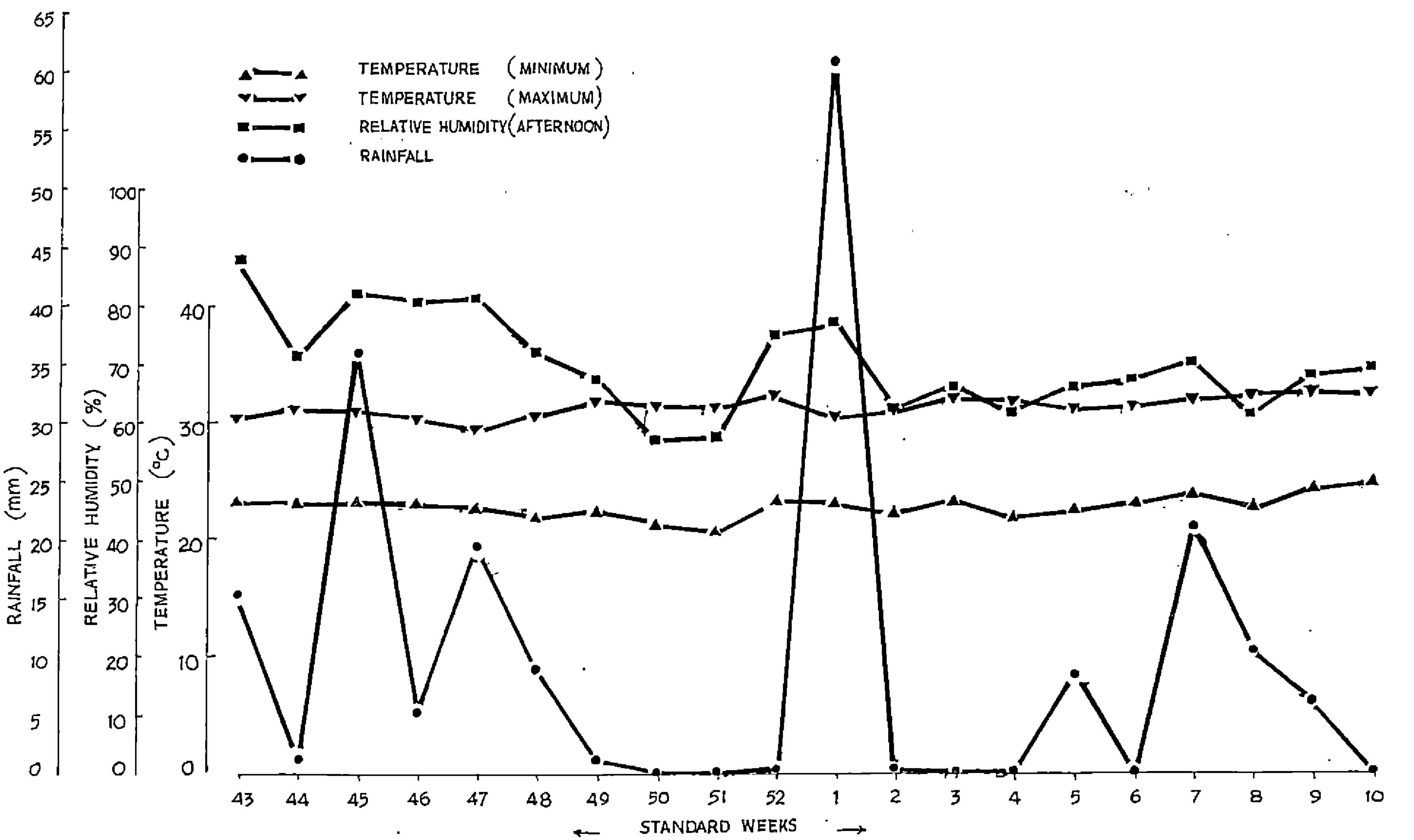
Table 1 Physical properties and chemical composition of the soil of the experimental area

Physical properties	
Sand	- 73.4%
Silt	- 8.6%
Clay	- 18.5%
Textural class	- Sandy loam
Chemical composition	
Available Nitrogen	- 412.9 kg/ha (M)
Available phosphorus	- 14.5 " (M)
Available potash	- 136 " (M)
pH	- 5.3 (Moderately acidic)
E.C. (m. mhos/ cm^2)	- 0.022 (Safe)

The experimental site enjoys a humid tropical climate. The data on weather parameters (weekly rainfall, mean maximum and minimum temperatures and relative humidity) during the cropping period are presented in Appendix I and graphically represented in Fig.1.

The mean maximum and minimum temperatures during cropping period ranged from 29.44°C to 32.66°C and 20.87°C to 24.85°C respectively. The mean RH ranged from 57.14% to 91.86%. The weekly rainfall of the cropping period ranged from 0.0 mm to 61.5 mm with a total receipt of 197.6 mm during the cropping period.

FIG 1. WEATHER CONDITIONS DURING THE CROPPING PERIOD



1.3 Cropping season

The experiment was conducted during the late Mundakan (Second crop season) of 1984-85, from 26 th November, 1984 to 8th March, 1985.

1.4 Variety

The variety used for the study was Jaya, a cross between TN-1 from Taiwan and an Indian variety T-141 from Orissa. It is a dwarf photoinsensitive, medium duration (130-140 days) variety, evolved at the All India Co-ordinated Rice Improvement Project, Rajendra Nagar, Hyderabad, India. It has got special features like long bold white grain with high stability in yield. The seeds for the experiment were obtained from C.S.R.C.Karamana itself.

2. Methods

2.1 Treatments

Four factors viz. Spacings, age of seedlings, depth of planting and number of seedlings per hill, were studied in split plot design with four replications. There were thirty six treatment combinations comprising of 6 main plot treatments and 6 sub plot treatments as detailed below.

A. Main plot

Six treatment combinations involving three spacings and two age of seedlings.

Spacing	Age of seedlings
1. s1 - 20 x 15 cm	1.a1 - 20 days old
2. s2 - 20 x 10 cm	2.a2 - 35 days old
3. s3 - 15 x 10 cm	

B. Sub plot

Six treatment combinations involving two depths of planting and three levels of seedling number per hill.

Depth of planting	Seedlings number / hill
1. d1 - 3 - 4 cm	1. n1 - 3 seedlings/hill
2. d2 - 6 - 8 cm	2. n2 - 6 -do-
	3. n3 - 9 -do-

The lay out plan is given in Fig.2. The gross plot size was 6 x 3 m and in total there were 144 plots.

Two rows of plants were left as border rows all around the plot. One additional row was left on the breadth-wise side to facilitate distructive sampling of the plants and again an additional row was left after the sampling row to avoid the possible effect on the net area.

FIG 2. LAY-OUT PLAN (SPLIT PLOT DESIGN)

N

TREATMENTS :-

SPACING -	AGE OF SEEDLINS	DEPTH OF PLANTING	NO: OF SEEDLINGS/HILL
S1 - 20 x 15 cm	A1 - 20 DAY OLD	D1 - 3-4 cm	N1 - 3
S2 - 20 x 10 cm	A2 - 35 DAY OLD	D2 - 6-8 cm	N2 - 6
S3 - 15 x 10 cm			N3 - 9

R1		R2		R3		R4	
S1 A1 D1 N3	S2 A2 D1 N1	S2 A1 D1 N3	S3 A2 D2 N2	S1 A1 D2 N3	S3 A1 D1 N2	S2 A2 D2 N3	S3 A1 D1 N1
S1 A1 D2 N3	S2 A2 D2 N1	S2 A1 D1 N2	S3 A2 D1 N3	S1 A1 D1 N1	S3 A1 D2 N3	S2 A2 D2 N1	S3 A1 D2 N3
S1 A1 D2 N1	S2 A2 D2 N2	S2 A1 D1 N1	S3 A2 D2 N3	S1 A1 D2 N1	S3 A1 D1 N1	S2 A2 D1 N2	S3 A1 D1 N2
S1 A1 D1 N2	S2 A2 D2 N1	S2 A1 D2 N1	S3 A2 D2 N1	S1 A1 D1 N3	S3 A1 D2 N2	S2 A2 D1 N1	S3 A2 D1 N2
S1 A1 D1 N1	S2 A2 D1 N3	S2 A1 D2 N2	S3 A2 D1 N2	S1 A1 D1 N2	S3 A1 D2 N1	S2 A2 D2 N2	S3 A1 D2 N1
S1 A1 D2 N2	S2 A2 D2 N3	S2 A1 D2 N3	S3 A2 D1 N1	S1 A1 D2 N1	S3 A1 D1 N3	S2 A2 D1 N3	S3 A1 D1 N3
S1 A2 D1 N3	S3 A2 D1 N1	S1 A1 D2 N2	S2 A2 D2 N1	S1 A2 D2 N1	S3 A2 D1 N1	S1 A1 D1 N1	S1 A2 D2 N1
S1 A2 D1 N1	S3 A2 D1 N2	S1 A1 D1 N2	S2 A2 D1 N2	S1 A1 D2 N1	S3 A2 D2 N1	S1 A1 D1 N3	S1 A1 D2 N3
S1 A2 D2 N2	S3 A2 D2 N2	S1 A1 D2 N1	S2 A2 D2 N2	S1 A2 D2 N2	S3 A2 D2 N1	S1 A1 D2 N1	S1 A2 D2 N3
S1 A2 D2 N3	S3 A2 D1 N3	S1 A1 D1 N1	S2 A2 D1 N1	S1 A2 D1 N2	S3 A2 D1 N3	S1 A1 D1 N2	S1 A2 D1 N3
S1 A2 D1 N2	S3 A2 D1 N1	S1 A1 D2 N3	S2 A2 D2 N3	S1 A2 D1 N3	S3 A2 D2 N2	S1 A1 D2 N3	S1 A2 D2 N2
S1 A2 D2 N1	S3 A2 D2 N3	S1 A1 D1 N3	S2 A2 D1 N3	S1 A2 D2 N3	S3 A2 D2 N3	S1 A1 D2 N2	S1 A2 D1 N2
S2 A1 D2 N1	S3 A1 D2 N1	S3 A1 D1 N3	S1 A2 D2 N2	S2 A1 D2 N3	S2 A2 D1 N1	S3 A2 D1 N2	S2 A1 D1 N3
S2 A1 D2 N2	S3 A1 D1 N1	S3 A1 D1 N1	S1 A2 D2 N3	S2 A1 D1 N1	S2 A2 D2 N3	S3 A2 D2 N1	S2 A1 D2 N1
S2 A1 D1 N2	S3 A1 D2 N3	S3 A1 D2 N1	S1 A2 D2 N1	S2 A1 D2 N2	S2 A2 D2 N1	S3 A2 D2 N3	S2 A1 D1 N1
S2 A1 D1 N1	S3 A1 D1 N3	S3 A1 D2 N2	S1 A2 D1 N2	S2 A1 D1 N2	S2 A2 D1 N2	S3 A2 D1 N3	S2 A1 D2 N3
S2 A1 D2 N3	S3 A1 D2 N2	S3 A1 D1 N2	S1 A2 D1 N3	S2 A1 D2 N1	S2 A2 D1 N3	S3 A2 D2 N2	S2 A1 D1 N2
S2 A1 D1 N3	S3 A1 D1 N2	S3 A1 D2 N3	S1 A2 D1 N1	S2 A1 D1 N2	S2 A2 D2 N3	S3 A2 D1 N1	S2 A1 D2 N2

2.2 Details of cultivation

The seedlings were raised on different dates as per the recommendations of the KAU package of practices (Anon-1984) so as to get 20 day and 35 days old seedlings at the time of planting.

The crop was raised using standard procedures and techniques following the package of practices recommendations of the KAU. The main field was ploughed, puddled, and levelled and plots of 6x 3 m size were laid out with bunds of 30 cm width around. Main and sub irrigation channels were provided wherever necessary. Individual plots were again puddled and perfectly levelled and basal dose of fertilizers as per package of practices were incorporated. Twenty day and thirty five day old, seedlings were transplanted on 26th November 1984 as per the treatments given previously. Gap filling was done on the seventh day after planting with seedlings of the respective age groups. The crop was handweeded at 20th day and 40th day after transplanting. Five centimeter water was maintained in the field with occassional draining and the water was cut off completely 10 days prior to harvest.

2.3 Fertilization

The recommended dose of 90:45:45 kg/ha of N, P_2O_5 and K_2O was applied in three splits giving 50% N, full dose of P_2O_5 and 50% K_2O basally, 25% N at tillering (20DAT) and

25% N and 50% K_2O at panicle initiation stage (40 DAT). Nitrogen was applied through ammonium sulphate (20.5% N) phosphorus through super-phosphate (18% P_2O_5) and potassium through Muriate of potash (60% K_2O).

2.4 Plant protection

Two sprayings with Ekalux and Hinosan against stem borer, leaf folder and leaf spot at tillering stage and one dusting with BHC 10% at heading stage to control ear head bug, were given.

2.5 Harvest

The crop planted with 35 day old and 20 day old seedlings were harvested on 94 and 102 DAT respectively. Plants in the border rows were harvested first. Thereafter the crop in the net area of the individual plot was harvested separately, threshed, cleaned, dried, winnowed and the yield recorded.

2.6 Observations recorded

A. Vegetative characters

Biometric observations such as plant height and number of tillers/hill were recorded at 20, 40, 60 DAT and at harvest. The LAI was recorded at 20,40 and 60 DAT.

1. Height of plants

Height of 10 plants was measured from the base of the plant to the tip of the topmost leaf at 20,40 and 60 DAT.

At harvest the height was recorded from the base of the plants to the tip of the longest panicle. The mean height was computed and expressed in cm

ii. Number of tillers/ hill

The total number of tillers from the 10 sample hills were counted and the number of tillers/hill was calculated.

iii. Number of leaves per hill

The total number of green leaves from the observation plants were counted and average worked out.

iv. Leaf area index (LAI)

Leaf area index for each plot was determined at 20,40 and 60 DAT with leaves not removed from the plants as suggested by Gomez (1972).

Selected at random 10 sample hills from each plot after making sure that each hill is surrounded by living hills. Counted the tillers for each sample hill in each plot. Measured the length and maximum width of each leaf on the middle tiller and computed the area of each leaf based on the length-width method and then the total leaf area of the middle tiller.

$$\text{Leaf area} = k \times l \times w$$

where k is the adjustment factor (0.75), l is the length and w is the maximum width of the leaf. Then the leaf area per hill and the LAI was calculated as follows.

Leaf area per hill = total leaf area of middle tiller x total number of tillers in the hill.

$$\text{Leaf area index (LAI)} = \frac{\text{total leaf area of 10 sample hills } (cm^2)}{\text{spacing provided for 10 hills } (cm^2)}$$

B. Chemical analysis

i. Plant analysis

The chemical analysis was done from the plant samples collected at harvest. From the observation... plants, the grain and straw were taken and oven-dried at 80 $\pm$ 5°C till a constant weight was obtained. It was then finely ground using a Wiley mill and sieved through 2 mm sieve. A known weight of this sample was then digested and the digest was chemically analysed. The nitrogen, phosphorus and potash contents of grain and straw were determined separately.

The total nitrogen content of the digest of each sample was analysed employing the modified micro-kjeldahl method (Jackson 1967). The total phosphorus content was determined colorimetrically using the vanado-molybdo-phosphoric yellow colour method (Jackson 1967). The colour intensity was read in a klett-summerson photoelectric colorimeter. An 'EEL' flame photometer was used to determine the total potash content.

The total quantities of the three major nutrients, viz. nitrogen, phosphorus and potash absorbed by the crop at harvest was calculated. The value of total uptake was obtained as the sum of the products of the percentage content of these nutrients in the straw and grain at harvest and the respective dry weights of the same. The values were expressed in kilogram per hectare.

(ii) Soil analysis

Soil samples were taken from the experimental area before the experiment and analysed for available nitrogen, available phosphorus and available potash. The available nitrogen content in the soil was determined by alkaline permanganate method (Subbiah and Asija 1956), available phosphorus content by Bray's method (Jackson 1967) and available potash by ammonium acetate method (Jackson 1967).

(C) <u>Yield attributes and yield</u>

The following observations were recorded using the method suggested by Gomez (1972).

1. Number of panicles per square metre

The total number of panicles from the 10 hills selected was counted and the number of panicles per m^2 was calculated.

ii. Length of panicle

The length of the middle panicle of 10 hills measured from the neck to the tip, and the mean length calculated and expressed in centimeter.

iii. Number of filled grains per panicle

The filled grains per panicle were separated out and the average computed for 10 panicles.

iv. Number of unfilled grains per panicle

The unfilled grains were separated out from the spikelets removed from each panicle and these were counted and the mean computed for 10 panicles.

v. Percentage of filled grains

Total grains and filled grains from the panicle were separately counted and their percentage of filled grains were worked out.

vi. Thousand grain weight

Thousand grains were counted from the grain samples drawn from every plot, the weight recorded and adjusted to 14 per cent moisture.

D. Observation on grain and straw yield

1. Grain yield

Yield of grain from the net area was recorded and adjusted to 14 per cent moisture and expressed in quintals per hectare.

ii. Straw yield

Straw obtained from the net area was uniformly dried, weighed and yield of straw recorded and expressed in quintals per hectare.

iii. Harvest index

Harvest index was worked out by dividing the weight of grains with the total weight of grain and straw.

$$\text{Harvest Index} = \frac{\text{Economic yield}}{\text{Biological yield}}$$

2.7 Statistical analysis

The data collected were statistically analysed by the analysis of variance technique as suggested by Snedecor and Cochran (1967).

RESULTS

R E S U L T S

The data collected were analysed statistically and presented in Tables 2 to 17. The abstract of analysis of variance in respect of different characters are presented in Appendix I to IX. As the second order and third order interactions were mostly absent the data in respect of the same are not presented. The results obtained from the study are briefly presented below. For convenience in the presentation of the results the various characters are grouped under the following main heads.

I Growth characters
II Nutrient uptake
III Yield attributes and yield.

I Growth characters

1. Height of plant (Tables 2 to 5 and Appendix II)

The plant height was not affected by change in spacing. But the age of seedlings had profound influence on plant height at all growth stages except at 60 DAT. The crop raised from 35 day old seedlings had more height at 20 and 40 DAT while at harvest the crop raised with 20 day old seedlings was taller.

The effect of depth of planting on plant height was noticed only at 40 DAT and the plants were taller at the depth of planting of 3-4 cm than at 6-8 cm.

Table 2 Effect of spacing, age of seedlings, depth of planting and number of seedlings per hill on growth characters at different stages of growth

	Plant height (cm)				Tiller number per hill				Number of leaves per hill		
	20 DAT	40 DAT	60 DAT	H	20 DAT	40 DAT	60 DAT	H	20 DAT	40 DAT	60 DAT
s1	30.5	55.1	64.7	66.7	7.2	11.3	10.3	10.8	22.0	40.5	34.3
s2	29.8	53.9	64.3	67.4	6.6	9.2	8.0	8.5	19.3	34.9	27.1
s3	31.3	53.5	63.1	66.8	6.5	8.4	7.6	7.8	21.5	30.7	26.4
SE ±	0.6	0.5	0.5	0.5	0.2	0.3	0.2	0.3	0.5	0.9	0.9
CD	NS	NS	NS	NS	NS	0.9	0.6	0.9	1.5	2.8	2.6
a1	29.0	53.3	64.0	68.2	6.7	10.1	8.9	8.5	19.6	35.2	31.0
a2	32.0	55.1	64.0	65.8	6.9	9.2	8.6	9.2	22.3	35.5	27.6
SE ±	0.5	0.4	0.5	0.4	0.1	0.3	0.2	0.3	0.4	0.8	0.7
CD	1.4	1.2	NS	1.2	NS	0.8	NS	NS	1.2	NS	2.2
d1	30.8	54.9	68.9	67.9	7.0	9.9	8.7	9.1	21.5	36.3	29.9
d2	30.3	53.5	64.1	66.9	6.6	9.3	8.6	8.7	20.4	34.4	28.7
SE ±	0.4	0.3	0.3	0.5	0.2	0.2	0.1	0.2	0.4	0.4	0.5
CD	NS	0.8	NS	NS	NS	0.5	NS	NS	NS	1.2	NS
n1	29.6	54.1	65.3	67.1	5.6	9.1	8.2	8.6	17.5	33.7	28.7
n2	30.3	54.0	63.1	66.8	6.7	9.8	8.7	8.8	20.5	36.0	29.1
n3	31.7	54.5	64.7	66.1	8.1	10.0	9.0	9.3	25.0	36.4	30.0
SE ±	0.4	0.4	0.4	0.5	0.2	0.2	0.2	0.2	0.5	0.5	0.6
CD	1.2	NS	1.0	NS	0.5	0.6	0.5	NS	1.5	1.5	NS

DAT : Days after transplanting H : Harvest CD: Critical difference at 5% level

Sapcings
s1 - 20 x 15 cm
s2 - 20 x 10 cm
s3 - 15 x 10 cm

Age of seedlings
a1 - 20 days old seedling
a2 - 35 days old seedling

Depth of planting
d1 - 3-4 cm
d2 - 6-8 cm

No. of seedlings/hill
n1 - 3 seedlings/hill
n2 - 6 seedlings/hill
n3 - 9 seedlings/hill

Table 3 S x A and S x D interaction means on growth characters at different stages of growth

	Plant height (cm)				Tiller number per hill				Number of leaves per hill		
	20 DAT	40 DAT	60 DAT	H	20 DAT	40 DAT	60 DAT	H	20 DAT	40 DAT	60 DAT
s1a1	29.4	53.9	64.6	67.9	7.0	11.3	10.2	10.3	20.5	40.6	37.0
s1a2	31.6	56.3	64.9	65.5	7.3	11.2	10.5	11.4	23.5	40.5	31.7
s2a1	28.1	43.7	64.6	69.2	6.4	9.7	7.9	7.8	17.6	32.5	27.1
s2a2	31.5	54.3	64.0	65.7	6.8	8.6	8.0	9.1	21.1	37.2	27.2
s3a1	29.6	52.4	62.9	67.5	6.6	9.2	7.9	7.5	20.8	32.6	28.9
s3a2	33.0	54.7	63.3	66.1	6.5	7.6	7.3	7.2	22.2	29.9	23.9
SE ±	0.8	0.7	0.8	0.7	0.3	0.4	0.3	0.4	0.7	1.3	1.3
CD (1) (2)	NS	NS	NS	NS	NS	NS	NS	NS	NS	3.9	NS
s1d1	31.0	55.4	63.8	66.6	7.0	11.6	10.5	11.1	22.3	41.2	35.2
s1d2	30.0	54.7	65.6	66.9	7.3	10.9	10.2	10.5	21.7	39.9	33.5
s2d1	29.9	54.9	64.5	67.7	7.2	9.4	8.0	8.6	20.0	36.1	27.8
s2d2	29.6	53.0	64.1	67.1	6.1	8.9	7.9	8.4	18.7	33.7	26.5
s3d1	31.4	54.4	63.4	66.4	6.7	8.7	7.6	7.5	22.3	31.7	26.5
s3d2	31.2	52.6	62.7	67.1	6.4	8.1	7.6	7.2	20.7	29.7	26.3
SE ±	0.6	0.5	0.5	0.7	0.3	0.3	0.2	0.3	0.8	0.7	0.8
CD (1) (2)	NS	NS	2.5 2.0	NS	NS	NS	NS	NS	NS	NS	NS

DAT : Days after transplanting H: Harvest

CD(1) - To compare two Main plot treatment at same level of sub plot treatment
CD(2) - To compare two sub plot treatment at same or different levels of the Main plot treatment

Table 4 S x N and A x D interaction effects on growth characters at different stages of growth

	Plant height at (cm)				Tiller number per hill				Number of leaves per hill		
	20 DAT	40 DAT	60 DAT	H	20 DAT	40 DAT	60 DAT	H	20 DAT	40 DAT	60 DAT
s1n1	28.3	53.8	65.6	67.3	5.8	10.4	9.8	10.8	17.8	38.1	33.4
s1n2	31.1	56.1	63.2	66.3	6.8	11.6	10.4	10.7	23.0	41.1	33.8
s1n3	32.0	55.2	65.2	66.5	8.9	11.8	10.8	11.0	25.3	42.4	35.9
s2n1	29.7	54.8	55.3	67.4	5.8	8.7	7.2	7.6	18.1	34.0	6.2
s2n2	28.5	52.4	62.8	67.0	6.7	9.3	8.1	8.8	18.9	25.3	26.9
s2n3	31.1	54.6	64.7	67.8	7.4	9.5	8.6	9.1	21.0	85.4	28.4
s3n1	30.7	53.5	63.2	66.4	5.2	8.2	7.5	7.3	16.5	29.0	26.7
s3n2	31.3	53.4	53.2	67.3	6.6	8.5	7.7	7.0	19.5	31.6	26.8
s3n3	31.9	53.6	62.8	60.7	7.9	8.5	7.7	7.7	28.6	31.5	25.8
SE ±	0.8	0.6	0.7	0.8	0.4	0.4	0.3	0.4	9.9	0.9	1.0
CD 1) 2)	NS	NS	NS	NS	NS	NS	NS	NS	3.8 3.8	NS	NS
a1d1	29.4	54.4	63.8	68.8	6.8	10.5	8.9	8.8	19.5	35.1	32.2
a1d2	28.6	52.2	64.2	67.6	6.6	9.7	8.5	8.3	19.7	35.3	29.8
a2d1	32.1	55.4	64.0	65.0	7.1	9.3	8.5	9.3	23.5	37.7	27.6
a2d2	31.9	54.7	64.0	66.5	6.6	9.0	8.7	9.1	21.1	37.3	27.6
SE ±	0.3	0.4	0.4	0.6	0.2	0.2	0.2	0.2	0.6	0.6	0.7
CD 1) 2)	NS	NS	NS	2.9 2.0	NS	NS	NS	NS	3.8 2.1	3.1 2.5	NS

DAT : Days after transplanting H: Harvest

Table 5 A x N and D x N interaction means on growth characters at different stages of growth

	Plant height at (cm)				Tiller number per hill				Number of leaves per hill		
	20 DAT	40 DAT	60 DAT	H	20 DAT	40 DAT	60 DAT	H	20 DAT	40 DAT	60 DAT
a1n1	28.6	53.6	64.2	68.4	5.6	9.6	8.3	8.5	17.3	38.1	30.3
a1n2	28.7	53.2	64.6	68.2	6.6	10.3	8.9	8.6	19.2	35.9	31.2
a1n3	29.6	53.0	63.2	67.9	7.9	10.3	8.8	8.7	22.4	36.7	31.5
a2n1	30.5	53.2	65.2	65.7	5.6	8.6	8.1	8.6	17.6	34.3	27.2
a2n2	31.8	54.7	61.6	65.5	6.7	9.4	8.6	9.2	21.7	36.2	27.1
a2n3	33.7	55.9	65.3	66.1	8.3	9.6	9.2	9.8	27.6	36.2	28.5
SE ±	0.6	0.5	0.5	0.7	0.3	0.3	0.2	0.3	0.8	0.7	0.8
CD 1) 2)	NS	NS	2.1 1.6	NS	NS	NS	NS	NS	3.1 3.1	NS	NS
d1n1	30.2	55.1	64.7	67.2	6.0	9.5	8.1	8.9	18.2	34.9	29.7
d1n2	30.0	54.5	62.4	67.2	6.5	10.0	8.7	8.7	20.3	36.3	29.5
d1n3	32.1	55.0	64.5	66.2	8.4	10.2	9.3	9.6	26.0	37.8	30.4
d2n1	28.9	53.0	64.7	66.8	5.2	8.7	8.2	8.3	16.7	32.5	27.8
d2n2	30.6	53.4	63.7	66.5	6.9	9.6	8.8	8.9	20.6	35.7	28.8
d2n3	31.3	53.9	63.9	67.8	7.7	9.7	8.7	8.9	23.9	35.0	29.6
SE ±	0.6	0.5	0.5	0.7	0.3	0.3	0.2	0.3	0.8	0.7	0.8
CD 1) 2)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

DAT : Days after transplanting

H : Harvest

Changing the seedling number per hill from 3 to 9 influenced the plant height at 20 DAT and 60 DAT but the effect did not persist upto harvest. The highest seedling rate (9 seedlings per hill) resulted in more plant height during early stages. But in the later stages the lower seedling rate (3 seedlings per hill) produced the tallest plants.

The interaction effects between the treatment factors were rare with respect to this character. However, the A x D interaction influenced plant height at harvest and the crop raised by planting 20 day old seedlings at 3-4 cm depth (a1 d1) was taller.

2. <u>Tiller Number per hill</u> (Table 2 to 5 and Appendix III)

Change in plant spacings influenced the tiller production per hill and this was observed at all the stages of plant growth, except at 20 DAT. The highest number of tillers per hill (11.3) was observed with the wider spacing (20 x 15 cm) and tiller number decreased with decrease in plant spacing. However the difference in tiller production between 20 x 10 cm and 15 x 10 cm was not marked.

The age of seedling influenced tiller production per hill at 40 DAT and 20 day old seedlings produced the highest number of tiller per hill. However this effect did not persist upto the later stages of plant growth.

The effect of planting depth on tiller production per hill was noticeable only at 40 DAT and shallow planting (3-4 cm depth) produced more tillers per hill (9.9) compared to deep planting (6-8 cm).

Marked effect of seedling number per hill on tiller production was observed at 20,40 and 60 DAT and n3 (9 seedlings per hill) produced the highest number of tillers per hill compared to n2 and n1 (6 and 3 seedlings per hill). However this effect was not visible at the harvest stage.

The interaction effects were absent with respect to tiller number per hill.

3. Number of leaves per hill (Table 2 to 5 and Appendix IV)

Spacing influenced the number of leaves per hill at all the stages of plant growth, and the highest number of leaves per hill was observed with the wider spacing (20 x 15 cm).

Seedling age also influenced this aspect, the effect being observed at 20 DAT and 60 DAT. While more number of leaves per hill was produced at 20 DAT by the crop raised from 35 day old seedlings, at 60 DAT the one raised from 20 day old seedlings produced the highest number of leaves per hill.

The influence of planting depth on leaf production per hill was seen at 40 DAT and the crop planted at 3-4 cm depth produced more number of leaves.

As in the case of tiller number per hill, leaf number per hill was also affected by changing the seedling number per hill. This was observed at 20 and 40 DAT and the crop raised by planting 9 seedlings per hill produced highest number of leaves. However this effect was not observed at 60 DAT.

The "spacing x seedling age" interaction was marked at 40 DAT and the treatment combination s1a1 (20 x 15 cm spacing and 20 day old seedling) produced the highest number of leaves per hill.

The S x N interaction effect on leaf number per hill was noticed at the early stages (20 DAT) and s3n3 (15 x 10 cm spacing and 9 seedlings per hill) produced more leaves per hill. " Seedling age x planting depth" interaction on leaf number per hill was seen at 20 and 40 DAT and the highest number of leaves per hill was produced with a2d1 (35 day old seedlings and 3 to 4 cm deep planting).

Interaction effect between seedling age and seedling number per hill on leaf production was noticed only at 20 DAT and the crop raised from "35 day old seedlings planted @ 9 seedlings per hill" produced the highest leaf number per hill. All other interaction effects failed to be significant with respect to this character.

4. <u>Leaf Area Index</u> (Table 6 to 9, Appendix V and Fig.3to5)

The different plant spacings influenced the LAI at all stages of growth (20,40 and 60 DAT). The highest LAI was noticed at the closer planting (15 x 10 cm).

The seedling age also influenced LAI at 20 and 60 DAT. The crop raised from 35 day old seedlings showed higher LAI (1.18) during early stage while the one raised from 20 day old seedlings expressed the highest LAI (3.78) at the later stage (60 DAT).

The effect of planting depth on LAI was evident only at 40 DAT and the highest LAI (3.68) was observed with the crop raised by planting seedlings at 3-4 cm depth. The effect of seedling number per hill and the interaction effects were not in any way pronounced in the case of this character.

II. <u>Nutrient uptake</u>

(i) N uptake at harvest (Table 6 to 9 and Appendix VI)

The effect of spacing, seedling age, planting depth and seedling number per hill did not influence the N uptake at harvest. The "Planting depth x number of seedlings per hill" interaction alone influenced N uptake. The crop raised by planting "seedling @ six per hill at a depth of three to four centimeter" removed the highest amount of 70.9 kg N/ha.

Table 6 Effect of spacing, age of seedlings, depth of planting and number of seedlings per hill on Leaf Area Index stagewise and NPK uptake at harvest

	Leaf Area Index			NPK Uptake (kg/ha)		
	20 DAT	40 DAT	60 DAT	N	P	K
s1	0.73	3.01	3.15	70.1	17.1	97.7
s2	0.96	3.70	3.44	64.3	16.9	98.5
s3	1.35	3.94	4.12	67.4	16.8	92.5
SE ±	0.08	0.14	0.11	3.7	1.0	6.1
CD	0.24	0.42	0.34	NS	NS	NS
a1	0.84	3.46	3.78	66.5	17.0	93.4
a2	1.18	3.60	3.36	68.1	16.2	99.0
SE ±	0.06	0.11	0.09	3.1	0.8	5.4
CD	0.19	NS	0.28	NS	NS	NS
d1	1.06	3.68	3.70	67.6	16.1	94.0
d2	0.09	3.42	3.51	66.9	17.1	98.5
SE ±	0.04	0.08	0.08	1.0	0.3	1.7
CD	NS	0.22	NS	NS	0.8	NS
n1	0.80	3.46	3.59	66.3	16.7	95.9
n2	0.94	3.57	3.55	68.7	17.3	97.3
n3	1.29	3.62	3.58	66.8	15.8	95.4
SE ±	0.09	0.10	1.33	0.4	2.10	
CD	NS	NS	NS	NS	1.00	NS

DAT: Days after transplanting. CD = Critical difference at 5% level.

Spacings
s1 - 20 x 15 cm
s2 - 20 x 10 "
s3 - 15 x 10 "

Age of seedlings
a1 - 20 days old seedling
a2 - 35 days old seedling

Depth of planting
d1 - 3-4 cm
d2 - 6-8 "

No. of seedlings/hill
n1 - 3 seedlings/hill
n2 - 6 seedlings/hill
n3 - 9 seedlings/hill

Table 7 S x A and S x D interaction means for Leaf Area Index stagewise and NPK uptake at harvest

	Leaf Area Index			NPK uptake (kg/ha)		
	20 DAT	40 DAT	60 DAT	N	P	K
s1a1	0.63	2.95	3.41	72.7	18.1	100.2
s1a2	0.82	3.07	2.89	67.6	16.1	95.2
s2a1	0.84	3.64	3.56	59.2	15.4	88.7
s2a2	1.08	3.76	3.33	69.4	16.5	108.3
s3a1	1.06	3.80	4.37	67.4	17.5	91.3
s3a2	1.64	4.08	3.88	47.4	16.2	93.7
SE ±	0.11	0.2	0.16	5.1	1.3	9.3
CD (1) (2)	NS	NS	NS	NS	NS	NS
s1d1	0.72	3.07	3.24	69.6	16.5	93.0
s1d2	0.73	2.95	3.07	70.7	17.7	102.3
s2d1	1.06	3.93	3.56	65.2	15.3	98.8
s2d2	0.86	3.47	3.32	61.4	16.7	98.2
s3d1	1.42	4.02	4.10	68.1	16.7	90.0
s3d2	1.28	3.85	4.15	66.7	17.1	95.0
SE ±	0.77	0.14	0.15	1.7	0.5	3.0
CD (1) (2)	NS	NS	NS	NS	NS	NS

DAT: Days after transplanting

CD : Critical difference at 5% level

Table 8 S x N and A x D interaction means for Leaf Area Index stage-wise and NPK Uptake at harvest

	Leaf Area Index			NPK Uptake (kg/ha)		
	20 DAT	40 DAT	60 DAT	N	P	K
s1n1	0.58	2.83	3.04	70.2	17.5	98.4
s1n2	0.75	2.87	3.14	71.9	18.1	102.3
s1n3	0.85	3.33	3.26	68.3	15.6	92.3
s2n1	0.87	3.61	3.45	62.6	16.2	97.5
s2n2	0.40	3.67	3.25	66.1	16.0	97.7
s2n3	1.11	3.82	3.62	64.2	15.7	100.1
s3n1	0.96	3.93	4.29	66.2	16.4	92.0
s3n2	1.17	4.19	4.24	58.1	17.8	91.8
s3n3	1.92	3.70	3.85	67.9	16.3	93.7
SE ±	0.09	0.17	0.18	2.1	0.6	3.6
CD (1) (2)	NS	NS	NS	NS	NS	NS
a1d1	0.87	3.62	3.90	67.3	16.4	91.2
a1d2	0.82	3.31	3.65	65.6	17.6	95.6
a2d1	1.26	3.74	3.36	67.9	15.8	96.7
a2d2	1.10	3.53	3.37	68.3	16.7	101.4
SE ±	0.06	0.11	0.12	1.4	0.4	2.4
CD (1) (2)	NS	NS	NS	NS	NS	NS

DAT : Days after transplanting

Table 9 A x N and D x N interaction means for Leaf Area Index stagewise and NPK uptake at harvest

	Leaf Area Index			NPK uptake (kg/ha)		
	20 DAT	40 DAT	60 DAT	N	P	K
a1n1	0.75	3.37	3.78	64.9	16.2	93.2
a1n2	0.79	3.56	3.83	69.1	18.4	98.3
a1n3	0.99	3.46	3.72	55.3	16.3	88.7
a2n1	0.86	3.54	3.40	67.7	17.2	98.8
a2n2	1.09	3.59	3.26	68.3	16.2	96.3
a2n3	1.60	3.79	3.43	68.4	15.4	102.1
SE ±	0.77	0.14	0.15	1.7	0.5	2.9
CD (1) (2)	NS	NS	NS	NS	NS	NS
d1n1	0.88	3.70	3.70	67.4	16.1	93.2
d1n2	0.93	2.53	3.49	70.9	17.2	97.7
d1n3	1.37	3.73	3.30	64.6	15.1	90.9
d2n1	0.72	3.15	3.48	65.3	17.4	98.7
d2n2	0.94	3.61	3.60	66.4	17.4	96.8
d2n3	1.21	3.51	3.45	69.1	16.6	99.9
SE ±	2.51	0.77	0.14	0.1	1.7	0.5
CD	NS	0.39	NS	4.9	NS	NS

DAT : Days after transplanting

(ii) P uptake at harvest (Table 6 to 9 and Appendix VI)

P uptake at harvest was not affected by change in spacing or seedling age. But change in planting depth affected the P uptake and the crop raised by planting seedling at 6-8 cm depth removed more amount of P (17.1 kg per ha) compared to the one raised by shallow planting (3 to 4 cm). Change in seedling number per hill affected the P uptake at harvest. The highest P uptake (17.3 kg per ha) was noticed when planting was done @ 6 seedlings per hill. The various interaction effects failed to influence this character.

(iii) K uptake at harvest (Table 6 to 9 and Appendix VI)

The main effects of spacings, seedling age, planting depth and number of seedlings per hill did not influence the K uptake considerably. Among the various interactions "seedling age x planting depth" interaction effect alone was marked and the highest uptake of 101.4 kg K per ha was observed with the crop raised by planting " 35 day old seedlings at 6-8 cm depth".

III Yield attributes and Yield

(i) Number of panicles per m^2 (Table 10 to 13 and Appendix VI

The spacings, seedling age, planting depth, seedling number per hill and their interactions did not influence the panicle number per m^2.

Table 10 Effects of spacing, age of seedlings, depth of planting and number of seedlings per hill on yield attributes

	No. of panicles per sq. meter	Panicle length (cm)	No. of filled grains/ panicle	No. of unfilled grains/ panicle	Percentage of filled grains	Thousand grain weight (g)
s1	281.7	20.6	53.1	31.3	62.7	27.07
s2	280.1	19.4	44.4	34.6	55.2	27.04
s3	285.8	18.6	43.0	31.2	56.9	26.98
SE ±	12.0	1.2	2.0	1.5	1.3	0.28
CD	NS	NS	6.1	NS	4.1	NS
a1	287.0	19.6	46.9	36.9	55.9	27.40
a2	278.3	19.4	46.5	27.8	60.8	26.80
SE ±	9.8	1.6	0.2	1.2	1.1	0.23
CD	NS	NS	NS	NS	3.3	NS
d1	276.8	19.6	47.9	33.1	58.6	27.03
d2	288.5	19.4	45.4	31.6	57.9	27.05
SE ±	4.8	0.1	1.2	1.0	1.2	0.18
CD	NS	NS	NS	NS	NS	NS
n1	283.8	19.9	49.1	31.9	58.0	27.19
n2	276.4	19.3	44.7	32.0	57.6	26.85
n3	287.8	19.4	46.3	33.2	53.3	26.21
SE ±	5.3	1.2	1.4	1.2	1.5	0.22
CD	NS	0.5	NS	NS	NS	NS

<u>Spacings</u>

s1 - 20 x 15 cm
s2 - 20 x 10 "
s3 - 15 x 10 "

<u>Age of seedlings</u>

a1 - 20 days old
a2 - 35 days old

<u>Depth of planting</u>

d1 - 3 to 4 cm
d2 - 6 to 8 "

<u>Number of seedlings/hill</u>

n1 - 3 seedlings/hill
n2 - 6 seedlings/hill
n3 - 9 seedlings/hill

Table 11 S x A and S x D interaction means for yield attributes

	No.of panicles per sq. meter	Panicle length (cm)	No.of filled grains/ panicle	No. of unfilled grains/ panicle	Percent-age of filled grains	Thousand grain weight (g)
s1a1	280.9	19.7	55.6	35.3	16.9	27.46
s1a2	282.5	19.4	50.6	27.4	64.6	26.68
s2a1	289.7	19.5	44.1	39.5	52.1	27.45
s2a2	271.2	19.3	43.8	29.6	58.3	26.62
s3a1	290.4	19.6	40.9	36.0	54.6	27.28
s3a2	281.3	19.4	45.1	26.4	59.1	26.68
SE ±	16.9	0.3	2.9	2.1	1.9	3.39
CD	NS	NS	NS	NS	NS	NS
s1d1	277.1	19.7	52.6	31.7	61.5	27.26
s1d2	288.3	19.5	53.6	30.9	64.0	26.88
s2d1	274.0	19.4	47.1	36.4	56.4	26.63
s2d2	286.9	19.4	40.8	32.7	54.0	27.44
s3d1	279.3	19.9	44.0	31.0	58.0	27.80
s3d2	292.4	19.2	42.0	31.3	55.7	27.75
SE ±	7.5	0.2	1.9	1.9	2.1	0.31
CD 1) 2)	NS	NS	NS	NS	NS	NS

Table 12 S x N and A x D interaction means for yield attributes

	No.of panicles per sq. meter	Panicle length (cm)	No. of filled grains/ panicle	No. of unfilled grains/ panicle	Percent- age of filled grains	Thousand grain weight (g)
s1n1	288.3	20.0	56.3	34.0	61.7	26.82
s1n2	286.9	19.5	51.1	31.6	61.8	27.16
s1n3	269.8	19.3	51.9	28.4	64.7	17.23
s2n1	271.8	19.9	44.6	36.9	55.6	26.40
s2n2	273.1	19.1	44.0	32.5	56.6	26.6
s2n3	296.5	19.2	43.2	34.2	53.4	27.14
s3n1	291.4	19.8	46.2	28.8	60.6	27.36
s3n2	269.1	19.2	39.1	31.8	55.5	26.81
s3n3	297.0	19.6	43.7	33.0	54.5	26.76
SE ±	9.2	0.3	2.4	2.1	2.6	0.37
CD 1) 2)	NS	NS	NS	NS	NS	NS
a1d1	286.3	19.9	48.8	36.4	56.9	27.43
a1d2	287.7	19.8	44.9	37.2	54.8	27.4
a2d1	267.3	19.4	47.0	29.4	60.3	26.63
a2d2	289.4	19.3	46.0	26.1	61.0	26.70
SE ±	6.1	0.2	1.6	1.4	1.7	0.25
CD 1) 2)	NS	NS	NS	NS	NS	NS

Table 13 A x N and D x N interaction means for yield attributes

	No. of panicles per sq.metre.	Panicle length (cm)	No. of filled grains per panicle	No. of unfilled grains per panicle	Percentage of filled grains	Thousand grain weight (g)
a1n1	288.7	19.9	46.9	37.5	56.6	27.55
a1n2	281.8	19.3	45.4	36.6	56.5	27.17
a1n3	290.6	19.6	48.2	36.8	55.4	27.49
a2n1	279.0	19.8	51.2	29.0	62.0	26.83
a2n2	271.0	19.2	44.0	27.4	60.4	27.55
a2n3	285.0	19.1	44.3	26.9	59.7	26.60
SE ±	7.5	0.2	2.0	1.7	2.1	0.31
CD 1) 2)	NS	NS	NS	NS	NS	NS
d1n1	282.2	19.9	50.0	35.5	58.5	27.56
d1n2	276.1	19.3	45.9	32.3	58.6	26.50
d1n3	272.2	19.6	47.9	31.4	58.8	27.04
d2n1	285.5	19.8	48.1	31.0	69.0	26.82
d2n2	276.7	19.2	43.6	31.6	57.4	27.20
d2n3	303.3	19.0	44.7	32.3	56.3	27.05
SE ±	7.5	0.2	2.0	1.7	2.1	0.31
CD 1) 2)	NS	NS	NS	NS	NS	NS

(ii) Panicle length (Table 10 to 13 and Appendix VII)

Of the four factors considered for the study, only seedling number per hill had any pronounced effect on panicle length. The longest panicles were produced by the crop raised by planting seedlings @ three per hill and the panicle length decreased with increase in seedling number per hill.

None of the interaction effects changed the panicle length.

(iii) Number of filled grains per panicle (Table 10 to 13 and Appendix VII and VIII)

The effect of spacing was considerable on number of filled grains per panicle. The highest value (53.1) was observed in the crop raised at the wider spacing of 20 x 15 cm. The effects of 20 x 10 cm and 15 x 10 cm spacings were on par with respect to this character. The main effects of seedling age, planting depth and seedling number per hill and the various interaction effects were not considerable on the number of filled grains per panicle.

(iv) Number of unfilled grains per panicle (Table 10 to 13 and Appendix VII)

The effect of spacings, seedling age, planting depth, seedling number per hill and their interactions had no influence on the number of unfilled grainsper panicle.

(v) Percentage of filled grains (Table 10 to 13 and Appendix VII)

Change in plant spacings changed the filled grain percentage. The highest percentage of filled grains (62.7) was noticed in the crop raised under wider spacing (20 x 15 cm) compared to the two narrow spacings. The effects of the narrow spacings (20 x 10 cm and 15 x 10 cm) were comparable.

There was an increase in percentage of filled grains from 55.9 to 60.8 when the seedling age was increased from 20 days to 35 days. The effects of planting depth, seedling number per hill and the various interactions were not pronounced on percentage of filled grains.

(vi) Thousand grain weight (Table 10 to 13 and Appendix VII and VIII)

Neither the main effects of spacings, seedling age, planting depth and number of seedling per hill nor their interactions could influence the thousand grain weight to any considerable extent.

(vii) Grain yield (Table 14 to 17 and Appendix VII and VIII)

The grain yield was considerably affected by altering the plant spacings. The highest grain yield of 25.20 q per ha was obtained when the crop was raised at a spacing of 20 x 15 cm and this spacing was better than two closer

Table 14 Effect of spacing seedling age planting depth and number of seedlings per hill on grain yield, straw yield and harvest index

	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
s1	25.20	43.42	0.36
s2	22.56	47.25	0.33
s3	21.75	47.36	0.32
SE ±	0.64	2.66	0.01
CD	1.92	NS	NS
a1	23.37	45.19	0.34
a2	22.97	46.83	0.33
SE ±	0.52	2.17	0.01
CD	NS	NS	NS
d1	23.02	45.35	0.34
d2	23.32	46.67	0.33
SE ±	0.32	0.77	0.01
CD	NS	NS	NS
n1	24.22	46.16	0.35
n2	22.92	45.76	0.35
n3	22.37	46.1	0.33
SE ±	0.39	0.95	0.01
CD	1.11	NS	NS

<u>Spacing</u>

s1 - 20 x 15 cm
s2 - 20 x 10 "
s3 - 15 x 10 "

<u>Age of seedlings</u>

a1 - 20 day old
a2 - 35 "

<u>Depth of planting</u>

d1 - 3 to 4 cm
d2 - 6 to 8 "

<u>No. of seedlings/ hill</u>

n1 - 3 seedlings/ hill
n2 - 6 "
n3 - 9 "

Table 15 S x A, S x D interaction means for grain yield, straw yield and harvest index

	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
s1a1	26.73	42.15	0.36
s1a2	23.66	44.68	0.35
s2a1	21.62	44.41	0.34
s2a2	23.51	50.08	0.32
s3a1	21.75	49.00	0.33
s3a2	21.75	45.73	0.32
SE ±	0.90	3.76	0.02
CD	2.71	NS	NS
s1d1	25.94	43.48	0.37
s1d2	24.46	43.36	0.34
s2d1	21.82	46.60	0.32
s2d2	23.31	47.90	0.33
s3d1	21.29	45.97	0.33
s3d2	22.21	48.75	0.32
SE ±	0.56	1.34	0.01
CD 1	2.73	NS	NS
CD 2	3.14		

Table 16 S x N and A x D interaction means for grain yield, straw yield and harvest index

	Grain yield (q/ha)	Straw yield (q/ha)	Harvest Index (%)
s1n1	25.86	43.96	0.36
s1n2	25.90	43.77	0.36
s1n3	23.84	43.53	0.35
s2n1	23.90	46.38	0.35
s2n2	21.76	47.72	0.32
s2n3	22.02	47.64	0.32
s3n1	22.90	48.14	0.33
s3n2	21.90	46.81	0.34
s3n3	21.25	47.14	0.31
SE ±	0.68	1.65	0.01
CD 1) CD 2)	NS	NS	NS
a1d1	23.27	45.56	0.35
a1d2	23.46	44.82	0.34
a2d1	22.76	45.14	0.33
a2d2	23.19	48.52	0.33
SE ±	0.45	1.09	0.08
CD 1) CD 2)	NS	NS	NS

Table 17 A x N and D x N interaction means for grain yield, straw yield and harvest index

	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
a1n1	24.43	46.67	0.35
a1n2	23.02	46.34	0.34
a1n3	22.65	43.55	0.34
a2n1	24.02	46.65	0.34
a2n2	22.82	45.19	0.33
a2n3	22.08	48.65	0.31
SE ±	0.56	1.34	0.01
CD 1) CD 2)	NS	NS	NS
d1n1	23.80	45.38	0.35
d1n2	22.92	46.16	0.34
d1n3	22.32	44.52	0.33
d2n1	24.64	46.95	0.34
d2n2	22.92	45.37	0.34
d2n3	22.41	47.68	0.32
SE ±	0.56	1.34	0.01
CD	NS	NS	NS

spacings. The grain yields obtained with the spacings of 20 x 10 cm and 15 x 10 cm were 22.56 q per ha and 21.75 q per ha respectively and their effects were comparable.

Seedling age and planting depth did not affect the grain yield. But the seedling number per hill had a notable influence on grain yield. The highest yield of 24.22 q per ha was obtained, when the crop was raised by planting three seedlings per hill. This was better than the other two seedling rates. The crops raised by planting seedlings @ six and nine per hill respectively produced grain yields of 22.92 q per ha and 22.37 q per ha and their affects were on par.

The "spacing x age of seedlings" interaction effects was considerable on grain yield. This means that the effect of spacing on grain yield was modified by seedling age. The highest grain yield due to "spacing x seedling age" interaction (26.73 q per ha) was observed when the crop was raised by planting " 20 day old seedlings at 20 x 15 cm spacing" and this was superior to all other combinations. This was followed by s1a2 (20 x 15 cm spacing and 35 day old seedlings) which yielded 23.66 q per ha and by s2a2 (20 x 10 cm and 35 day old seedlings) with a grain yield of 23.51 q per ha. The effects of s1a2 and s2a2 were on par.

The effect of spacing on grain yield was altered by planting depth. While the crop raised by planting seedlings at 20 x 15 cm spacing and three to four centimeter deep, produced the highest grain yield of 25.94 q per ha s2d1 (20 x 10 cm with three to four centimeter depth) and s3d1 (15 x 10 cm spacing with three to four centimeter depth) could produce only 21.82 and 21.29 q per ha respectively.

The effects of the other interactions were not marked on grain yield.

(viii) Straw yield and Harvest Index (Table 14 to 17 and Appendix IX

Neither the main effect of spacings, seedling age, planting depth and seedling number per hill nor their interactions influence the straw yield or Harvest Index considerably.

DISCUSSION

DISCUSSION

The present study was undertaken to develop suitable planting techniques such as optimum spacing, seedling age, planting depth and seedling number per hill for medium duration rice during Mundakan season.

The results obtained from the study are discussed below.

A. Growth characters

1. Plant height

The results presented in Tables 2 to 5 revealed that the plant height was not affected by the spacings at any of the growth stages. Nonsignificant influence on plant height due to change in plant spacing was reported by Seva Ram et al (1973) and Shahi et al (1976). Increase in plant height at wider spacings was observed by Fagundo et al (1978) and Ibrahim et al (1980). The light environment of the plants grown under the different spacings (20 x 15 to 15 x 10 cm) might have been optimum and perhaps there might not have been any competition for light. This can be the possible reason for the observed trend in the present study.

Seedling age influenced plant height at all growth stages except at 60 DAT. The crop raised with 35 day old seedlings showed more height during early stage of growth, while at harvest the one raised with 20 day old seedlings was taller. A similar pattern of behaviour of rice in response to seedling age was reported by Enyi (1963). The superiority of aged seedlings during early stages can be attributed to the age difference itself. But in the course of development the rate of growth of the younger seedlings had surpassed that of the aged seedlings, and as a result the younger seedlings exhibited more height at later stages of growth.

The younger seedlings not only suffered less severe competition for light and nutrients in the nursery but also had the advantage of more time in the main field compared to the old ones. In addition they had a higher meristematic activity than aged seedlings. Barthakur and Gogoi (1974) and Murty and Sahu (1979) also recorded similar results.

Effect of planting depth on plant height was seen at 40 DAT and shallow planting (3 to 4 cm deep) produced taller plants than deep planting (6 to 8 cm deep). It is a common observation that root production and nutrient absorption is more with the crop planted shallow compared to deep planted ones and hence the result. However, the difference in plant height reported above disappeared in the later stages. Orsi (1960) found that plant height increased when seedlings were transplanted at a depth of three centimeter compared to six and ten centimeter.

Increasing the number of seedlings per hill from three to nine resulted in an increase in plant height during the early stages, while a reverse trend was observed during the later stages (60 DAT). However this difference did not persist upto harvest. The decrease in plant height due to higher seedling rates observed in the later stages may be due to severe competition. Sahu and Lenka (1956) observed decrease in plant height due to increase in the number of seedlings per hill.

The interaction effects between the treatment factors, were rare with respect to plant height. However, the "seedling age x planting depth" interaction on plant height was noticed at harvest and the crop raised by " 20 day old seedlings planted at three to four centimeter depth" was taller than the others. The superiority of " 20 day old seedlings" at harvest as well as "three to four centimeter deep planting" at 40 DAT on plant height is evident from Table 2 to 5 and this might be responsible for the above results.

ii. Tiller number per hill

Spacing influenced tiller production at all stages of plant growth except at 20 DAT. The widest spacing under the trial viz. 20 x 15 cm gave the highest tiller count (11.3). The higher tiller production under wider spacing may be due to lesser competition between plants for nutrients as well as for the other growth requirements. The results obtained in the present study is supported by the findings of Chang and Su (1977), Fagundo et al (1978) and Ibrahim et al (1980).

Though the younger seedlings produced more tillers at 40 DAT this difference disappeared in the later stages. Younger seedlings, which suffer less competition for plant nutrients and light in the nursery, also had the advantage of longer period in the main field for tiller formation. In the present study however, as the age difference of the seedling is only 15 days, the adverse effect due to competition, if at all experienced in the nursery might have been compensated in the main field. This may be the reason for the disappearance of the effect of seedling age on tiller production in the later stage. Enyi (1963) and Prasad Rao (1970) observed higher tiller production when younger seedlings were transplanted compared to older ones. But Murty and Sahu (1979) observed no difference in tiller production due to difference in seedling age in medium and late duration rice varieties.

As in the case of seedling age the effect of planting depth on tiller production was seen only at 40 DAT. Shallow planting (three to four centimeter depth) produced more tillers per hill (9.9) compared to deep planting (6 to 8 cm). More root production and consequent absorption of more nutrients might be responsible for the beneficial effect of shallow planting. Orsi (1960) and Enyi (1963) observed similar results.

The data presented in Tables 2 to 5 revealed a consistent superiority of high seedling rate (9 seedlings per hill) in producing more tillers per hill at all stages except at harvest. The higher tiller production observed at the higher seedling rate may be due to the difference in the seedling rate itself. Shahi et al (1976) noticed more tiller production with increase in number of seedlings per hill. There was no interaction between any of the treatment factors with respect to tiller number per hill.

iii. Number of leaves per hill

The results presented in Tables 2 to 5 revealed that there was marked increase in the number of leaves per hill due to spacing. The highest number of leaves per hill was observed with the wider spacing (20 x 15 cm). Availability of more space both above and below the soil reduced the competition for light and nutrients from the neighbouring hills and this might have helped the plant to produce more number of leaves per hill. Similar observations were made by Ibrahim (1980) and Sobhana (1983).

The effect of seedling age on leaf number per hill was noticed at 20 and 60 DAT. During the early stage, aged seedlings (35 day old) produced more number of leaves, while in the later stage (60 DAT) younger seedlings (20 day old) performed better with respect to this character. More number of leaves per hill observed in the aged seedlings during the early stages of growth can be due to age difference itself. But in due course younger seedlings, due to high meristematic activities, produced leaves at a faster rate than the aged ones and expressed more number of leaves at the later stages of plant growth. Singh and Tarat (1978) reported higher leaf number with the crop raised from 29 day old seedlings compared to the one raised from older ones. As in the case of tiller number per hill, leaf number per hill was influenced by planting depth at 40 DAT and three to four centimeter deep planting resulted in more number of leaves per hill. However this effect disappeared in the later stages. Root production and nutrient absorption might be more at shallow planting. In the present study the effect of planting depth on tiller production was noticed at this particular stage (40 DAT), with more tillers under shallow planting. This may be the reason for more number of leaves per hill at this planting depth. Padalia and Mahapatra (1965) reported that the leaf production was less when seedlings were transplanted deep.

There was an increase in leaf number per hill with an increase in the seedling number per hill and this effect was noticed at the early stages (20 and 40 DAT). The crop raised by planting nine seedlings per hill produced the highest number of leaves per hill (36.4) compared to the lower seedling rates. However this difference did not persist upto the later stages. The higher leaf number per hill observed with the higher seedling rate in the early stage was due to the difference in the seedling number itself. Further it can be seen from the Tables 2 to 5 that during the early stages, tiller production per hill was also higher with the higher seedling rates (nine seedlings per hill).

A slight decline in leaf number per hill was also observed between 40 and 60 DAT and this may be due to senescence.

"Spacing x Seedling age" interaction was noticed at 40 DAT and the crop planted at 20 x 15 cm spacing with 20 day old seedlings" produced highest number of leaves per hill.

The interaction between "spacing x seedling number per hill" was noticed at 20 DAT and the crop planted at "15 x 10 cm spacing @ nine seedlings per hill" produced more leaves per hill. "Seedling age x planting depth" interaction was observable at 20 and 40 DAT and " 35 day old seedlings planted at three to four centimeter depth" produced highest number of leaves. Interaction between "seedling age and seedling number per hill" was noticed only at the initial stage and " 35 day old seedlings planted @ nine seedlings per hill" produced more number of leaves. All the other interaction effects were absent.

iv. Leaf area index (LAI)

The results presented in Tables 6 to 9 and Fig. 3 to 5 revealed that the LAI increased with decrease in spacing and this was consistently noticed through out the crop growth. The highest LAI was observed with the crop planted at 15 x 10 cm at all the stages of plant growth. At 20 and 60 DAT the closer spacing 15 x 10 cm was superior to other two wider spacings with respect to LAI. It may be noted that closer

FIG 3. EFFECT OF SPACING ON LEAF AREA INDEX

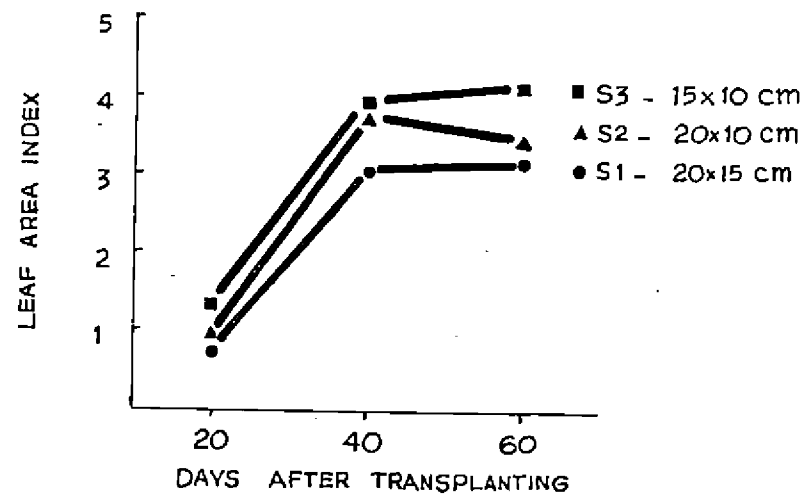


FIG 4. EFFECT OF SEEDLING AGE ON LEAF AREA INDEX

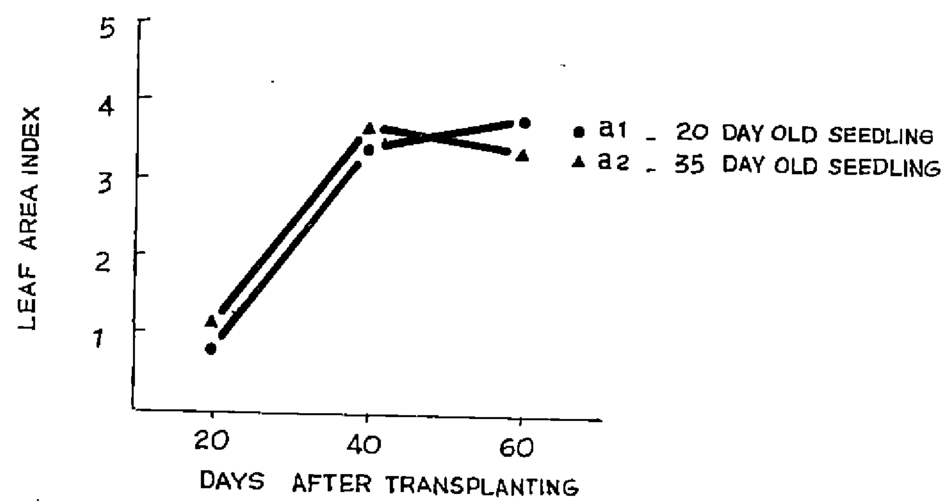
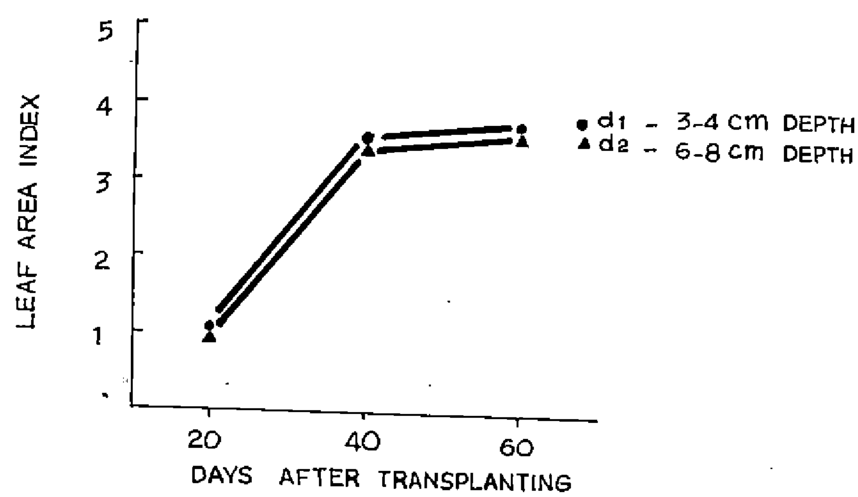


FIG 5. EFFECT OF PLANTING DEPTH ON LEAF AREA INDEX



spacing produced lower number of tillers per hill and lesser number of leaves per hill throughout the crop growth. Inspite of the above facts, a reverse trend in LAI was noticed with reference to spacing. LAI being the leaf area per unit of land area, the reduction in tiller production and leaf production under closer spacing might have been more than compensated by reduction in land area and hence the above result. In the trials conducted by Chang (1968) on japonica rice, it was found that LAI increased with reduction in spacing. Golingai and Mabbayad (1969), Fagade and Datta (1971) and Sobhana (1983) also reported similar results.

The crop raised by 35 day old seedlings showed a higher LAI of 1.18 in the initial stages of plant growth. But an opposite trend was noticed during the later stages (60 DAT) and the crop raised with 20 day old seedlings expressed the highest LAI of 3.78.

The effect of seedling age on number of leaves per hill was similar to that on LAI (Tables 2 to 9) and hence the reasons attributed for the difference in leaf number per hill due to seedling age holds good for LAI as well. Enyi (1963) reported that the LAI at ear emergence was higher when younger seedlings were transplanted compared to older ones. Murty and Sahu (1979) observed low LAI when aged seedlings were transplanted compared to young seedlings, in short duration rice. The above reports are in line with the findings of the present study.

Planting depth influenced LAI at 40 DAT and the highest LAI of 3.68 was observed with the crop raised by shallow planting (three to four centimeter). However, this difference due to planting depth disappeared in the later stage. It may be noted from Tables 2 to 5 that shallow planting resulted in higher number of tillers per hill as well as higher number of leaves per hill at this particular stage (40 DAT). This might have resulted in a higher LAI at this particular planting depth (three to four centimeter). The nonsignificant effect of planting depth on LAI observed in the later stages of plant growth (60 DAT) in the present study is supported by the findings of Enyi (1963).

The number of seedlings per hill as well as the interaction between any of the treatment factors did not exert any change on LAI.

v. <u>Nutrient uptake</u>

Spacing and age of seedlings did not influence the uptake of N, P or K as revealed by the results represented in tables 6 to 9. Similar effect of plant spacing on N uptake was reported by Sankara Panicker (1975).

The depths of planting and seedling number per hill did not change N uptake. The "planting depth x number of seedlings" interaction alone influenced N uptake and the crop raised by planting " Six seedlings per hill at three to four centimeter depth" removed the highest amount of 70.9 kg N/ ha. Planting depth has influenced the P uptake and deep planted crop (six to eight centimeter depth) removed more amount of P compared to the shallow planted (3 to 4 cm) ones. The P uptake by plant was different due to difference in seedling number per hill and the highest P uptake (17.3 kg/ha) was observed when planted @ six seedlings per hill. Interaction between treatment factors did not change the P uptake.

The K uptake was also not altered by change in planting depth or number of seedlings per hill. But the uptake of this nutrient was influenced by " seedling age x planting depth" interaction and the highest K uptake of 101.4 kg/ha was noticed with the crop raised by " 35 day old seedlings planted at six to eight centimeter deep". All the other interaction effects were absent with respect to K uptake.

vi. Yield attributes

The results on the yield attributes presented in Tables 10 to 13 revealed that the effect of spacing was considerable on number of filled grains per panicle and on percentage of filled grains. In both the cases the highest values were observed with the crop raised under wider spacing (20 x 15 cm) and the effects of the two narrow spacings (20 x 10 and 15 x 10 cm) were on par. Chang (1968) reported a decrease in grain number per panicle with closer spacing. Murty and Murty (1980) and Sobhana (1983) observed similar results. Yield attributes such as number of panicles per m^2, panicle length, number of unfilled grains per panicle and 1000 grain weight remained unaffected by spacing. Pillai and George (1973) and Shahi et al (1976) reported nonsignificant influence of spacing on test weight.

Seedling age did not change any of the yield attributes other than the percentage of filled grains. When the seedling age increased from 20 to 35 days the percentage filled grains increased from 55.9 to 60.8. Sankara Panicker (1975) observed higher percentage of filled grains in the crop raised from 35 and 28 day old seedlings compared to 21 day old ones. None of the yield attributes was affected by change in planting depth.

The effect of seedling number was noticed only on panicle length. The crop raised by planting three seedlings per hill produced the longest panicle and the panicle length decreased with increase in seedling number per hill. Mahapatra et al (1963) observed decrease in panicle length with increase in number of seedlings per hill.

Interaction effects between the treatment factors on yield attributes were absent.

vii. Grain yield (Fig. 6 to 8)

The results presented in Tables 14 to 17 revealed that the grain yield was highest with 20 x 15 cm spacing (25.20 q/ha). The wider spacing was better than the two narrow spacings. The grain yield obtained with 20 x 10 cm and 15 x 10 cm spacings were on par. Reducing the spacing was found to cause a decline in yield. This may be due to the fact that as the plant spacing decreases, the plant density increases leading to heavy competition for light and nutrients among the plants. As a result the perplant yield under closer spacing might have been drastically reduced resulting in decreased yield per unit area.

A perusal of the data on the effect of spacing on growth characters such as tiller number per hill and leaf

FIG 6. INTERACTION EFFECT BETWEEN SPACING AND SEEDLING AGE ON GRAIN YIELD

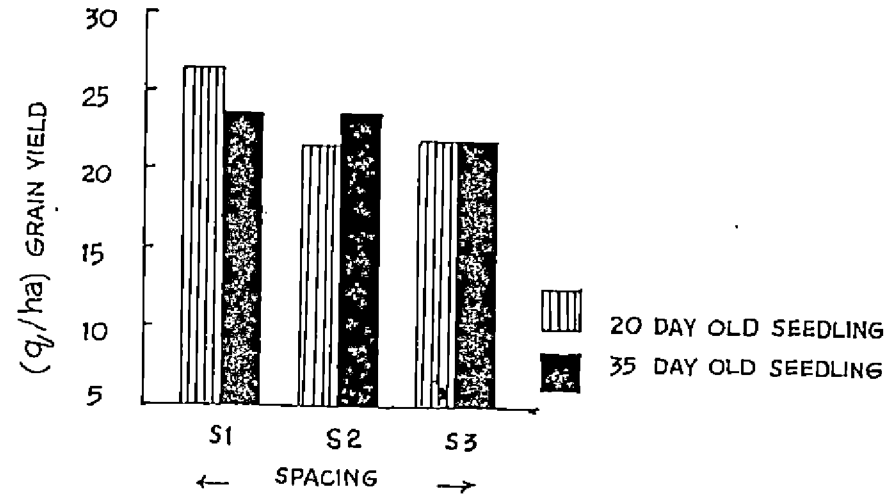


FIG 7. INTERACTION EFFECT BETWEEN SPACING AND DEPTH OF PLANTING ON GRAIN YIELD

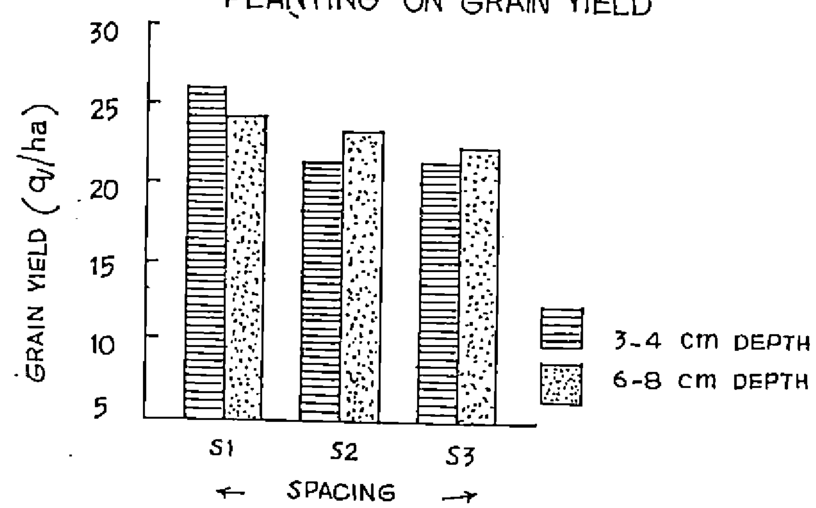
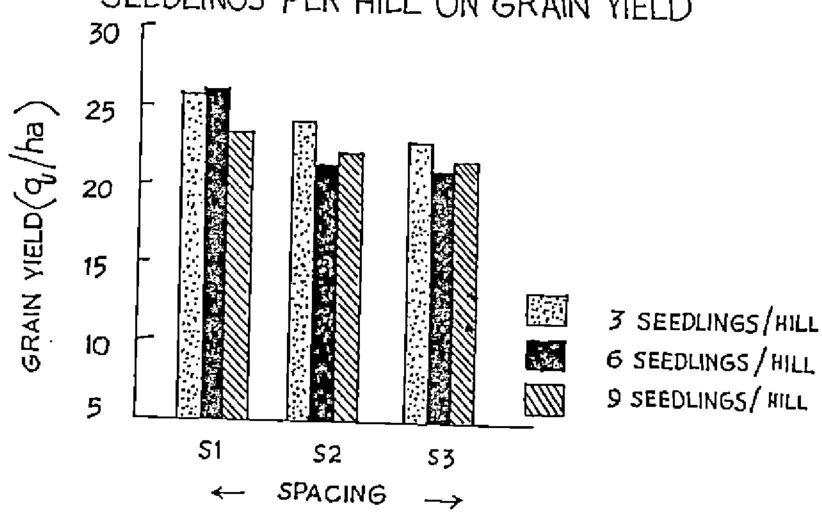


FIG 8. INTERACTION EFFECT BETWEEN SPACING AND NUMBER OF SEEDLINGS PER HILL ON GRAIN YIELD



number per hill clearly indicates the superiority of the wider spacing (20 x 15 cm) over the closer spacing (15 x 10 cm). More number of filled grains per panicle as well as percentage filled grains were noticed under wider spacing. The closer spacings (20 x 10 and 15 x 10 cm) proved to be inferior to the wider spacing (20 x 15 cm). This may be due to the fact that the closer spacings produced lesser number of tillers. Similarly the number of filled grains per panicle as well as percentage of filled grains were also low at closer spacings. This can be attributed to severe competition between plants under high plant density. All these factors compounded to prove the inferiority of the closer spacing. Chang and Su (1977) reported increased grain yield with increase in spacing. Ghosh et al (1979) observed decline in yield under closer spacing (10 x 10 cm) and highest grain yield was obtained at a spacing of 20 x 20 cm. Chandrakar and Khan (1981) also observed similar results with medium duration rice variety.

The grain yield was not affected by seedling age or planting depth. Data presented in Tables 2 to 5 revealed that the effect of these factors on tiller production, though observed in the early stage, disappeared in the later stage. Data on yield attributes further revealed that seedling age could change only the percentage of filled grains while planting depth did not influence any of the yield contributing factors. The nonsignificant effect of seedling age on grain yield may be due to the above reasons. Similar results were observed by Sankara Panicker (1975), Anon (1976), Lal et al (1981) and Sahani et al (1984).

In the present study planting depth ranging from three to eight centimeters did not produce significant effect on grain yield. However reports of earlier workers indicate the superiority of shallow planting over deep planting to obtain higher yields in rice (Muhandiran Peiris 1956, Enyi 1963, Mahapatra and Padalia 1971 and Patel and Patel 1983).

Though change in seedling age as such did not influence the grain yield, it could modify the effect of plant spacing. In other words, there exist significant interaction between spacing and seedling age on grain yield. The highest grain yield due to this interaction (26.73 q/ha) was observed with the treatment combination S_1 a_1 (20 x 15 cm spacing and 20 day old seedlings) and this was better than all other " spacing - age" combinations. This is followed by s1,a2 (20 x 15 cm spacing and 35 day old seedlings) with an yield of 23.66 q/ha and then by s2a2 (20 x 10 cm spacing and 35 days old seedlings) with grain yield of 23.51 q/ha. However the effects of these two treatment combinations (s1a2 and s2a2) were on par. (Fig.6)

Under the same spacing (20 x 15 cm) when the seedling age was increased from 20 days to 35 days the yield declined from 26.73 q/ha to 23.66 q/ha, registering a 11.48 percentage decline in grain yield.

The above results point to the fact that planting of 20 day old seedlings at a spacing of 20 x 15 cm is optimum for a medium duration variety like Jaya during Mundakan season.

An increase in seedling number per hill from three to nine decreased the grain yield. The highest grain yield of 24.22 q/ha was obtained when the crop was raised by planting 3 seedlings per hill. The other two seedling rates (six seedlings per hill and nine seedlings per hill) produced lower grain yields of 22.92 q/ha and 22.37 q/ha and were thus inferior to the seedling rate of three per hill. It may be noted from table 10 that panicle length was more with crop raised by planting three seedlings per hill. It can also be seen from this table that, though the effects of seedling rate per hill on other yield attributes were not significant the highest values of number of filled grains per panicle, " percentage filled grains" and 1000 grain weight were observed with the seedling rate of three per hill. The compounded effect of all these parameters might be responsible for the advantage at the lowest seedling rate of three per hill. Bain and Singh (1967) obtained highest grain yield by planting two seedlings per hill compared to higher seedling rates. Thus the results suggest that planting seedlings @ three per hill is optimum for obtaining higher grain yields.

The results obtained from the present study also revealed that changing the depth from three to eight centimeter as such does not affect the grain yield in medium duration rice. But there exists an interaction between plant spacing and planting depth on grain yield. The highest grain yield due to this interaction (25.94 q/ha) was observed with s1d1 (20 x 15 cm spacing and three to four centimeter deep planting). This was followed by s1d2 (20 x 15 cm spacing and six to eight centimeter deep planting) with an yield of 24.46 q/ha). The effect of s1d1 and s1d2 were on par. The superiority of s1d1 over the other "spacing x planting depth" combinations was very evident. (Fig.7)

It may be noted that under the same planting depth (three to four centimeter) when the plant spacing was decreased from 20 x 15 cm to 20 x 10 cm there was a drastic decline in yield from 25.94 q/ha to 21.82 q/ha registering a 15.9 per cent reduction. A further reduction in spacing to 15 x 10 cm at the same planting depth also reduced the grain yield though not significantly. A more or less similar pattern of influence of spacing on grain yield was discernible under d2 (six to eight centimeter deep planting), but the rate of reduction in yield was not as marked as with d1 (three to four centimeter deep planting).

The above results revealed that planting seedlings three to four centimeter deep with a spacing of 20 x 15 cm is optimum for a medium duration rice variety like Jaya.

It can further be seen from the data on grain yield that the yield level achieved was not high, the highest yield obstained being 26.73 q/ha. It is to be mentioned here that the crop in general suffered from a severe attack of rice bug inspite of adoption of scientific protective measures. Further data on LAI (Tables 6 to 9) revealed that the crop has not attained the LAI optimum. The above reasons can be attributed to the low level of productivity observed.

From the discussions made so far the following conclusions can be drawn.

1. A spacing of 20 x 15 cm is optimum for medium duration variety like Jaya for higher yield in Mundakan season.

2. Seedling age ranging from 20 to 35 days and planting depth ranging from three to eight centimeter as such have no effect on grain yield during Mundakan in medium duration rice.

3. A seedling rate of three per hill provides higher yields.

4. Among the interaction effects between the treatment factors only "spacing x seedling age" and "spacing x depth of planting" interactions exerted influence on grain yield.

5. Planting " 20 day old seedlings"at 20 x 15 cm spacing gave the highest yield.

6. Planting seedlings at "three to four centimeter depth at a spacing of 20 x 15 cm also gave higher yield.

viii. Straw yield and Harvest index

Data presented in Tables 14 to 17 revealed that neither the main effects of spacing, seedling age, planting depth, and seedling number per hill, nor their interactions influenced straw yield or harvest index.

Results of practical utility

Following are the highlights of the present study. For medium duration rice, planting either " 20 day old seedlings at 20 x 15 cm spacing" or planting seedlings "three to four centimeter deep at 20 x 15 cm spacing" gives higher grain yield in Mundakan season. This being a "low cost technology", can be adopted by a larger number of farmers irrespective of their economic condition. It is hoped that the above results will be of greater utility to the farming community of Kerala.

SUMMARY

SUMMARY

An experiment was conducted at the Cropping Systems Research Centre, Karamana, Trivandrum, during 1984-'85 Mundakan season to identify the optimum spacing, seedling age, planting depth and seedling number per hill in rice, to study the interaction effects between these factors on growth and yield of rice and to assess the uptake of fertilizer nutrients as influenced by the treatments.

The experiment was laid out in split plot design with 4 replications. In the main plot there were six treatments formed by the combinations of 3 spacings (20 x 15 cm, 20 x 10 cm and 15 x 10 cm) and two age of seedling (20 day old and 35 day old seedlings). In the sub plot also there were six treatments formed by the combinations of 2 depths of planting (3 to 4 cm and 6 to 8 cm) and 3 seedling rates per hill (3,6 and 9 seedlings per hill). In total there were 36 treatment combinations. The variety used was Jaya. The results of the experiments are summarised below.

(1) Plant height was influenced by seedling age, and 20 day old seedlings produced the tallest plant at harvest.

(2) Crop raised by planting 9 seedlings per hill produced more plant height in the early stage while the one raised by planting 3 seedlings per hill expressed more plant height during the later stages (60 DAT). The effect of spacing,

planting depth and the interaction between the treatment factors were not pronounced in this character.

(3) A spacing of 20 x 15 cm consistently produced more number of tillers. The crop raised by planting 9 seedlings per hill produced more tillers in the early stages of crop growth. The effect of seedling age, planting depth and the interaction between the treatment factors did not influence tiller number per hill.

(4) Leaf production was more with the wider spacing (20 x 15 cm) compared to the closer spacing (15 x 10 cm). While the crop raised from 35 day old seedlings produced more number of leaves in the early stages, the one raised from 20 day old seedlings expressed its superiority at harvest. Shallow planting resulted in more number of leaves at 40 DAT. Crop raised by planting 9 seedlings per hill produced more number of leaves in the early stages. The interaction effects on leaf production were not consistent and can be ignored.

(5) LAI increased with decrease in spacing and the closer spacing (15 x 10 cm) produced the highest LAI at all stages of growth. LAI increased with seedling age at the initial stages of plant growth. But at harvest the crop raised with 20 day old seedlings expressed higher LAI. The effects of planting depth, seedling number per hill and interaction effects of all the treatment factors on LAI were considerable.

(6) The main effects of spacing, seedling age, planting depth, seedling number per hill and the interaction between the treatment factors on the uptake of N, P and K can be treated as absent.

(7) Increase in spacing, increased the number of filled grains per panicle and percentage of filled grains. The other yield contributing factors such as number of panicles per m^2, panicle length, number of unfilled grains per panicle and thousand grain weight remained unaffected due to spacing. Seedling age influenced percentage of filled grains only, and the crop raised from aged seedlings (35 day old) produced the highest percentage of filled grains. Planting depth did not influence any of the yield attributes. Seedling rate influenced panicle length only and the crop raised by planting 3 seedlings per hill produced the longest panicle. Panicle length decreased with increase in seedling number per hill. Yield components remained unaffected due to the interaction between the treatment factors.

(8) The main effect of spacing on grain yield was considerable, the optimum being 20 x 15 cm for medium duration rice variety in Mundakan season. Seedling age ranging from 20 to 35 days, and planting depth ranging from 3 to 8 cm as such have no effect on grain yield. The "spacing x age of seedling" and "spacing x depth of planting" interactions influenced grain

yield. Planting "20 days old seedlings at 20 x 15 cm spacing" gave the highest grain yield. Similarly when " spacing x planting depth" interaction is considered, the highest yield was observed when the crop was raised by planting seedling at "3 to 4 cm depth with a spacing of 20 x 15 cm".

(9) A seedling rate of 3 seedlings per hill provides higher yields.

(10) Neither the main effects of spacing, seedling age, planting depth and seedling number per hill nor their interactions influenced straw yield or harvest index.

Results of practical utility

Following are the highlights of the present study. For medium duration rice, planting either "20 day old seedlings at 20 x 15 cm spacing" or planting seedlings "three to four centimeter deep at 20 x 15 cm spacing" gives higher grain yield in Mundakan season. This being a "low cost technology", can be adopted by a larger number of farmers irrespective of their economic condition. It is hoped that the above results will be of greater utility to the farming community of Kerala.

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APPENDICES

APPENDIX I

Meterological data during the crop season 1984-85 - Weekly average

Standard weeks	Dates	Weekly total rainfall m.m	Maximum tempera-ture °C	Minimum tempera-ture °C	R.H % Forenoon	R.H % Afternoon
43	Oct.22-Oct.28	15.1	30.45	23.75	83	88
44	Oct.29-Nov.4	0.0	31.23	23.47	82.14	71
45	Nov.5 -Nov.11	36.1	31.06	23.67	91.14	82.71
46	Nov.12- Nov.18	5.2	30.36	23.63	82.43	80.29
47	Nov.19- Nov.25	22.9	29.44	22.94	91.00	81.29
48	Nov.26- Dec.2	8.9	30.34	22.13	82.71	72.29
49	Dec.3- Dec.9	1.3	31.93	22.54	68.14	68.86
50	Dec.10-Dec.16	0.0	31.84	21.17	67.00	57.14
51	Dec.17-Dec.23	0.0	31.70	20.87	65.00	58.71
52	Dec.24-Dec.30	0.0	32.11	23.86	82.00	75.38
1	Dec.31-Jan. 6	61.5	30.53	23.33	91.86	77.14
2	Jan.7- Jan.13	0.0	31.47	22.13	81.71	63.71
3	Jan.14- Jan.20	0.0	32.17	23.20	75.00	66.86
4	Jan.21-Jan.27	0.0	32.07	22.00	71.00	62.29
5	Jan.28-Feb.3	8.6	31.63	22.91	81.00	66.29
6	Feb.4- Feb.10	0.0	31.69	23.07	83.29	67.14
7	Feb.11-Feb.17	21.0	32.39	23.53	85.14	70.57
8	Feb.18-Feb.24	10.6	32.26	22.83	75.86	61.29
9	Feb.25- Mar. 3	6.4	32.66	24.23	80.14	68.57
10	Mar.4- Mar.10	0.0	32.33	24.85	80.25	69.50
	Total	197.6				

APPENDIX II

Abstract of Analysis of variance table on height of plants

Source	df	MSS			
		20 DAT	40 DAT	60 DAT	H
Replication	3	197.55*	47.62*	49.33*	21.07
Main plot treatments	5	79.49*	38.64*	15.07	49.62*
S	2	28.02	29.42	34.21	7.30
A	1	329.12*	110.07*	0.02	207.12*
S x A	2	6.14	12.14	3.46	13.19
Error a	15	15.29	11.44	14.35	10.65
Sub plot treatments	5	28.75*	18.10*	18.45*	7.55
D	1	9.25	76.12*	1.73	0.85
N	2	56.55*	3.43	33.48*	0.52
D x N	2	10.70	3.75	11.78	17.92
Main plot x sub plot interaction	25	18.66*	9.63*	18.95*	19.36
SD	2	2.19	4.62	23.35*	6.59
SN	4	18.21	23.11*	10.04	5.08
SDN	4	35.18*	7.65	3.69	38.74*
AD	1	4.66	21.39	1.78	65.20*
AN	2	14.95	14.01	85.13*	3.05
ADN	2	20.87	8.69	8.15	1.60
SAD	2	16.40	3.21	2.78	41.65*
SAN	4	32.23*	4.38	29.23*	4.94
SADN	4	3.89	4.47	15.32	29.52
Error b	90	8.97	5.78	6.50	12.42
Total	143				

* Significant at 5% level

DAT - Days after transplanting

H - Harvest

S - Spacing

A - Age of seedlings

D - Depth of planting

N - Number of seedlings per hill

Abstract of Analysis of variance table on Number of tillers per hill

Source	df	M S S			
		20 DAT	40 DAT	60 DAT	H
Replication	5	2.40	9.15	3.54	4.54
Main) treatments plot)	5	2.66	50.74	42.66*	67.74*
S	2	5.12	106.11*	103.62*	152.50*
A	1	0.76	28.98*	0.13	16.95
SA	2	1.15	6.25	2.96	8.37
Error a	15	1.43	4.62	1.68	4.51
Sub) treatments plot)	5	32.86*	6.84	4.22*	4.77
D	1	4.59	12.48*	0.61	5.84
N	2	74.79	10.03*	8.62*	6.08
DN	2	5.08	0.82	1.62	2.94
Main plot x sub plot interactions	25	3.75*	1.68	2.09*	2.75
SD	2	5.79	0.16	0.30	0.50
SN	4	3.65	1.24	1.44	3.13
SDN	4	7.37*	3.14	5.64*	0.84
AD	1	0.76	1.00	1.10	0.81
AN	2	0.42	0.33	1.41	2.64
ADN	2	1.90	0.48	1.10	0.01
SAD	2	0.91	2.62	0.30	6.14
SAN	4	1.25	1.49	2.92	2.89
SADN	4	6.51*	2.36	0.99	5.48*
Error b	90	2.12	1.99	1.21	2.08
Total	143				

* Significant at 5% level

APPENDIX IV

Abstract of Analysis of variance table on Number of leaves per hill

Source	df	M S S		
		20 DAT	40 DAT	60 DAT
Replication	3	35.56	209.80*	76.27
Main) treatments plot)	5	96.26*	554.29*	499.22*
S	2	96.77*	1167.77*	524.76*
A	1	259.21*	3.48	417.86*
S x A	2	14.28	216.21*	114.35
Error a	15	12.46	41.765	37.23
Sub plot treatments	5	291.13*	74.78*	19.60
D	1	45.79	135.65*	46.13
N	2	687.20*	103.50*	20.78
D x N	2	17.74	17.71	5.16
Main plot X sub plot interaction	25	50.57*	34.11*	16.70
SD	2	2.59	4.06	6.91
SN	4	111.71*	8.91	16.75
SDN	4	57.47*	92.79*	13.42
AD	1	65.07 *	104.04*	51.24
AN	2	74.09*	8.75	4.43
ADN	2	22.80	45.28*	13.15
SAD	2	51.60	10.31	17.22
SAN	4	10.71	21.80	3.63
SADN	4	44.36*	29.44	8.91
Error b	90	14.19	12.74	16.05
Total	143			

* Significant at 5% level

APPENDIX V

Abstract of Analysis of variance table on Leaf Area Index

Source	df	M S S		
		20 DAT	40 DAT	60 DAT
Replication	3	1.93*	2.50	1.76
Main plot treatment	5	2.93*	4.72*	6.19
S	2	4.76*	11.18*	12.08*
A	1	4.12*	1.06	6.17*
S x A	2	0.51	0.97	0.31
Error a		0.31	0.94	70.61
Sub plot treatment		1.35	1.19	0.31
D	1	0.41	2.30*	0.50
N	2	3.05*	0.33	0.03
D x N	2	0.11	1.50*	0.50
Main plot x sub plot interaction	25	0.34*	0.70	0.59
SD	2	0.14	0.41	0.26
SN	4	0.78*	1.03	0.82
SDN	4	0.37*	1.55*	0.41
AD	1	0.05	0.09	0.62
AN	2	0.78*	0.25	0.23
ADN	2	0.32	0.71	0.56
SAD	2	0.17	0.19	0.83
SAN	4	0.14	0.62	1.10
SADN	4	0.09	0.37	0.28
Error b	90	0.14	0.40	0.52
Total	143			

* Significant at 5% level

APPENDIX VI

Abstract of Analysis of variance table on NPK Uptake at harvest

Source	df	MSS		
		N	P	K
Replication	3	653.43	81.64	4206.65
Main plot treatments	5	475.07		
S	2	405.67	16.64	503.65
A	1	101.14	17.75	1148.88
S x A	2	731.32	33.33	1921.88
Error a	15	670.71	44.95	2066.58
Sub plot treatment	5	137.42		
D	1	17.15	36.05*	744.40
N	2	75.01	26.23*	44.85
D x N	2	259.96*	5.73	302.63
Main plot X Sub plot interactions	25	76.69		
SD	2	30.74	3.57	293.12
SN	4	21.85	7.51	206.12
SDN	4	290.24*	7.29	53.19
AD	1	40.84	1.03	0.32
AN	2	57.84	31.87*	502.15
SAD	2	205.52	24.79*	533.85
SAD	2	100.29	23.78*	464.27
SAN	4	101.13	7.92	528.14
SADN	4	83.69	2.95	150.42
Error b	90	73.66	5.89	214.63
Total	143			

* Significant at 5% level

APPENDIX VII

Abstract of Analysis of variance table on Number of panicles per square meter, Panicle length and Number of filled grains per panicle

Source	df	MSS		
		No. of panicles/square meter	Panicle length	No. of filled grains/panicle
Replication	3	3548.38	2.16	729.13
Main plot treatments	5	1184.28	0.54	693.31
S	2	383.89	0.83	1480.72*
A	1	2721.36	0.95	4.00
S x A	2	1216.13	0.04	250.50
Error a	15	6918.59	1.89	196.86
Sub Plot treatments	5	2996.85	3.33*	138.25
D	1	4923.36	3.33	220.52
N	2	1609.14	5.80*	229.89
D x N	2	3421.30	0.86	5.50
Main plot x sub plot interaction	25	1183.52	1.46	81.09
SD	2	59.42	1.46	163.11
SN	4	3320.10	0.57	38.13
SDN	4	252.59	3.25*	35.45
AD	1	3823.36	1.98	75.11
AN	2	89.17	0.52	209.54
ADN	2	428.13	0.37	69.10
SAD	2	316.00	3.93	114.97
SAN	4	548.10	1.13	81.34
Error b	90	1362.22	1.30	95.60
Total	143			

* Significant at 5% level

APPENDIX VIII

Abstract of Analysis of Variance table on Number of unfilled grains per panicle, percentage of filled grains per panicle and 1000 grain weight

Source	df	MSS		
		No. of unfilled grains/panicle	Percentage of filled grains	1000 grain weight
Replication	3	70.90	448.45*	2.96
Main plot treatments	5	681.58*	477.89*	3.98
S	2	173.59	754.06*	0.10
A	1	3033.25*	840.81*	19.36*
S x A	2	13.74	20.25	0.12
Error a	15	109.01	86.58	3.72
Sub plot treatments	5	61.35		3.03
D	1	72.39	19.30	0.001
N	2	28.40	39.19	1.41
D x N	2	88.77	49.83	6.17
Main plot x Sub plot interaction	25	76.70	89.98	1.93
SD	2	52.60	95.10	5.98
SN	4	125.89	198.87	1.94
SDN	4	16.58	33.99	2.03
AD	1	64.50	74.57	0.19
AN	2	5.88	3.38	0.25
ADN	2	144.54	45.94	2.46
SAD	2	33.54	170.64	0.51
SAN	4	30.43	32.89	2.85
SADN	4	155.93	210.41	0.56
Error b	90	73.52	110.60	2.23
Total	143			

* Significant at 5% level.

APPENDIX-IX

Abstract of Analysis of Variance table on Grain yield, straw yield and harvest index

Source	df	MSS		
		Grain yield	Straw yield	Harvest index
Replication	3	80.84*	710.74	0.069
Main plot treatments	5	93.66*	214.98	0.007
S	2	156.01*	241.98	0.014
A	1	5.56	97.24	0.005
S x A	2	75.33*	246.87	0.001
Error a	15	19.47	340.08	0.008
Sub plot treatments	5	19.70*	32.28	0.002
D	1	3.43	62.40	0.001
N	2	43.45*	2.20	0.005
D x N	2	2.57	47.30	0.001
Main plot x Sub plot interactions	25	8.70	46.96	0.001
SD	2	29.87	25.22	0.004
SN	4	8.29	20.24	0.001
SDN	4	8.37	55.62	0.0003
AD	1	0.50	152.58	0.00002
AN	2	0.42	121.21	0.002
ADN	2	4.93	26.25	0.0005
SAD	2	1.76	4.26	0.0005
SAN	4	14.22	82.18	0.001
SADN	4	4.89	18.91	0.001
Error b	90	7.44	43.04	0.002
Total	143			

* Significant at 5% level.

STANDARDIZATION OF PLANTING TECHNIQUES IN RICE

BY

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ABSTRACT OF THE THESIS
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ABSTRACT

With a view to identify suitable planting techniques for medium duration rice in Mundakan season, an experiment was conducted at the Cropping Systems Research Centre, Karamana, Trivandrum during 1984-85. The experiment was laid out in split plot design. In the main plot there were six treatments formed by the combinations of three spacings (20 x 15 cm, 20 x 10 cm and 15 x 10 cm) and two age of seedling (20 day old and 35 day old). In the sub plot there were six treatments formed by the combinations of two depth of planting (3 to 4 cm and 6 to 8 cm) and three seedling rates per hill (3, 6 and 9 seedlings per hill). In total there were 36 treatment combinations. The variety used was Jaya. The abstract of results are given below.

Tiller production and leaf production per hill was highest with the wider spacing (20 x 15 cm) while LAI was more with the closer spacing (15 x 10 cm). Plant height was not affected due to plant spacing. Crop raised by planting 20 day old seedlings produced more plant height at harvest, more tillers at 40 DAT, and more leaves and LAI at 60 DAT, compared to the one raised by aged seedlings (35 day old). Shallow planting resulted more plant height, number of tillers per hill, number of leaves per hill, and LAI and this effect was seen only at 40 DAT. Crop raised by planting

nine seedlings per hill produced more number of tillers and leaves per hill. LAI was not affected due to difference in seedling rate per hill. The interaction effects between treatment factors on growth characters such as plant height, tiller number per hill, leaf number per hill and LAI were not pronounced.

The main effects of spacing, seedling age, planting depth and seedling number per hill and the interaction between the treatment factors on the uptake of N, P and K can be treated as absent.

Wider spacing (20 x 15 cm) resulted more number of filled grains per panicle and percentage filled grains. Crop raised by planting 35 day old seedlings produced highest percentage of filled grain. Planting @ three seedlings per hill produced longer panicles.

A spacing of 20 x 15 cm gave the highest grain yield for medium duration rice in Mundakan season. Seedling age ranging from 20 to 35 days, and planting depth ranging from three to eight centimeter as such have no effect on grain yield. A seedling rate of three seedlings per hill provides higher yields. Planting " 20 day old seedling at 20 x 15 cm spacing or planting seedlings at "three to four centimeter depth with a spacing of 20 x 15 cm gives higher grain yields. Neither the treatment factors nor their interactions influenced straw yield or harvest index.