RESPONSE OF RICE TO METHODS OF SOWING UNDER VARYING SEED RATES AND LEVELS OF NITROGEN

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Response of rice to methods of sowing under varying seed rates and levels of nitrogen" is a bonafide record of research work done by me during the period of my P.G. course 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 this or any other University or Society.

Vellayani,

12th April 1989

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CERTIFICATE

Certified that this thesis, entitled "Response of rice to methods of sowing under varying seed rates and levels of nitrogen" is a bonafide record of research work done independently by Sri. Anil Kumar, N.R. under my guidance and supervision and that this has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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LIST OF ABBREVIATIONS

cm	Centimetre.
cm^2	Square centimetre.
DAS	Days after sowing
DMP	Dry matter production.
g	Gram
HI	Harvest Index
LAI	Leaf Area Index.
ha	Hectare
kg	Kilogram
KAU	Kerala Agricultural University.
m^2	Square metre.
mm	Millimetres.
C	Celsius.
CRRI	Central Rice Research Institute.
IRRI	International Rice Research Institute.
FYM	Farm yard manure.
IARI	Indian Agricultural Research Institute.
C.V.	Cultivar
Var	Variety

INTRODUCTION

I INTRODUCTION

Rice production in India has increased substantially during the last one and half decades. This remarkable progress has been triggered off by a proper blend of science-based technology, services and government policies which stimulate both production and consumption.

However the increase in production of rice has not been sharp as in the case of other cereals. Since for the majority of Indian population and almost for the entire population of the State rice being the main food item and also keeping in view of the population growth, it is very essential to direct all efforts to raise the production of rice.

Even now some of the local practices (Sahadevan, 1966) of rice cultivation are popular among the farmers, which are claimed to be more advantageous than the other methods. One such type of cultivation of rice is the 'pinch' method of sowing which is followed in certain parts of the State. This method according to the farmers have advantages like placement effect of cowdung, conservation of moisture near the root zone etc.

In several Training and Visit (T&V) workshops of the extension workers and researchers, the efficiency of this method has been put forth for discussion and in the absence of adequate research data a proper recommendation could not be given. This warrants the standardisation of agro-techniques

for such a popular practice of rice cultivation to suit specific environment.

Not much scientific efforts have been made so far to ascertain the merits if any of this practice of rice cultivation over other methods already recommended. As a primary effort it was felt necessary to find out a proper recommendation to this practice.

Hence the present investigation was under taken with the following objects:

1. To find out comparative efficiency of "pinch" and "broadcast" methods of rice cultivation.
2. To find out optimum seed rate for maximum yield under "pinch" and "broadcast" methods.
3. To find out optimum level of nitrogen for the economic yield under both the situations.
4. To study the economics of production.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

The use of optimum seed rate and level of nitrogen combined with an appropriate method of sowing will help to reduce cost of production of rice and thereby increase net return from rice cultivation. In this study the main objectives of finding out optimum seed rates and level of nitrogen under broadcast and pinch method of sowing were dealt with. This chapter is a brief review of research work done on the effect of different seed rates, levels of nitrogen and methods of sowing and their interactions on the growth, yield and nutrient uptake of rice and their effect on economic production.

METHOD OF SOWING

I Influence of methods of sowing on growth characters of rice.

Since "pinch" method of sowing being a local practice, not much literature is available on this aspect, this method is considered as dibbling for the purpose of comparison.

1.1 Crop establishment

Investigations carried out at a number of research stations in the country have shown that line sowing by dibbling ensures uniform crop stand that is advocated (Chaudhary and Patnaik, 1971). Singh et al. (1973) based on the results obtained from the study on methods of seeding of rice in

puddled soil revealed that broadcasting gave highest plant stand at harvest. Chandramohan and Mohammsadali (1976) reported that broadcasting recorded adequate plant establishment. Banba and Ohkubo (1977) obtained greatest emergence rate with drilling than broadcasting.

I.2 Plant height

Experiments conducted during Navarai season in Tamil Nadu showed no appreciable difference in plant height between broadcasting and transplanting as reported by Dawood et al. (1971). Studies conducted at Central Rice Research Institute, Cuttack (1984) showed no significant difference in plant height between broadcasting and dibbling the farmyard manure coated paddy seeds in rice variety CR-222-M.W.10 (105 days).

I.3 Number of tillers/m^2

Singh et al. (1973) reported that dibbling of seeds in puddled soil gave highest average number of tillers/m^2 when compared to broadcasting. Prasad et al. (1981) based on the experiments conducted at IARI reported that the number of tillers/m^2 was greater with transplanted rice.

I.4 Leaf area index

Mukherjee and Chatterjee (1970) obtained higher leaf area index values in rice crops sown broadcast than direct drilled crop.

I.5 Drymatter production

Araki and Susuki (1966) reported that direct sown plants produced less drymatter than transplanted crop. Mukherjee and Chatterjee (1970) based on the results obtained on growth analysis of direct seeded and transplanted rice reported that drymatter accumulation rates were higher in crops sown broadcast than in direct drilled or transplanted crop. While studying the response of rice to different seed rates and methods of sowing under rainfed conditions Dixit and Singh (1975) found that broadcast method of sowing recorded higher drymatter production than drilling the seeds.

II Influence of methods of sowing on the yield and yield attributes of rice

II.1 Number of productive tiller/m^2

Mukherjee and Chatterjee (1970) obtained highest value of number of productive tillers with direct drilled followed by broadcast and transplanted crop. Dawood et al. (1971) observed maximum number of productive tillers for the direct sown crop compared to transplanted crop. Rao et al. (1983) reported that the number of productive tillers were highest with dibbling than transplanting or broadcasting.

II.2 Spikelets/panicle

Mukherjee and Chatterjee (1970) reported that the number of spikelets/panicle were higher with direct drilled followed by broadcast and transplaned rice crop. Gu tamand

Sharma(1987) while studying different methods of planting rice obtained a result which showed that number of spikelets/panicle were higher with transplanted rice followed by direct drilling and broadcast sowing.

II.3 Length of panicle

While investigating the performance of rice on methods of seeding rice in dry and puddled soil, Singh et al. (1973) observed that methods of seeding viz. dibbling and broadcasting did not influence significantly the length of panicle.

Studies conducted at Central Rice Research Institute, Cuttack (1984) revealed that the methods of sowing influenced significantly the length of panicle. Farm yard manure coated seeds when sown recorded higher length of panicle than broadcasting of uncoated sprouted seeds.

II.4 Weight of panicle

Singh et al. (1973) while studying the methods of seeding in dry land and puddled soil found that the methods of seeding did not influence the weight of panicle significantly. But studies conducted at C.R.R.I. Cuttack (1984) showed no significant difference in the weight of panicle between two methods of sowing.

II.5 Percentage of unfilled grain

Nair. (1971) found no significant difference in the percentage of unfilled grain between the methods of sowing.

broadcasting and dibbling during the second crop season. But experiments at C.R.R.I., Cuttack (1984) showed decreased percentage in the case of dibbling of F.Y.M. coated seeds.

II.6 Thousand grain weight

According to Nair (1971) thousand grain weight was not altered by the methods of sowing. Similarly Nair. (1976) also observed that thousand grain weight was not significantly influenced by methods of seeding.

II.7 Grain yield

Pedalia (1970) obtained similar results with drilling and broadcasting with 4 varieties of rice, Bala, Padma, Hamsa and C.R.44-1. Nair et al. (1971) found that dibbling sprouted seeds gave higher yield than broadcasting sprouted seeds on mud. Sahu ——— (1971) while comparing the methods of sowing rice with I.R. 8 obtained higher yield from broadcast sowing than those from direct drilled or dibbled from sprouted seeds sown on puddled soil. Singh et al. (1973) observed that dibbling of seeds in puddled soil did not confer any advantage over broadcasting either in respect of growth or yield of economic produce. Rao (1976) obtained similar yield from broadcasting and sowing in rows on puddled soil. Highest paddy yields were obtained with drilling than broadcasting. (Gupta et al. 1977) Dixit and Singh (1978) obtained similar yield of paddy from broadcast and drill sowing. Sahu and Singh (1981) reported that C.V. Sita sown

broadcast and dibbling gave 4.83 t ha^{-1} and 5.36 $t.ha^{-1}$ paddy.

Rao et al. (1983) observed that rice grown by dibbling gave paddy yield of 5.32 to 5.92 $t.ha^{-1}$ in 1978 as compared with 4.58 $t.ha^{-1}$ to 5.49 $t.ha^{-1}$ when grown by broadcasting or drilling sprouted seeds. Studies conducted at C.R.R.I., Cuttack (1984) showed that grain yield with farmyard manure coated seeds was significantly higher as compared to that of uncoated seeds irrespective of shallow or deeper depth or broadcast sowing with a short duration variety C.R. 222 MW 10 (105 days).

II.8 Straw yield

Chandramohan and Mohammadali (1976) reported that direct sown crop recorded 14.7% increase in straw yield over transplanted crop. Nair (1971) found significant yield difference with respect to straw yield, dibbling recorded a straw yield of 5818 kg ha^{-1} which was on par with transplanting. Studies at C.R.R.I., Cuttack (1984) also recorded higher straw yield from FYM coated seed dibbled than from broadcasting of uncoated seeds.

II.9 Harvest index

According to Chandramohan and Mohammadali (1976), the direct seeded crop recorded higher harvest index than transplanted crop.

III Influence of methods of sowing on the nutrition of nitrogen

III.1 N uptake

According to Araki and Susuki (1966) N content was higher in direct sown plants than in transplanted rice. Studies at C.R.R.I., Cuttack (1984) indicated that better uptake of N was recorded from dibbling of FYM coated seeds than broadcasting of uncoated seeds.

III.2 N content of the soil after experiment

The result obtained showed that the method of sowing did not effect content of N available in the soil.

SEED RATES

I. Influence of seed rates on growth characters of rice

I.1 Crop establishment

Manna et al. (1982) while studying the establishment of upland rice obtained no significant impact of seed rate on the final stand and productivity of rice crop. Sonnier et al. (1982) reported on the basis of the experiment with C.R. Saturn that heavier sowing rate produced denser stands. Studies at C.R.R.I, Cuttack (1984) showed that a seeding intensity of 200 seeds/m^2 would provide adequate stand for puddled seeded crop in medium duration variety. Reddy and Panda (1985) while investigating the effect of depth of seeding, seed rate and fertiliser level on growth and yield of rice found that initial plant stand was higher with the use of higher seed rate. Aliaga et al. (1986) obtained marked response to seed rate in the number of emerged plants.

I.2 Plant height

While studying the performance of 10 high yielding rice varieties during Navarai season of 1970 Dawood et al. (1971) found no appreciable difference in plant height when the seed rates used were 60, 90, and 120 kg ha^{-1}. Singh (1971) also observed that the seeding rates did not influence plant height significantly in rice. Aliaga et al. (1986) reported that plant height was not influenced by seed rate and shown that the seed rate was not a principal factor influencing plant height.

I.3 Number of tiller/m^2

Sasak et al. (1966) found that plant at high density tended to have fewer tillers per plant. Hukkeri and Chauhan (1968) observed that higher yield with higher seed rate was due to increased number of total tillers and higher percentage of productive tillers. Rao and Rao (1979) studied the seed rate and fertiliser nitrogen requirement of puddled seeded culture AC.540 X Ratna and obtained a result showing that lower seed rate resulted in lower tiller number. Ghosh and Reddy (1980) while investigating the effect of seed rate and variety on growth and yield of rice observed a progressive increase in the number of tillers with increase in seed rate. But Aliaga et al. (1986) did not obtain any significant response of seed rate on the number of tillers produced.

I.4 Leaf area index

Enyi (1965) found that LAI was higher with higher plant population. Golingai and Mabbayad (1969) reported that grain yield was positively correlated with LAI at flowing. Pothiraj et al. (1977) while investigating the effect of plant population and number of seedlings/hill on LAI of rice found that LAI was more with lower seedling density than higher seedling density. Wells and Faw (1978) pointed out that LAI increased with increase in seed rate and nitrogen rate and was weakly correlated with grain yield except at high seed rate.

I.5 Drymatter production

Enyi (1965) found higher drymatter production with higher plant density. Experiments conducted at I.R.R.I., Philippines (1970) showed that plant drymatter increased with increasing plant density. When a study of the growth analysis of direct seeded and transplanted rice was conducted, Mukherjee and Chatterjee (1970) found that rate of drymatter accumulation was higher with 90 kg ha^{-1} seed rate than 60 kg ha^{-1}. Similarly Gautam and Sharma (1987) also obtained a result which revealed that increasing plant density had significant increase in plant drymatter.

II. <u>Influence of seed rate on the yield and yield attributes of rice</u>

II.1 Productive tillers/m^2

Sasak et al. (1966) observed that the number of effective tillers increased with increase in plant density.

Mukkery and Chauhan (1968) observed that higher yield was due to higher percentage of productive tillers to total tillers. Jindal and Kalia (1969) pointed out that the effect of reduced plant population could not be compensated by narrow number of effective tillers. While attempting to find out optimum seed requirement for direct seeded rice in wet soil Subbiah et al. (1977) found that in I.R. 20 rice variety increase in seed rates from 60 to 160 kg ha^{-1} did not significantly influence the productive tillers per meter square, but in Bhavani rice variety they found that productive tillers increased as the seed rate increased. Prasad and Mishra (1981) also reported that an increase in the number of panicles/m^2 increased with increase in seedling density.

Gautam and Sharma (1983) observed marked influence of plant density on number of panicles/m^2 and they found that high plant density resulted in more panicles/m^2. Similarly Jones and Snyder (1987) reported that increased sowing rates increased the number of panicles/m^2.

II.2 Spikelets/panicle

Akamatsu (1969) reported that number of spikelets/panicle were not influenced by sowing density. The number of spikelets increased when a change in seed rate from 60 to 90 kg ha^{-1} in I.R. 8 variety of rice was made as reported by Mukherjee and Chatterjee (1970). Dawood et al. (1976) obtained a decreased number of spikelets per panicle when seed rate was increased from 40 to 80 kg ha^{-1}. Gautam and

and Sharma (1983) while studying the aspect of improving the yield attributes of short duration varieties of rice through planting densities found that higher plant density resulted in higher number of spikelets/panicle.

II.3 Length of panicle

Hukkeri and Chauhan (1968) pointed out that higher seed rate resulted in a reduction in panicle length, Dawood et al. (1971) observed that panicle length tanded to increase with increase in seed rate. Singh (1971) observed that panicle length was higher with higher seed rate.

II.4 Weight of panicle

Sasak et al. (1966) found increase in the weight of panicle with increase in seeding density. Dawood et al. (1976) obtained decreased panicle weight with increasing seed rate from 40 to 80 kg ha^{-1}. While assessing the optimum requirement of seed for I.R.8 and Bhavani varieties of paddy Subbiah et al. (1977) found that panicle weight was not significantly influenced by seed rate. Prasad and Mishra (1981) reported that panicle weight decreased with increasing seeding rate due to poor development of panicle in rice. Similarly Reddy and Ghosh (1983) reported that weight of panicle decreased with increase in seed rate.

II.5 Percentage of unfilled grains

Hukkeri and Chauhan (1968) observed increased percentage of unfilled grain with increase in seed rate. Gautam

and Sharma (1983) obtained marked influence on number of unfilled grain per panicle and they found that high plant density resulted in lower percentage of unfilled grains. Jones and Snyder (1987) reported increased percentage of unfilled grains with increased sowing rates.

II.6 Thousand grains weight

Sasak et al. (1966) found that thousand grain weight was higher with higher seed rate but only to a medium density. Akamatsu (1969) reported that thousand grain weight was not influenced by sowing density. Singh (1973) obtained a result which showed that thousand grain weight was not altered by plant population.

II.7 Grain yield

Sasak et al. (1966) showed that rice yield/unit area increased with increase in seed rate. Pedalia (1970) reported that high seed rates depressed the yield considerably because of heavy plant population. Singh and Singh (1973) obtained higher yield with higher plant population. Mukherjee and Chatterjee (1973) did not obtain significant yield difference by sowing 60 or 90 kg ha^{-1} by broadcast sowing. Purushothaman et al. (1976) obtained no significant difference in yield in I.R.20 at different seed rates of 60 to 140 kg ha^{-1}. Subbiah et al. (1977) also obtained similar results in I.R.20. Dixit and Singh (1978) while studying the response of different seed rates and methods of sowing under rainfed conditions with C.V. Cavery obtained a result which showed that 110 kg ha^{-1} seed rate gave highest paddy yield by trying a range of seed

rates from 44 to 132 kg ha^{-1}.

Manna et al. (1982) revealed that seed rates had no significant impact on productivity of rice. In field experiments conducted at I.R.R.I. Philippines (1984) showed that a sowing rate up to 110 kg ha^{-1} did not increase grain yield compared with recommended dose of 50 kg ha^{-1}. Gautam and Sharma (1987) reported that production efficiency increased with increase in plant density in the case of short duration varieties of paddy.

II.8 Straw yield

Enyi. (1965) reported that higher plant population resulted in higher yield of straw. H ten Have (1970) observed that the straw yield increased with rate of seeding and nitrogen levels. Verma (1972) also reported that higher plant population brought about significant improvement in straw yield. According to Lal et al. (1982) increasing plant density increased straw yield due to increased plant population per unit area.

II.9 Harvest index

H ten Have (1970) reported that the grain to straw ratio increased with decreased seeding density. Verma (1972) observed that harvest index was higher as number of plants/ unit area increased.

III Influence of seed rate on the nitrogen uptake

III.1. N uptake

Verma (1972) pointed out N uptake increased with

decreased seed rate explaining that greater feeding zone available per clumb due to lower seeding density might have possibly affected the uptake and effective translocation of nutrients. Ramkumar reddy et al. (1978) reported that N uptake increased with increase in rate of seeding. Rai et al. (1981) reported no correlation between N uptake and grain yield.

III. 2 N content of soil after experiment

The N content of soil after experiment was not altered by the different seed rates.

LEVELS OF NITROGEN

I Influence of levels of nitrogen on the growth characters of rice

I.1 Crop establishment

Studies conducted at C.R.R.I., Cuttack (1984) showed that better establishment rate was obtained with dibbling of farm yard manure coated paddy seeds than broad casting of uncoated sprouted seeds in the puddled soil.

I.2 Plant height

Nair (1968) did not get any effect of nitrogen on plant height. Pillai (1971) reported an increase in plant height with graded doses of nitrogen supply upto 100 kg ha^{-1} level. Application of nitrogen significantly influenced the plant height upto 60 kg ha^{-1} in Triveni rice variety as reported by Meera Sahib ——— (1974) and based on the result

they concluded that in the case of Triveni rice significant increase in height beyond 60 kg ha^{-1} could not be achieved.

While investigating the fertiliser requirement of Lekshmi variety of rice at Rice Research Station, Kayamkulam, Sreekumaran (1981) reported that plant height was not significantly influenced by different levels of nitrogen. Based on the investigation carried out at Rice Research Station, Pattambi, Ajith Kumar (1984) also reported similar results with Mashoori variety of rice.

I.3 Number of tillers/m^2

Enhancement of tiller production as a result of nitrogen supply has been reported earlier by several workers (Tanaka, 1964; Ramanujan and Sekharan Rao, 1971). Similarly Alexander et al. (1972) and Meera Sahib et al. (1974) reported that tiller production was found to be significantly influenced by nitrogen application in Triveni rice. But Nair et al. (1976) did not obtain significant influence of nitrogen rates on tiller production. Gunasenan et al. (1979) and De Datta and Surjith (1981) observed an increase in the number of tillers per plant with increased rate of N application. Sreekumaran (1981) and Sushamakumari (1981) also observed that N application had considerable influence on tiller production in all stages of growth. Findings of Ajithkumar (1984) and Surendran (1985) were also in confirmity with the above observations.

I.4 Leaf area index

Trials conducted at IRRI, Philippines, to study the

variability of leaf area index and leaf thickness at various nitrogen levels revealed that leaf area index was highest at flowering(Anon 1985). Rai and Murthy (1979) observed no correlation of LAI with levels of nitrogen applied. But Murthy and Murthy (1981) observed that enhanced application resulted in an increase in leaf area index. Results of the experiments conducted by Sreekumaran (1981) showed that there was an increase in leaf area index along with an increase in the level of nutrition. According to Surendran (1985) level of nitrogen significantly increased LAI at flowering. But Vaijainthi (1986) did not get any influence of N rates on the LAI at booting stage in Lekshmi variety.

I.5 Dry matter production

Dry matter production has been reported to increase with increase in N application (Ramanujam and Rao, 1971). Nair (1976) observed significant increase in dry matter production at harvest in direct sown Triveni when level of nitrogen was raised from 50 to 70 kg ha^{-1}. Sharma and Prasad (1980) reported that dry matter production increased with increase in rate of applied nitrogen. Significant increase in drymatter production with increase in level of nitrogen first from 45 to 60 kg ha^{-1} and again from 60 to 90 kg ha^{-1} was observed at tillering, flowering and harvesting in an experiment with Jaya variety at R.S.S. Kayamkulam (Sushamma kumari 1981). Surendran (1985) reported progressive increase in drymatter production for Lekshmi variety when level of nitrogen was increased from 20 to 80 kg ha^{-1}.

II. Influence of levels of nitrogen on the yield and yield attributes of rice

II.1 Number of productive tillers/m^2

Rathinam (1974) reported that increasing rates of nitrogen from zero to 160 kg ha^{-1} produced linear increase in average number of productive tillers per hill. Nair (1976) observed that effect of levels of nitrogen on the number of productive tillers/m^2 was not significant. Pillai (1978) from an experiment conducted at R.R.S., Pattambi. pointed out that nitrogen exerted significant influence on the number of panicles per hill. Dixit and Singh (1979) reported that N application increased the number of productive tillers/plant. Sushama kumari (1981) observed significant effect of nitrogen levels upto 90 kg N ha^{-1} on the number of panicle per unit area. Balasubramonium (1984) reported that number of panicle per hill increased with increase in nitrogen application and were highest at 120 kg N ha^{-1}. Surendran (1985) reported progressive increase in number of panicle with enhanced application of nitrogen from 20 to 80 kg ha^{-1}.

II.2 Number of spikelets/panicle

In a trial conducted by Prasad and Sharma (1973) the higher nitrogen level of 225 kg ha^{-1} more than doubled the number of spikelets per panicle as against the control with no nitrogen. Nair (1976) reported that the number of spikelets per panicle was not influenced by levels of nitrogen in direct sown Triveni rice. Sushamakumari (1981) observed that levels

of nitrogen significantly influenced the number of spikelets per panicle when Jaya variety was grown with varying levels of nitrogen. Similar findings were also reported by Anon (1984 b) and Alexander (1972). De Datta and Surjith (1981) reported that nitrogen increases the number of spikelets/panicle in rice. Surendran (1985) and Vaijayanthi (1986) observed significant increase in spikelets number to the levels of nitrogen upto 60 kg ha^{-1} in Lekshmi variety of rice.

II.3 Length of panicle

Ghose et al. (1960), Tomy (1963), Sreenivasalu and Pawar (1965) concluded that the panicle length was a varietal character. Nair (1968 b), Adam (1969), Paul mathew (1971) and Unnikrishna kurup (1971) also observed similar results. Iyer (1967) found that panicle length was little influenced by nitrogen application. Chaudhary et al. (1969) observed a positive relationship between length of panicle and nitrogen levels in T.N.1. and I.R.8, Nair (1976) observed no significant effect due to levels of nitrogen on length of panicle, Dexit and Singh (1979) reported that length of panicle increased with increase in N rates.

Sushama kumari (1981) reported significant increase in panicle length due to increase in level of nitrogen. On the other hand Sreekumaran (1981) did not observe any significant difference in length of panicle due to increased levels of fertiliser. Similar findings are also reported by Ajith kumar (1984) and Surendran (1985).

II.4 Weight of panicle

Pillai (1971) reported inceased panicle weight up to 100 by level of nitrogen application. Dixit and Prasad (1979) reported an increase in the weight of panicle with increased level of nitrogen. Sushama kumari (1981) reported significant increase in panicle weight at 60 and 90 kg levels of nitrogen in Jaya variety. Vaijayanthi (1986) observed no significant difference in weight of panicle due to different doses of nitrogen.

II.5 Percentage of unfilled grains

Kallanikutty et al. (1968) reported higher percentrage of chaffiness with enhanced application of nitrogen. Meera Sahib (1974) observed that application of 90 kg N ha^{-1} produced minimum percentage of unfilled grain in Triveni variety. Nair (1976) reported that application of nitrogen did not influence percentage of unfilled grain in Triveni variety. But Bhaumik and Ghose (1977) reported that the number of filled grain per panicle increased with increase in N rates applied. Surendran (1985) observed linear increase in percentage of unfilled grain with increase in an N dose from 20 to 60 kg ha^{-1} but at 80 kg level a marked increase in percentage of unfilled grain was observed.

II.6 Thousand grain weight

Baba (1961) opinioned that thousand grain weight is varietal character and not influenced by fertilisation. Alexander et al. (1972) found that thousand grain weight was increased by N levels in Triveni. Pillai et al.(1976) pointed out that 1000

grain weight was not affected by nitrogen levels in rice. Kalyanikutty and Morachan (1974) obtained highest thousand grain weight at 120 kg N ha^{-1} in (C.O.33) a dwarf *indica* variety. Nair (1976) observed a significant increase in test weight when level of nitrogen was enhanced from 50 to 70 kg N ha^{-1} in *Triveni* rice. Ajith kumar (1984) did not obtain any significant increase in thousand grain weight with higher levels of nitrogen. Surendran (1985) reported that thousand grain weight increased due to application of nitrogen only up to 60 kg ha^{-1} level in *Lakshmi* variety of rice.

II.7 Grain yield

Nair (1968 a) found that there was a positive linear response upto 100 kg per ha^{-1} for I.R.8 variety. The study conducted by Ramanujam and Rao (1971) to assess responsiveness of *ADT-27* variety of rice to different levels of nitrogen ranging from 0-180 kg ha^{-1} revealed that levels of nitrogen beyond 90 kg ha^{-1} did not contribute yield. Pillai et al. (1975) pointed out that the rate of increase of grain yield beyond 80 kg N ha^{-1} was not significant in the case of variety Annapurna. Rethinam ——— (1974) observed steady increase in yield with enhanced doses of nitrogen and highest yield was obtained with 160 kg N ha^{-1}. Pillai et al. (1976) suggested that more than 100 kg N ha^{-1} need not be applied for realising the yield potential and maximum profits in dwarf *indica* varieties of rice. Wells and Faw (1978) reported that N rate was weakly correlated with yield except at high seed rates. Guna

sena (1979) obtained increased yield from 3.63 to 6.52 to ha^{-1} when level of nitrogen was raised from 0 to 90 kg ha^{-1} in Sri Lanka. Ayyaswamy et al. (1983) reported that application of N in different levels significantly increased yield during kharif and 120 kg N ha^{-1} recorded highest yield. Surendran (1985) reported that an increase in level of nitrogen from 20 to 60 kg ha^{-1} has brought about a progressive increase in yield. Vaijayanthi (1986) obtained a significant increase in grain yield with increase in level of N in Lekshmi variety of rice. Babu Mathew (1987) observed that grain yield showed an increasing trend with increase in the level of nitrogen upto 112.5 kg ha^{-1} in Jaya variety of rice.

II.8 Straw yield

Significant increase in straw yield to increased application of nitrogen was observed by Sahu and Lenka (1967). Raj et al. (1974) pointed out that straw yield was increased by the application of nitrogen from 0-250 kg ha^{-1}. Venkiteswaralu (1978) stated that straw yields increased with increase in nitrogen levels upto 200 kg ha^{-1} only beyond which it declined. Bhaumik and Ghose (1977) reported that straw weight increased with increase in N rates. Nair (1976) reported that effect due to levels of nitrogen was highly significant in Triveni variety of rice. Surendran (1985) reported an increase in straw yield with successive addition of nitrogen from 20 to 80 kg ha^{-1} and was highest at 80 kg ha^{-1} in Lekshmi variety of rice. Vaijayanthi (1986) reported similar results in Lekshmi variety. Babu mathew et al. (1987) based on experiment conducted at Cropping Systems Research Centre, Karamana revealed that straw

yield was influenced by levels of nitrogen.

II.9 Harvest index

Prasad (1981) reported a decrease in harvest index with increase in the level of N from 0-100 kg ha^{-1}. Nair (1976) obtained a significant influence of levels of nitrogen on harvest index and obtained a higher harvest index with 50 kg N ha^{-1} in Triveni variety. Sreekumaran (1981) observed a significant reduction in grain to straw ratio with increase in level of nitrogen. But Sushamakumari (1981) reported a marked influence of nitrogen on grain straw ratio and obtained a highest value of 0.51 with 45 kg N ha^{-1}. Surendran (1985) noted highest harvest index of 0.335 with 40 kg N ha^{-1} and beyond that a decrease was observed with 60 and 80 kg N levels. Vaijayanthi (1986) showed that harvest index was influenced by graded levels of fertiliser.

III Influence of levels of nitrogen on the N uptake of rice

III.1 N uptake

Gopalaswamy (1977) reported that increase in the rate of applied nitrogen from 0-200 kg ha^{-1} produced linear increase in the uptake of nitrogen. Abraham et al. (1976) found that N levels exerted a profound influence on N uptake by Triveni variety, and N uptake by straw increased upto 120 Kg ha^{-1} level and N uptake of grain upto 80 kg ha^{-1} level and N uptake pattern showed an increasing trend from maximum tillering stage to harvest. Rai and Murthy (1979) reported significant increase in

nitrogen uptake with rates upto 80 kg ha^{-1}. Sharma and Prasad (1980) reported that N content and N uptake were increased with increase in rate of N applied. Sushamakumari (1981) reported that levels of N significantly influenced nitrogen uptake at all stages of growth. Surendran (1985) also reported similar results in Lekshmi variety. Prasad Rao (1983) reported that N uptake gradually increased upto panicle initiation with further steep increase upto flowering and remaining more or less same at harvest. Babu mathewet al. (1987) observed that N concentration of plant was marked at all stages of growth and showed an increasing trend with increase in N levels upto 112.5 kg ha^{-1} in Jaya variety and uptake of N increased with increase in rate of N applied.

III.2 N content of soil after experiment

The levels of nitrogen did not affect the N content of soil after the experiment.

MATERIALS AND METHODS

III MATERIALS AND METHODS

A field experiment was conducted in the wet lands of the Instructural farm, College of Agriculture, Vellayani (8.5° N, 76° 57' E and 29m above mean sea level) during Kharif (June - October) 1986 to study the merits and demerits of pinch method and broadcasting in puddled soil under different seed rates and nitrogen levels on growth, yield and nutrient uptake of rice. The materials used and methods followed are presented below:

Materials

a. Soil

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

b. Meterological parameters

The experimental site enjoys a humid tropical climate. The data on various weather parameters (rainfall, mean maximum and minimum temperatures and relative humidity) during the cropping period and for the last 25 years are given in appendix 1 and 2 and graphically presented in Fig. 1. The mean maximum and minimum temperatures during the cropping period ranged from 29.06°C to 21.40°C. The mean relative himidity was 72.98%. The monthly rainfall ranged from 106mm to 452.9mm. A total of 853mm rainfall was received during the cropping period. The data on various parameters showed that the weather was quite normal during the cropping period.

Table 1 Physico-chemical properties of soil of the experimental field

A. Mechanical composition			
Coarse sand	...	...	46.0%
Fine sand	...	...	10.4%
Silt	...	...	6.6%
Clay	...	...	33.0%
Textural class	...	...	Clay loam
B. Chemical composition			Rating (Anon 1985 b)
Available nitrogen	...	206 $kgha^{-1}$	Medium
Available P_2O_5	...	21.8 $kgha^{-1}$	Medium
Available K_2O	...	60 $Kgha^{-1}$	Low
PH	...	5.4	
EC	...	0.016 $mmhos/cm^2$	
CEC	...	7.41 meq/100g	

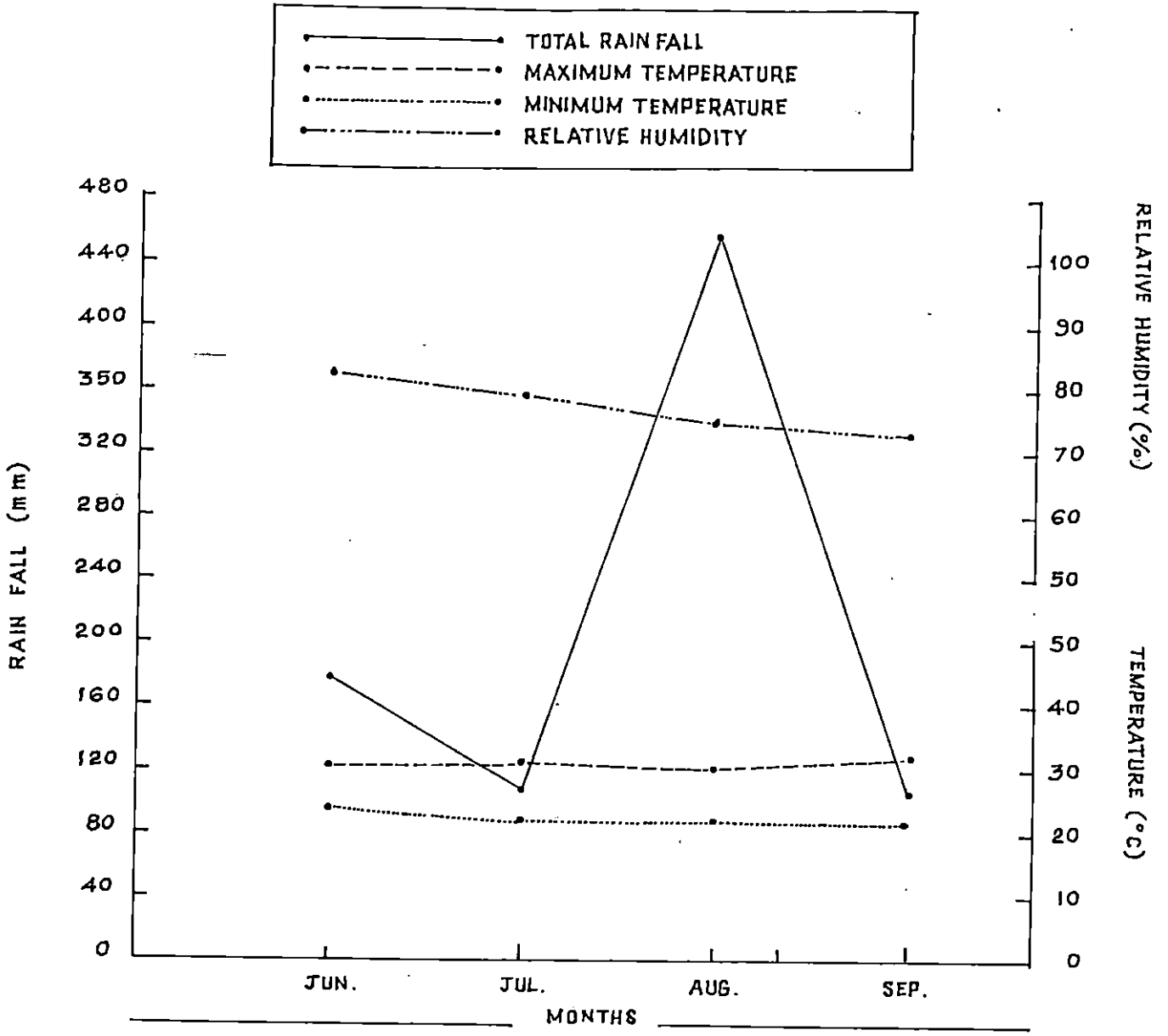


FIG. 1. WEATHER CONDITIONS DURING THE CROPPING PERIOD.

c. Season

The experiment was conducted during Ist crop season (kharif) of 1986. The crop was sown on 25-6-1986 and harvested on 2-10-1986.

d. Cropping history.

The experimental area was under bulk crop of paddy during the previous season.

e. Variety

The variety used for the study was Triveni, a cross between a dwarf indica strain Annapurna and ptb-15. It is a high yielding short statured photo-insensitive variety of 95-105 days duration evolved at the Central Rice Research Station, Pattambi. It has got a long bold white grain with tolerance to brown plant hopper. The seeds were obtained from the Cropping Systems Research Centre, Karamana. The seeds were tested for viability and were found to give 95% germination.

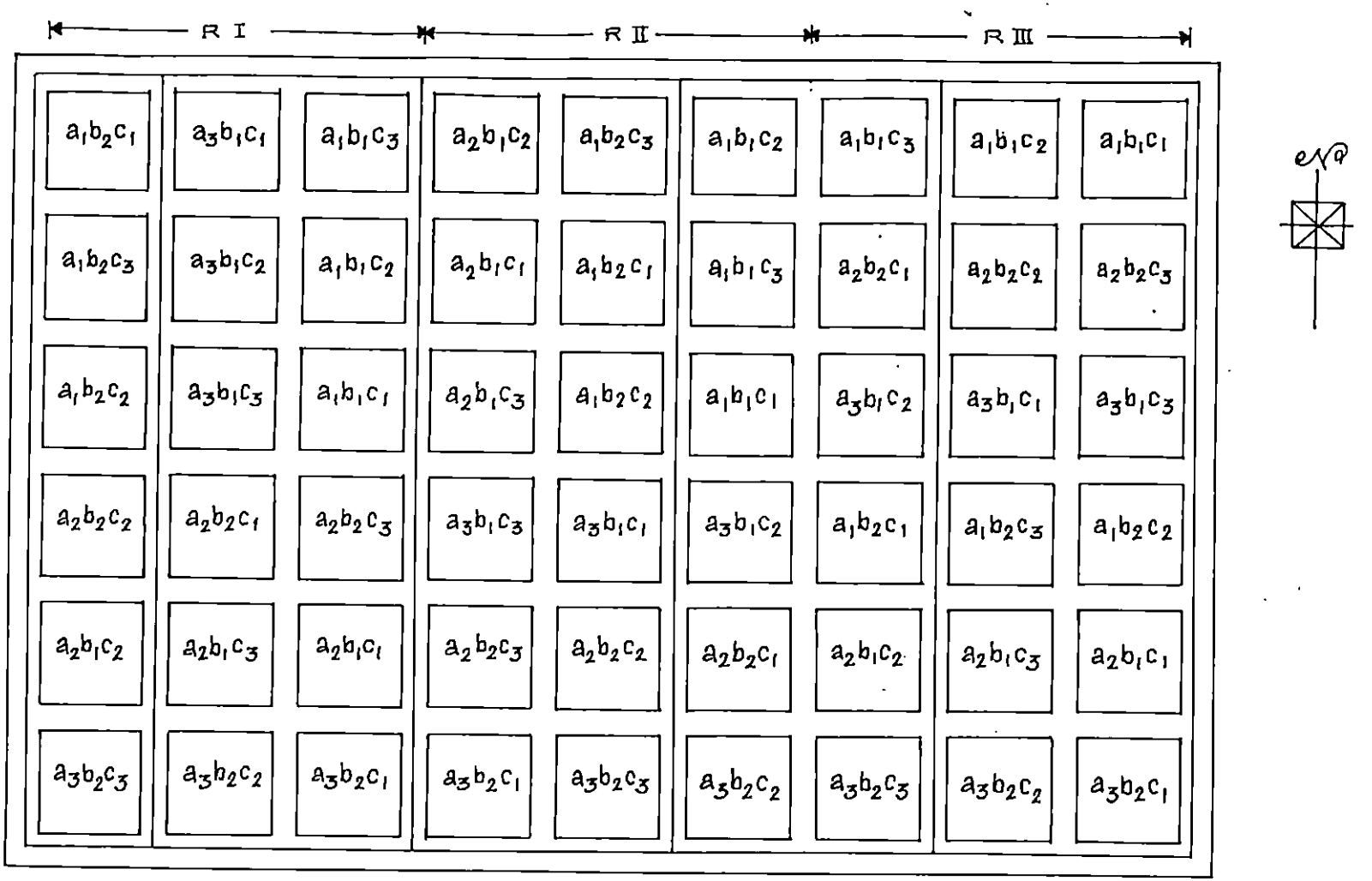
f. Fertilisers used

The fertilisers used for the experiment contained urea (46% N) super phosphate (16% P_2O_5) muriate of potash (60% K_2O).

Methods

a. Design of the experiment

The experiment was laid out as split plot in three rnndonised block design. The layout plan is presented in Fig. 2. The gross main plot size was 13.5 X 4.5m and gross sub plot size was 4.5 X 4.5m. A spacing of 15 X 10cm was adopted for pinch method of sowing. A strip of crop covering 40 cm width was left for border effect on all sides in



SEED RATES

a_1 - 60 kg ha^{-1}
a_2 - 90 kg ha^{-1}
a_3 - 120 kg ha^{-1}

METHODS OF SOWING

b_1 - BROAD CAST
b_2 - PINCH

LEVELS OF NITROGEN

C_1 - 50 kg ha^{-1}
C_2 - 70 kg ha^{-1}
C_3 - 90 kg ha^{-1}

FIG. 2. LAY OUT PLAN OF EXPERIMENT IN SPLIT PLOT DESIGN.

each broadcast (in puddled soil) sub plot and one row on either side and two plants in each row on the other opposite side were left out as border row in the pinch method of sowing. The net sub plot for broadcast (in puddled soil) rice was 3.7 X 3.7m and net sub plot for pinch method was 4.2 X 4.1m.

b. Treatments

All possible combination of three factors namely methods of sowing (A) seed rates (B) and levels of nitrogen (C) were studied. Six treatments involving combinations of two methods of sowing and three seed rates were assigned to the main plots. The levels of nitrogen (3) were tested in the sub plot. In all there were eighteen treatment combinations (6 for main plots and 3 for sub plots) as detailed below:

1. Main plot

Seed Rates	Methods of Sowing
a_1 - 60 kg ha^{-1}	b_1 - Broadcasting (in puddled soil)
a_2 - 90 kg ha^{-1}	b_2 - Pinch method of sowing
a_3 - 120 kg ha^{-1}	

2. Sub plot

Nitrogen levels

c_1 - 50 kg ha^{-1}

c_2 - 70 kg ha^{-1}

c_3 - 90 kg ha^{-1}

3. Treatment combinations

1	a_1	b_1	c_1	10	a_2	b_2	c_1
2	a_1	b_1	c_2	11	a_2	b_2	c_2
3	a_1	b_1	c_3	12	a_2	b_2	c_3
4	a_1	b_2	c_1	13	a_3	b_1	c_1
5	a_1	b_2	c_2	14	a_3	b_1	c_2
6	a_1	b_2	c_3	15	a_3	b_1	c_3
7	a_2	b_1	c_1	16	a_3	b_2	c_1
8	a_2	b_1	c_2	17	a_3	b_2	c_2
9	a_2	b_1	c_3	18	a_3	b_2	c_3

c. Field culture

i) Preparation of land

The experimental field was ploughed twice and levelled and plots were laid out with bunds of 30cm width around. Main and sub irrigation channels were provided. Individual plots were again puddled and levelled. The crop was raised adopting standard procedures and techniques as per the package of practices recommendation of the Kerala Agricultural University (1982).

ii) Application of fertilisers

In plots where broadcasting in puddled soil was done an equal quantity of cowdung, which was used for pinch method was applied and incorporated in the soil. Nitrogen was given in two split doses - half as basal dose and half at tillering stage. A uniform dose of 35 kg P_2O5 ha^{-1} and 35 kg K_2O ha^{-1} were applied entirely as basal in all the plots.

iii) Seeds and sowing

The sprouted seeds were broadcasted in the main plots intented for broadcasting in puddled soil. The seeds intented for pinch method were mixed well with ten times its weight of partially dried cowdung and made into pinch in such a way that each pinch should contain an equal number of seeds under a given rate of seeding and placed at spacing of 15 x 10cm. Water was let into the plots after a week gradually raising the level to 5cm.

iv) Maintenance of the crop

The crop was hand weeded twice on the 15th and 30th days after sowing. The general stand of the crop was satisfactory. A depth of 5cm water was maintained in the field continuously and the water was cut off 10 days prior to harvest. The level of water in each plot was controlled effectively to avoid possible loss of nutrients. Need based plant protection measures were also undertaken.

v) Harvest

The border rows were harvested separately on the previous day, threshed and bulked. The crop in the net area of individual sub plots were harvested, threshed, cleaned, dried and winnowed and grain yield at 14 percent moisture was recorded. The weight of sun dried straw was also recorded for individual plots.

Observations

I Growth characters

Observations on growth characters, yield attributes and

yield were recorded as suggested by Gomez (1972).

I.1 Crop establishment (number/m^2)

The number of plants established per m^2 was recorded on 3rd, 5th, 7th and 9th days after sowing.

I.2 Height of plant

The height of plant was measured at 20, 45, 70 days after sowing and also at harvest. Height was measured from the base to the tip of the longest leaf at 20, 45 and 70 days after sowing and to the tip of the longest panicle at harvest. The mean height was computed and expressed in cm.

I.3 Number of tillers per m^2

The tillers from 60 x 40cm area in the middle of each plot were counted at 20, 45 and 70 days after sowing and the number of tillers per m^2 was calculated.

I.4 Leaf area index

Leaf area index was computed at flowering. Four sample hills were randomly selected in each sub plot and the number of tillers were counted in each hill. The mean length and the mean maximum breadth of leaves in the middle tiller of all the sample hills were measured separately and leaf area was computed based on length breadth method. (LBK Method). (Gomez, 1972).

Leaf area = K X L X B. Where 'K' is the adjustment factor (0.75) 'L' is the length and 'B' is the maximum breadth. Thereafter the leaf area per hill and leaf area index were calculated using the following formulae.

Leaf area/hill = Total leaf area of middle tiller x total number of tillers.

$$\text{Leaf area index} = \frac{\text{Sum of leaf area per hill of 'n' sample hill } (cm^2)}{\text{Area of land covered by 'n' hills } (cm^2)}$$

I.5 Dry matter production

Random samples of 10 hills were selected from the rows ear marked for destructive sampling at 20, 45 and 70 days after sowing and at harvest. At harvest the sum total yield of grain and straw was taken as dry matter production. Thereafter the samples were first dried in the sun and then oven dried at a temperature of $80^{\circ}C \pm 5^{\circ}C$ to constant weights. The weight of oven - dried samples were recorded and the dry matter production was expressed in kg ha^{-1}.

II Yield and yield attributes

II.1 Number of productive tillers/m^2

The number of productive tillers from an area of 60 x 40cm was counted at 70 DAS and from this the number of productive tillers/m^2 was computed.

II.2 Number of spikelets/panicle

The number of spikelets was recorded from the 10 panicles selected at random from each plot and the average number of spikelet/panicle was computed.

II.3 Length of panicle

The length from the neck to the tip of 10 panicles from randomly selected hills was measured from each plots and expressed in cm.

II.4 Weight of panicle

Weight of 10 panicles selected at random from each plot was recorded and mean weight worked out and expressed in g.

II.5 Percentage of unfilled grain

The main culm panicles from all 10 randomly selected hills were seperated based on height of individual panicles and were thrushed and number of filled grains (f) number of unfilled grains (u) and weight of filled grains (w) determined.

The rest of the panicles from all the 10 hills were also threshed and number of unfilled grains (U) and weight of filled grains (W) were assessed.

The percentage of unfilled grains were worked out using the formulae given below: (Gomez, 1972)

$$\text{Percentage of unfilled grain} = \frac{U + u}{f\,(W+w)/W + U + u} \times 100$$

II.6 Thousand grain weight

From the values obtained for calculating the percentages of unfilled grain, 1000 grain weight was calculated and adjusted to 14 percent moisture using the following formulae proposed by Gomez (1972)

$$\text{Thousand grain weight} = \frac{100-M}{86} \times \frac{W}{f} \times 1000$$

Where M is the moisture content in filled grains.

II.7 Grain yield

Yield of grain from the net area harvested was recorded and adjusted to 14 percent moisture and expressed in kg ha^{-1}.

II.8 Straw yield

Straw obtained from the net plot was uniformly sun dried, weighed and expressed in kg ha^{-1}.

II.9 Harvest index

Harvest index was worked out by dividing the weight of

grains (economic yield) with the total weight of grain and straw (biological yield).

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}} = \frac{\text{Total weight of grain}}{\text{Total weight of grain} + \text{Total weight of straw}}$$

XII Economic of rice production

XII.1 Cost : benefit ratio

This was worked out by dividing gross return obtained with the total expenditure incurred on a per hectare basis.

IV Chemical studies

The chemical analysis was done from plant samples collected at different stages of growth (20, 45, 70 days and at harvest). It was then finely ground using a Wileey mill and sieved through 2mm sieve. A known weight of sample was then digested and chemically analysed.

IV.1 Plant analysis

a. Uptake of nitrogen

The nitrogen content of plant samples at 20, 45 and 70 days after sowing and at harvest were determined by modified micro-kjeldahl digestion method as suggested by Jackson (1967). Nitrogen concentrations thus obtained was multiplied with dry matter yield at the respective stages and uptake of nitrogen computed and expressed in kg ha^{-1}.

IV.2 Soil analysis

A composite soil sample before the experiment was collected and used for chemical and physical analysis and presented in table 1. Representative soil samples were collected from

individual plots immediately after harvest, air dried, powdered with wooden mallet, sieved through a 2mm sieve and used for chemical analysis.

a. Available nitrogen

Available nitrogen of soil was estimated using modified micro-kjeldahl digestion method as suggested by Jackson (1967) and expressed in kg ha^{-1}.

V. Statistical analysis

The data relating to various characters under study taken at various stages of crop growth were statistically analysed applying the analysis of variance technique for split plot in R.B.D. (Cochran and Cox 1965).

RESULTS

IV RESULTS

An experiment was conducted at Instructional farm, College of Agriculture, Vellayani, Trivandrum to study the comparative merits of 'Pinch' method of sowing over 'broadcast' (in puddled soil) method. The various treatments studied were combinations of three rates of seeding, two methods of sowing and three levels of nitrogen.

The experimental data were subjected to statistical analysis to bring out the main effect of the treatments and also their interactions. The results obtained are presented under the following sections.

1. Growth characters
2. Yield and yield attributes
3. Economics of rice production
4. Chemical studies.

I. Growth characters

I.1 Crop establishment (number/m^2) (vide Table 2)

The data on crop establishment were analysed and result obtained are furnished below:

The number plants established per m^2 increased with increase in seed rates. This difference in crop establishment was conspicuous on the 7th and 9th days after sowing. The plots sown with s_3 seed rate were on par with s_2 and significantly superior to s_1 but there was no significant difference between s_2 and s_1.

Table 2 Effect of treatments on crop establishment (number/m^2)

	3 DAS	5 DAS	7 DAS	9 DAS
Seed rates				
a_1	79.74(8.93)	152.76(12.36)	254.72(15.96)	408.44(20.21)
a_2	89.87(9.48)	164.35(12.82)	336.35(18.34)	604.66(24.59)
a_3	107.32(10.36)	227.71(15.09)	449.01(21.19)	690.63(26.28)
$F_{2,10}$	0.59	3.21	6.23*	4.07 *
SE	1.33	1.16	1.48	2.19
CD	--	--	3.30	4.88
Methods of sowing				
b_1	174.77(13.22)	297.56(17.25)	458.81(21.42)	681.73(26.11)
b_2	35.52(5.96)	92.35(9.61)	313.64(17.71)	557.43(23.61)
$F_{1,10}$	44.69**	65.27**	23.26	7.29 *
SE	1.09	(0.95)	1.21	1.79
CD	2.42	(2.11)	2.69	--
Levels of N				
c_1	87.05(9.33)	171.09(13.08)	313.64(17.71)	556.96(23.60)
c_2	103.02(10.15)	198.53(14.09)	242.74(15.58)	609.59(24.69)
c_3	86.30(9.29)	171.87(13.11)	338.19(18.39)	518.93(22.78)
$F_{2,24}$	0.73	0.71	0.95	1.02
SE	0.80	0.95	1.23	1.34

* significant at 5% level

** significant at 1% level

figures in brackets indicates transformed means.

Of the two methods of sowing, broadcasting was found to be significantly superior over pinch method of sowing in respect of crop establishment upto 7 DAS and at 9 DAS the difference was levelled off.

Neither the levels of nitrogen nor the interaction effects studied showed any difference in crop establishment.

I.2 Plant height (cm) (vide Table 3)

The main effect of seed rates, methods of sowing or levels of nitrogen or their interactions did not alter the plant height at any of the growth stages studied.

I.3 Number of tillers per m^2. (vide Table 4)

The number of tillers produced showed significant difference from a_1 seed rate to a_2 seed rate and this was noticed consistently at all stages of growth. a_2 seed rate produced maximum number of tillers and maintained the same throughout the growth stages. At the early stages a_1 and a_3 seed rates were on par and later stages a_3 and a_2 were on par.

The methods of sowing did not influence the tiller production at any stage of crop growth.

However the levels of nitrogen did influence tiller production. The tiller production was highest in plots supplied with highest level of nitrogen (c_3) during 45th and 70th DAS.

The interaction effects between seed rates, methods of sowing and levels of nitrogen did not influence tiller production.

Table 3 Effect of treatments on plant height (cm)

	20 DAS	45 DAS	70 DAS	Harvest
Seed rates				
a_1	27.94	46.09	65.29	68.80
a_2	28.29	48.10	65.97	68.51
a_3	29.50	49.89	67.07	68.85
$F_{2,10}$	1.27	1.17	0.33	1.52
SE	1.02	2.48	2.19	2.07
Method of sowing				
b_1	28.74	47.33	66.99	68.17
b_2	28.41	49.73	65.23	69.27
$F_{1,10}$	0.16	0.48	0.96	0.42
SE	0.84	2.02	1.79	1.69
Levels of N				
c_1	28.94	45.78	66.08	67.36
c_2	28.08	48.88	66.08	69.48
c_3	28.71	49.41	66.16	69.33
$F_{2,24}$	0.76	3.75	1.27	1.09
SE	0.72	1.42	1.65	1.59

Table 4 Effect of treatments on number of tillers (number/m^2)

	20 DAS	45 DAS	70 DAS
Seed rate			
a_1	153.89	292.67	356.67
a_2	221.11	398.39	467.56
a_3	167.17	357.22	431.28
$F_{2,10}$	9.00 **	7.21 *	6.45 *
SE	16.78	28.06	31.48
CD	37.40	62.53	70.14
Methods of sowing			
b_1	183.00	347.67	419.04
b_2	178.40	351.19	417.96
$F_{1,10}$	00.11	2.36	1.68
SE	13.70	22.91	25.70
Levels of N			
c_1	179.50	342.61	416.44
c_2	165.06	351.19	349.78
c_3	197.61	410.17	489.28
$F_{2,24}$	1.21	3.81 *	4.02 *
SE	20.99	41.79	49.22
CD	---	86.25	101.59

* Significant at 5% level

** Significant at 10% level

I.4 Leaf area index. (vide Table 5)

The leaf area index remained unaffected due to seeding rates, methods of sowing and levels of nitrogen or their interactions.

I.5 Drymatter production (vide Table 6)

The drymatter production increased with increase in seeding rates upto the highest level tried (a_3). a_3 seed rate recorded highest drymatter production in all stages of growth and it was significantly higher than a_1 and a_2 upto 70 DAS and at harvest a_2 was superior to a_1.

The methods of sowing did not influence dry matter production.

The effect of levels of nitrogen on drymatter production was significantly superior at each successive level at harvest. A progressive increase in dry matter production was noticed due to increase in the levels of nitrogen at harvest.

The interaction effect between factors had no effect on drymatter production.

II Yield and yield attributes

II.1 Productive tillers per m^2. (vide Table 7)

The number of ear bearing tillers were found to be the highest in plots sown with a_2 seed rate and was statistically significant over a_1 rate. However a_2 and a_3 rates were on par.

The pinch method of sowing did increase the number of productive tillers per m^2 numerically though not statistically significant.

Table 5 Effect of treatments on Leaf area index (LAI) at flowering (number)

Seed rate.		
s_1	-	4.50
s_2	-	4.70
s_3	-	4.77
$F_{2,10}$	-	1.50
SE	-	1.60
Methods of sowing		
b_1	-	4.70
b_2	-	4.62
$F_{1,10}$	-	0.44
SE	-	0.13
Levels of N		
c_1	-	4.64
c_2	-	4.76
c_3	-	4.58
$F_{2,24}$	-	1.22
SE	-	0.12

Table 6 Effect of treatment on drymatter production (kg ha^{-1})

	20 DAS	45 DAS	70 DAS	Harvest
Seed rates				
a_1	778	3467	5140	6543
a_2	779	3594	5552	8076
a_3	902	4423	7035	8657
$F_{2,10}$	2.66	5.52 *	8.16**	125.24 **
SE	62.14	312.75	493.49	137.83
CD	—	696.80	1009.49	307.39
Method of sowing				
b_1	880	4048	6073	7666
b_2	759	3609	5745	7851
$F_{1,10}$	5.71	2.96	0.66	12.70
SE	50.74	255.36	402.93	112.65
CD	—	—	—	—
Levels of N				
c_1	814	3727	5711	7342
c_2	827	3897	6102	7648
c_3	818	3860	5914	8286
$F_{2,24}$	2.95	0.23	0.59	23.64 **
SE	57.26	265.32	360.57	140.07
CD	—	—	—	289.12

* significant at 5% level.

** significant at 1% level.

Nitrogen application increase the number of ear bearing tillers and highest number of productive tillers was noticed at c_3 level and it was on par with c_2 level and superior over c_1 level.

The interaction between seeding rates, methods of sowing and levels of nitrogen did not change the number of productive tillers per m^2.

II.2 Number of spikelets per panicle. (vide Table 7)

The seeding rates, methods of sowing or levels of nitrogen did not change the number of spikelets per panicle. The interaction effect of treatments also did not change the number of spikelets per panicle.

II.3 Length of panicle. (vide Table 8)

The main effects of seeding rates, methods of sowing or levels of nitrogen or their interactions did not change the panicle length significantly.

II.4 Weight of panicle. (vide Table 8)

The result on weight of panicle obtained showed that it decreased with increase in seed rate, but methods of sowing and levels of nitrogen did not significantly affect the panicle weight.

II.5 Percentage of unfilled grains. (vide Table 8)

No change in the percentage of unfilled grains was observed with respect to any of the treatments.

II.6 Thousand grain weight. (vide Table 8)

No difference in thousand grain weight was observed due to seeding rates, methods of sowing or levels of nitrogen or their interactions.

Table 7 Effect of treatments on yield component of rice, productive tillers (number/m^2) and spikelets per pancile (number)

	No.of productive tillers/m^2	No.of spikelets per panicle.
Seed rates.		
a_1	204.5	79.72
a_2	324.2	78.78
a_3	299.1	82.83
$F_{2,10}$	12.80 **	1.08
SE	24.97	2.89
CD	55.63	--
Methods of sowing.		
b_1	269.3	80.63
b_2	282.5	80.25
$F_{1,10}$	0.42	2.45
SE	20.30	2.36
Levels of N		
c_1	220.4	80.33
c_2	291.7	79.16
c_3	325.7	81.83
$F_{2,24}$	4.20 *	0.43
SE	36.51	2.87
CD	75.35	--

* Significant at 5% level

** Significant at 1% level

Table 8 Effect of treatments on yield components of rice, weight of panicle (g) Lenght of panicle (cm) percentage of unfilled grain (%) and thousand grain weight (g)

	Weight of Panicle (g)	Length of panicle (cm)	Percentage of unfilled grains	Thousand grain weight (g)
Seed rates				
e_1	2.02	20.07	27.42	21.69
e_2	1.43	19.73	24.79	23.12
e_3	1.33	19.49	26.30	22.85
$F_{2,10}$	28.01 **	0.58	0.32	2.39
SE	0.09	0.54	3.29	0.69
CD	0.22			
Methods of sowing				
b_1	1.54	19.49	26.09	22.71
b_2	1.66	20.04	26.24	22.41
$F_{1,10}$	2.31	0.58	2.92	0.28
SE	0.08	0.44	2.69	0.57
Levels of N				
c_1	1.52	19.77	28.22	21.87
c_2	1.58	19.44	23.90	23.49
c_3	1.69	20.07	26.38	22.32
$F_{2,24}$	1.79	1.09	2.70	1.89
SE	0.09	0.42	1.87	0.86

** Significant at 1% level.

II.7 Grain yield (vide Table 9)

There was considerable difference in grain yield due to different seeding rates. a_3 seed rate recorded highest grain yield which was on par with a_2 rate and both a_2 and a_3 rates were significantly superior over a_1 rate.

The methods of sowing, level of nitrogen and the interaction effect between the factors studied did not influence the grain yield.

II.8 Straw yield. (vide Table 9)

As in the case of grain yield straw yield was also influenced by seeding rates. The straw yield increased with increase in seeding rate. The highest straw yield was obtained with a_2 which was on par with a_3 rate. Both a_3 and a_2 rates were significantly superior to a_1 rate.

Neither the methods of sowing nor the levels of nitrogen or interaction did influence the straw yield.

II.9 Harvest index. (vide Table 9)

No significant change in the harvest index was observed due to seeding rates, methods of sowing and levels of nitrogen. The interaction effect between the factors also did not influence the harvest index.

III Economics of rice production (vide Table 10)

The data on net return and cost benefit ratio are presented in table 10.

III.1 Net return and cost-benefit ratio.

The net return increased with increase in seed rates. a_3 rate was significantly superior to a_2 and a_1 rates. a_2 rate

Table 9 Effect of treatments of grain yield (kg ha^{-1}) straw yield (kg ha^{-1}) and harvest index (number)

	Grain yield	Straw yield	Harvest index
Seed rates.			
a_1	2754	4923	0.36
a_2	3540	5893	0.37
a_3	3710	6688	0.36
$F_{2,10}$	34.23 **	11.54	1.30
SE	123.22	363.31	0.01
CD	274.55	809.46	—
Method of sowing			
b_1	3381	5900	0.36
b_2	3287	5769	0.36
$F_{1,10}$	0.88	0.20	0.14
SE	100.65	296.40	0.09
Levels of N			
c_1	3293	5684	0.36
c_2	3293	5833	0.36
c_3	3416	5987	0.36
$F_{2,24}$	0.27	0.38	0.05
SE	193.57	345.97	0.01

** Significant at 1% level.

Table 10 Economics of rice production ('000 rupees)

	Cost of production excluding treatments	Cost due to treatment	Total expenditure	Total income	Net return	Cost of benefit ratio
Seed rates						
a_1	3.981	0.240	4.221	7.440	3.219	1.76
a_2	3.981	0.360	4.341	8.951	4.610	2.06
a_3	3.981	0.480	4.461	9.640	5.179	2.17
$F_{2,10}$					0.037	3.25
SE					0.233	0.108
CD					0.480	0.225
Methods of sowing						
b_1	4.149	0.075	4.224	8.673	4.449	1.87
b_2	4.149	0.575	4.724	8.943	4.219	1.79
$F_{1,10}$					0.002	0.27
SE					0.190	8.89
Levels of nitrogen						
c_1	4.061	0.239	4.300	8.723	4.423	1.79
c_2	4.061	0.334	4.395	8.531	4.136	1.82
c_3	4.061	0.430	4.491	8.934	4.443	1.92
$F_{2,24}$					0.003	0.380
SE					0.467	0.150

Cost of inputs

1. Nitrogen Rs.4.78/kg
2. Phosphorus Rs.3.54/kg
3. Potassium Rs.2.17/kg

Price of paddy - Rs.2.00/kg
Price of straw - Rs.0.50/kg

Labour charges

Men Rs.25.00/day
Women Rs.20.00/day

Table 11 Effect of treatments on nitrogen uptake (kg ha^{-1})

	20 DAS	45 DAS	70 DAS	Harvest
Seed rates				
a_1	21.84	54.26	64.35	62.29
a_2	22.04	57.87	70.35	69.27
a_3	25.10	73.17	94.92	89.17
$F_{2,10}$	1.82	10.46 **	23.85 **	73.27 **
SE	1.91	4.39	4.69	2.21
CD	—	9.78	10.45	10.45
Method of sowing				
b_1	24.59	62.09	74.72	71.54
b_2	21.40	61.44	78.35	75.61
$F_{1,10}$	4.21	3.29	0.90	4.68
SE	1.56	3.58	3.82	4.19
Levels of N				
c_1	22.53	60.57	72.34	67.22
c_2	23.34	61.33	77.20	73.20
c_3	23.12	63.41	80.04	80.30
$F_{2,24}$	0.13	0.28	1.20	13.80
SE	1.62	3.90	4.99	5.14

* Signiciant at 1% level

** Significant at 5% level

Table 12 Effect of treatments on N content of soil (kg ha^{-1}) after experiment

Seed rates	
a_1	93.00
a_2	84.67
a_3	85.44
$F_{2,10}$	0.78
SE	7.37
Method of sowing.	
b_1	85.19
b_2	90.22
$F_{1,10}$	0.70
SE	6.02
Levels of N	
c_1	93.78
c_2	87.67
c_3	81.67
$F_{2,24}$	0.70
SE	10.31

was also significantly superior to a_1 rate. Methods of sowing did not show any significant difference. Similarly the levels of nitrogen showed no significant influence on net return.

With regard to cost-benefit benefit ratio a_2 rate was significantly superior to a_1 rate. But a_3 and a_2 rates were on par in effect. The methods of sowing and levels of nitrogen did not show significant influence on the cost-benefit ratio.

IV Chemical studies

IV.1 N uptake (vide table 11)

Nitrogen uptake of plant increased with increase in seeding rate as was observed from the data analysed.

The methods of sowing did not cause significant change in the nitrogen uptake.

The levels of nitrogen enhanced the nitrogen uptake at harvest. At harvest highest nitrogen uptake was observed with highest level of nitrogen.

The interaction effects between the factors did not cause significant change in nitrogen uptake.

IV.2 N content of soil after expreiment. (vide table 12)

The result obtained revealed that the various treatments did not alter the residual nitrogen content of soil after experiment.

DISCUSSION

V DISCUSSION

The present experiment, "Response of rice to methods of sowing under varying seed rates and levels of nitrogen", was conducted in the Instructional farm, College of Agriculture, Vellayani to find out superiority if any for the age old practice of sowing rice by "pinch" method at different seed rates and levels of nitrogen adopted in some parts of the state over broadcast in puddled soil. The treatments included were three rates of seeding (60, 90 and 120 kg ha^{-1}), two methods of sowing (Pinch and Broadcast in puddled soil) and three levels of nitrogen (50, 70 and 90 kg ha^{-1}). The results obtained in the experiment are discussed below:

I Growth characters

I.1 Crop establishment (number of plants/m^2)

The results presented in Table 2 revealed that increased rates of seeding influenced the number of plants established/m^2 at 7 and 9 DAS. In the early stages of germination (3 and 5 DAS) the establishment was not significant, the reason may be time factor. In the later stages (7 and 9 DAS) the establishment was completed. Since the seeds had 95% germination the population varied per square metre according to seed rate used. Hence the higher seed rate had higher population compared to lower seed rate. Of the two methods of sowing, the broadcast in puddled soil method of sowing significantly influenced the plant establishment at all the four dates at which the data were recorded. However levels of

nitrogen did not influence the establishment of the crop.

The present finding that the number of plants established increased with increase in seeding rate is in agreement with the findings of several other scientists. Sonnier et al. (1982), Ghosh and Reddy (1983) and Jones and Synder (1987) also reported similar results. Reddy and Panda (1985) also observed higher initial plant population with higher seed rate. Aliaga et al. (1986) reported marked response to seed rate in the number of emerged plants.

Broadcast in puddled soil method of sowing recorded the highest establishment rate over the pinch method of sowing. From the data it may be seen that establishment was poor in early stages and at 9 DAS the differences were not significant indicating that in the pinch method the seeds were dibbled and so there was a time lag for the emergence but in broadcasting in puddled soil since the seeds were surface placed establishment rate was quicker. Singh et al. (1973) reported that broadcasting gave highest plant stand at harvest. Chandra Mohan and Mohammedali (1976) reported that broadcasting recorded adequate plant establishment.

However the present finding is not in agreement with the findings at C.R.R.I. Cuttack (1984) as reported in the annual report (1984) that better establishment rates were obtained with farm yard manure coated seeds as compared to uncoated seeds.

From the observation it was evident that levels of nitrogen did not significantly influence the establishment of

the crop. It may due to the fact that absorption of nutrients takesplace only after proper establishment of the seedling and hence a variation in fertiliser application could not bring about significant effect on establishment.

There was no interaction effect of various treatments tried in the experiment on plant establishment.

I.2 Plant height

The results presented in Table 3 revealed that the plant height was not influenced by methods of sowing, seed rates or levels of nitrogen at any of the growth stages studied.

The three seed rates tried viz. 60, 90 and 120 kg ha^{-1} did not alter the plant height at any of the growth stages of the rice crop var. Triveni. Similar result was obtained by Dawood et al. (1971), while studying the performance of ten varieties of rice at seeding rates of 60, 90 and 120 kg ha^{-1}. The findings of Singh (1971) and Aliaga et al. (1986) were also in conformity with these results.

The plant height recorded at any of the growth stages of the crop was not influenced by the methods of sowing. The results of the studies conducted at C.R.R.I. Cuttack (1984) also revealed no significant difference in plant height between broadcasting of sprouted seeds and dibbling of farm yard manure coated paddy seeds. Dawood et al. (1971) also reported similar results obtained in Tamil Nadu.

In the present investigation nitrogen at different levels did not alter the plant height. The variation in plant height could not be noted in var. Triveni due to levels of

nitrogen. This may be because of the fact that 50 kg N ha^{-1} was more than sufficient to bring plants to its normal height and any incremental dose of nitrogen could not influence this morphological character. The fact that 50 and 70 kg N ha^{-1} could not produce favourable effect in influencing plant height may be the genetic character of the variety. Nair et al. (1971) also found that nitrogen application had no effect on the height of plant. Sreekumaran (1981), Ajithkumar (1984) also got similar results. Based on the results obtained Meera Sahib (1974) concluded that in the case of Triveni variety of rice significant increase in height could not be achieved by the application of nitrogen beyond 60 kg ha^{-1}.

The interaction between the treatments was also not significant in influencing the plant height.

I.3 Number of tillers/m^2

The data on number of tiller/m^2 presented in Table 4 revealed that higher rates upto 90 kg ha^{-1} of seeding and application of higher levels of nitrogen significantly influenced the tiller production. The methods of sowing did not change the tiller count/m^2.

In this experiment the number of tillers/m^2 increased with increase in seed rate upto 90 kg ha^{-1} and further increase in seed rate from 90 to 120 kg ha^{-1} depressed production of tillers. Maximum tiller counts of 222, 398, 467 were recorded at 20, 45, 70 DAS with 90 kg ha^{-1} seed rate. From the data it may be concluded that for maximum tiller production a seed rate of

90 kg ha^{-1} was found to be more than sufficient. It is a common phenomenon that the increase in number of tillers continues until the maximum tillering stage. The plants stop producing tillers after the tertiary tillers have been produced. Rao and Rao (1979) also obtained similar results showing that lower seed rate resulted in lower tiller production. Aliaga et al. (1986) did not obtain significant response to seed rate with respect to production of tillers.

The number of tillers produced in the two method of sowings adopted did not show significant difference. Inconsistent findings are reported by several workers with respect to methods of sowing and production of tillers. Singh (1973) observed that dibbling of seeds in puddled soil gave highest average number of tillers/m^2 as compared to broadcasting. This was in conformity with the findings of Rao et al. (1981). But Prasad et al. (1983) obtained greater number of tillers with transplanting than broadcasting.

Application of nitrogen at higher levels produced higher tiller counts/m^2. The highest tiller count was obtained with plants supplied with 90 kg N ha^{-1}. The lowest number of tillers were registered with the lowest level of nitrogen (50 kg ha^{-1}) tried in the experiment. Enhancement of tiller production as a result of nitrogen supply has been reported by several workers. (Tanaka, 1964; Ramanujam and Sekharan, 1971; Meerasahib, 1974; Alexander, 1972). Uexkull (1976) profounded that tillering in rice plant is strongly influenced by genetic factors and by nitrogen and phosphorus levels in the soil. Sreekumaran (1981)

Sushamakumari (1981) Ajithkumar (1984) Babu mathew (1987) also obtained similar results showing that nitrogen application had considerable influence on tiller production.

There was no interaction effect between the treatments with regard to the tiller production.

1.4 Leaf area Index

The leaf area index as influenced by levels of seed rate, methods of sowing and levels of nitrogen are presented in table 5. From the data it is revealed that the leaf area index was not affected by seed rates, methods of sowing or levels of nitrogen.

The rate of seeding did not alter the leaf area index in Triveni rice in this experiment. The effect of seed rate on the leaf area index is inconsistent as reported by several workers. Enyi (1965) found that LAI was higher with higher plan population. According to Pothiraj et al. (1977) LAI was more with lower seedling density than higher seedling density. Well and Faw (1978) obtained increased LAI with increased seed rate.

Leaf area index values obtained in the present study did not show any difference due to methods of sowing. Though the difference between two methods of sowing was not significant, broadcasting in puddled soil showed a slightly higher LAI than pinch method of sowing. However this finding is not in agreement with that reported by Mukerjee and Chatterjee (1970) who obtained higher leaf area index in rice sown under broadcast than drilled crop.

The levels of nitrogen did not influence the leaf area index at flowering. This may be because of the fact that the

variation in the levels of nitrogen tried were only low (20 kg ha^{-1} between levels) which in turn produced no significant difference in LAI. However with the different levels tried 70 kg N ha^{-1} showed higher LAI compared to lower and higher levels (50 and 90 kg N ha^{-1}). This is in conformity with the findings of Rai and Murthy (1979) who reported that LAI had no correlation with levels of nitrogen. Vaijayanthi et al. (1986) also did not get any influence of nitrogen rates on the LAI at booting stage in rice-var-Lekshmi.

There was no interaction between the treatments with regard to their influence on LAI.

I.5 Dry matter production

Dry matter production (Table 6) at all stages of growth increased with increase in rate of seeding. The highest values of dry matter production recorded at 20, 45, 70 DAS and at harvest were 902, 4423, 7035 and 8657 kg ha^{-1} respectively with 120 kg ha^{-1} seed rate and lowest values were 778, 3467, 5140 and 6543 kg ha^{-1} respectively with seeding rate of 60 kg ha^{-1}. Experiments conducted at I.R.R.I. Philippines (1970) showed increased dry matter production at increased plant density. Mukherjee and Chatterjee (1970) also obtained higher dry matter production with a seed rate of 90 kg ha^{-1} than 60 kg ha^{-1}. The findings of Enyi (1965) and Gautam and Sharma (1987) are also in conformity with the findings obtained in this experiment. This increased dry matter production due to increased seed rate may be due to higher seed rate producing higher number of plants and tiller number per unit area.

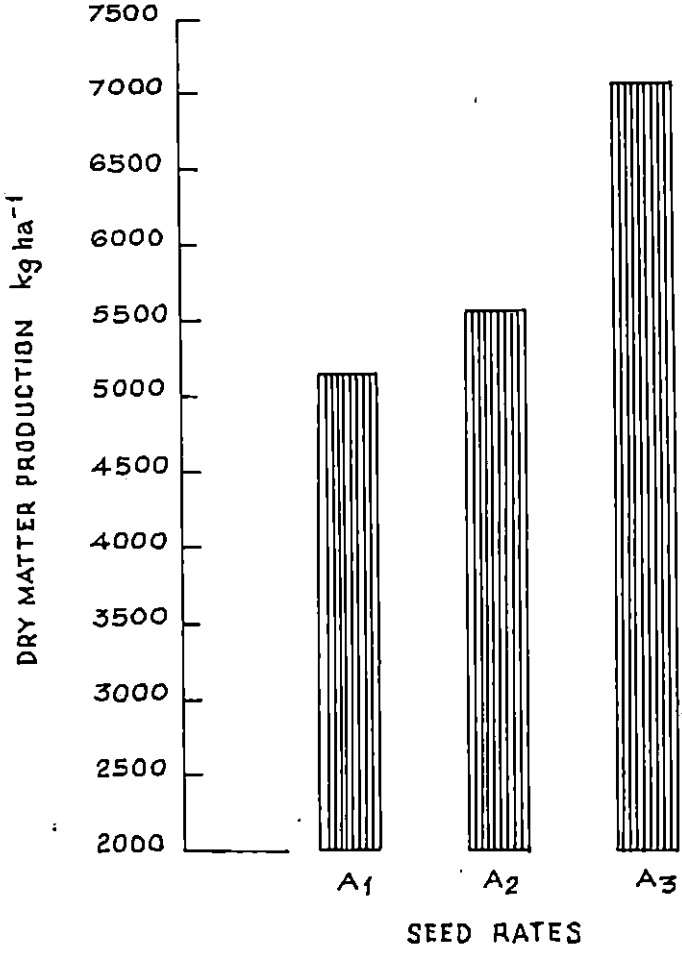


FIG. 3. DRY MATTER PRODUCTION AT HARVEST AS INFLUENCED BY SEED RATES.

The broadcast and pinch methods of sowing had no significant influence on the dry matter production. However the dry matter production in general was higher in the broadcast in puddled soil method than the pinch method of sowing. Mukherjee and Chatterjee (1970) and Dixit and Singh (1975) obtained higher dry matter production with broadcast method than direct drilled or transplanted rice which is in confirmity with the present findings.

The dry matter production increased with increased application of nitrogen significantly at harvest. The difference in dry matter production at harvest may be due to difference in grain formation. Upto 70 DAS there was no difference which may due to the uniform vegetative growth. Still it may be seen that 70 kg N ha^{-1} showed higher drymatter production only upto 70 DAS and at harvest 90 kg N ha^{-1} expressed its efficiency in increasing dry matter production. This may be due to the increase in grain formation by better utilisation of excess applied nitrogen. With the advancement growth and consequent production of larger numbers of productive tillers coupled with better availability of nutrients, the dry matter production also increased. The highest value of 8286 kg ha^{-1} of dry matter was obtained in plots which were supplied with 90 kg N ha^{-1}. Nair et al. (1976) observed significant increase in drymatter production at harvest in direct sown Triveni variety, when level of nitrogen was raised from 50 to 70 kg ha^{-1}. Similar results have been reported by many workers. Ramanujam and Rao, 1971; Anon, 1985; Anon, 1986; Vaijayanthi, 1986; Babu mathew, 1987. These results sug-

gests that increased tiller production due to application of higher doses of nitrogen might have led to enhanced biomass production.

No interaction effect was noticed among the treatments.

II. Yield and yield attributes

II.1 Number of productive tillers/m^2.

The data on the number of productive tillers per m^2 are presented in Table 7.

The lowest number of productive tillers/m^2 of 205 was obtained with seed rate of 60 kg ha^{-1} and the maximum number of productive tillers/m^2 of 325 was with seed rate of 90 kg ha^{-1}. As the seed rate was further increased to 120 kg ha^{-1} the number of productive tillers was on the decline as compared to 90 kg ha^{-1} seeding rate and it was 299/m^2. Subbiah et al. (1977) obtained increased number of productive tillers in rice variety Bhavani when seed rate was increased from 60 kg ha^{-1} to 160 kg ha^{-1} but in I.R.20 the different seed rates did not significantly influence the number of productive tillers. Similar findings have been reported by several workers in rice. Sasak, et a 1966: Jindal and Kalia, 1969: Gautam and Sharma, 1983: Jones and Snyder, 1987. The reduction in number of productive tillers with the highest seed rate might probably be due to inadequate space for development of tillers as the plant population itself was higher at highest level of seed rate. From these results it is evident that the number of productive tillers increase with increase in seed rate upto a certain rate of seed-

ing and beyond that it showed a decreasing trend. The plant population/m^2 were less in 60 kg ha^{-1} as compared to 120 kg ha^{-1}. This reflected in the number of productive tillers also. By referring to table 3 it may be seen that the total number of tillers were also maximum with 90 kg as compared to 60 and 120 kg ha^{-1}. This has been reflected in productive tillers.

The pinch method of sowing did influence the production of fertile tillers though not significant. The competition for nutrients, light, space and water between crop plants was more severe in broadcast crop which may be due to variation in spacing as compared to the line planted pinch method.

The number of productive tillers increased with increase in the rate of nitrogen applied. Highest number of productive tillers/m^2 (325) was obtained with 90 kg N ha^{-1} - the highest level of nitrogen tried in the experiment. Rice plant requires a large amount of nitrogen at the early and mid tillering stages to maximise the number of panicles (De Datta and Surjith, 1981). The role of nitrogen in increasing panicle number in tall indica had been stressed by Sood and Singh (1968). Rathinam (1974) reported that increasing rates of nitrogen from zero to 160 kg ha^{-1} produced linear increase in the average number of productive tillers per hill. The findings of Alexander (1972), Pillai (1975), Sushamakumari (1981), Anon (1984a) Surendran (1985), Babu mathew (1987) are also in agreement with this result.

No significant interaction was seen in the matter of tiller production.

II.2 Spikelets/panicle

It is observed from the results that there was no favourable effect of seed rates, methods of sowing or levels of nitrogen on the spikelets production.

The rate of seeding had no influence on the spikelets/panicle. Akamatsu (1969) observed that number of spikelets/panicle were not influenced by sowing density. Dawood et al. (1976) obtained a decreased number of spikelets/panicle when seed rate was increased from 40 to 80 kg ha^{-1}. However the present finding is not in conformity with the findings as reported by Mukherjee and Chatterjee (1970) who found that the number of spikelets increased when a change in the seed rate was made in I.R.8 variety from 60 to 90 kg ha^{-1}. Gautam and Sharma (1983) also obtained similar results.

The methods of sowing did not show superiority of one method over the other with regard to the number of spikelets per panicle. According to Mukherjee and Chatterjee (1970) the number of spikelets were higher with direct drilled followed by broadcast and transplanted crop. But Gupta et al. (1976) reported that the number of spikelets were higher with transplanted rice followed by direct drilling and broadcast sowing.

The number of spikelets per panicle as influenced by levels of nitrogen also did not show significant difference, though the highest level of nitrogen (90 kg N ha^{-1}) showed a numerical increase. The number of spikelets depends upon the activity of the plant during the reproductive phase. Numerous studies have shown that nutrient availability and

spikelets per panicle are positively correlated. The photo synthetic activity during the reproductive phase also acts to control the number of spikelets per panicle. De Datta and Surjith (1981) reported that nitrogen increase the number of spikelets per panicle in rice. Surendran (1985) and Vaijayanthi (1986) observed significant increase in spikelet number to the levels of nitrogen upto 60 kg ha^{-1} in Lekshmi variety of rice. But Nair (1976) reported that the number of spikelets/panicle was not influenced by levels of nitrogen in Triveni rice. From these it is evident that the lowest N level tried (50 kg ha^{-1}) in the experiment might be sufficient to produce maximum spikelets/panicle and any further addition of nitrogen had no effect on the spikelets/panicle.

No interaction effect was noticed between treatments tried in the experiment.

II.3 Length of panicle

From the results (Table 8) it is revealed that the length of panicle was not influenced significantly by rates of sowing, sowing methods or nitrogen rates.

The seed rates did not alter the length of panicle though the higher seed rates slightly reduced the length. Inconsistent reports have been made by several workers. According to Hukkeri and Chauhan (1968) higher seed rates resulted in a reduction in pancile length. Dawood et al. (1971) and Singh (1971) observed an increase in length of panicle with increase in seed rate.

The seeding methods also did not significantly influence the panicle length though the increase was numerically high for pinch method of sowing as was observed from the present results. Singh et al. (1977) observed that dibbling and broadcasting did not influence significantly the length of panicle. Studies at C.R.R.I. Cuttack (1984) revealed that farm yard manure coated seeds dibbled recorded higher length of panicle than the uncoated seeds broadcasted, which is in agreement with the present findings.

The nitrogen levels tried in the experiment had not affected the panicle length, but it showed an increasing trend with increase in nitrogen. Several workers concluded that the panicle length is a varietal character (Ghosh, 1960; Tomy, 1963; Sreenivasalu and Pawar, 1965; Nair, 1968.; Adam, 1969; Paul mathew, 1971; Unnikrishna kurup, 1971.) Iyer (1967) found that panicle length was little influenced by nitrogen application. Similar results were also reported by Nair, 1976; Sushamakumari, 1981; Vaijayanthi, 1986; Ajithkumar, 1984; Surendran, 1985 who did not observe any relationship between panicle length and nitrogen levels.

These results showed that the panicle length is a genetically controlled character which is little influenced by management practices like higher levels of nitrogen fertilisation, higher seed rates or sowing methods.

II.4 Weight of panicle

The weight of panicle as obtained in the present investigation is presented in table 8. The results showed

The above results indicate increase in plant density and consequent increase in the number of panicles per unit area, the mean weight of panicle decreased. It is also found that a nitrogen rate of 50 kg ha^{-1} is sufficient to produce maximum panicle weight and further increase in nitrogen application showed no effect.

There was no interaction between treatments tried in the trial.

II.5 Percentage of unfilled grains

The various treatments viz. seed rates, methods of sowing and rates of nitrogen did not influence the percentage of unfilled grains.

The percentage of unfilled grains was not affected by the rate of seeding as seen from the results obtained in the experiment and presented in table 8. A mixed trend was observed in percentage of unfilled grains with increase in seed rate. Gautam and Sharma (1983) also reported similar result that high plant density resulted in lower percentage of unfilled grains. But Hukkeri and Chauhan (1968) and Jones and Snyder (1987) obtained an increase in the percentage with increased sowing rates.

With regard to methods of sowing the percentage of unfilled grains remained unaffected indicating that the methods of sowings have any effect on grain filling and percentage of unfilled grains. This is inconfirmity with the finding of Nair (1971).

The percentage of unfilled grains was little affected by levels of nitrogen tried. Kalyanikutty (1968) reported that percentage of chaffness increased with increased application of nitrogen. Nair (1976) also obtained a non-significant influence of nitrogen in Triveni variety. However conflicting findings are also reported. According to Meera Sahib (1974) application of 90 kg N ha^{-1} produced minimum percentage of unfilled grains in Triveni variety. This is also in agreement with finding of several workers (Baumik and Chose, 1977: Surendran, 1985; Vaijayanthi, 1986).

No interaction effect was noticed between treatments experimented.

II.6 Thousand grain weight

The results on thousand grain weight showed that it was not significantly influenced by the treatments.

Although the maximum thousand grain weight of 23.12g was obtained with 90 kg ha^{-1} seed rate it was not significant over the other two seeding rates. Akamatsu (1969), Singh (1973) showed that thousand grain weight was not altered by sowing rate. The above findings supports the results obtained in the present investigation. With respect to methods of seeding, its effect was not conspicuous on thousand grain weight. Nair (1971) and Singh (1973) also obtained similar results.

The levels of nitrogen also did not influence the grain weight. Pillai (1976), Ajithkumar (1984) also reported that fertiliser had no effect on thousand grain weight. However conflicting reports are also available. Several workers

(Alexander, 1972; Morachan, 1974; Surendran, 1985; Vaijayanthi, 1986; Babu mathew, 1987) obtained a significant increase in thousand grain weight with higher levels of nitrogen.

The various treatments did not show any interaction effect on thousand grain weight.

II.7 Grain yield

The data on grain yield are presented in table 9. From the data it is seen that grain yield was highly significant on account of effect of seed rate. The other factors viz. methods of sowing and levels of nitrogen are not significant in increasing the grain yield.

The results indicated that the grain yield increased progressively with increase in rate of seeding. Highest grain yield was obtained with a seed rate of 120 kg ha^{-1} though it was on par with that obtained with 90 kg ha^{-1} seeding rate. The seeding rate of 90 kg ha^{-1} was found to be significantly superior to 60 kg ha^{-1}. A seed rate of 90 kg ha^{-1} increased the grain production by 785.5 kg ha^{-1} over a seed rate of 60 kg ha^{-1} the percentage increase being 28. When seed rate was increased from 60 to 120 kg ha^{-1} the grain yield increased from 2754 to 3709 kg ha^{-1} ie. an increase in seed rate of 60 kg ha^{-1} produced an extra yield of 955 kg ha^{-1} by a percentage of 35. Similarly the increase in seed rate from 90 to 120 kg ha^{-1} increased the grain yield by about 170 kg from 3539 to 3709 kg ha^{-1}, but this increase was not statistically significant. The most important yield contributing character viz. the number of productive tillers/unit area contributed to

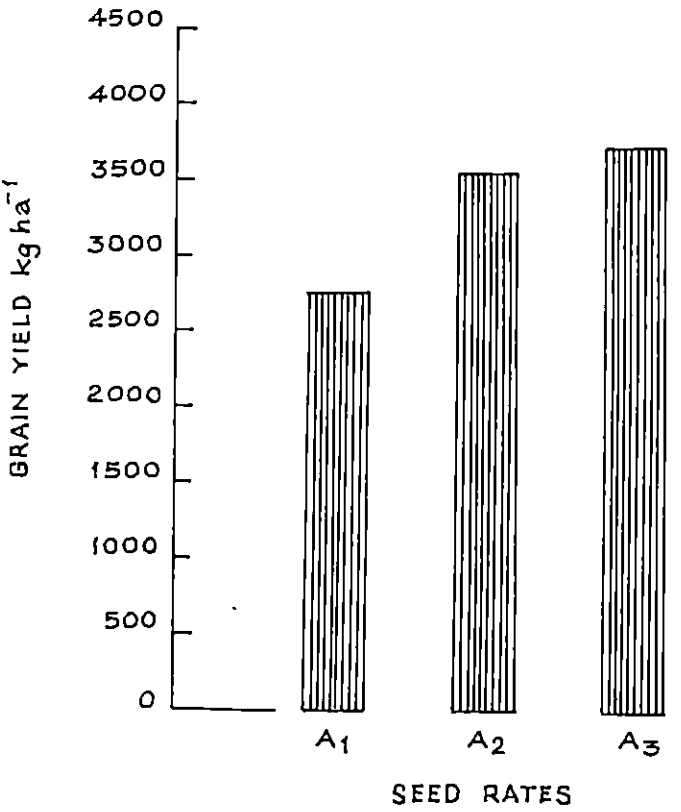


FIG. 4. GRAIN YIELD AS INFLUENCED BY SEED RATES.

the higher yield obtained. The increased grain yield with the seeding rate of 90 kg ha^{-1} might be attributed to increase in plant population coupled with better availability of nutrients and production of productive tillers. The plants exposed to optimum nitrogen uptake in each phase of growth give high yields. With optimum leaf area and adequate nitrogen, plants manufacture a large amount of carbohydrates during the reproductive and ripening phases which in turn results in a large number of well filled spikelets per panicle. These results shows that a seeding rate of 90 kg ha^{-1} is sufficient to produce maximum yield. Singh and Singh (1973) obtained higher yield with higher plant population, Dixit and Singh (1978) obtained highest paddy yield at 110 kg ha^{-1} with C.V. Cavery. Gautam and Sharma (1987) reported that production efficiency increased with increase in plant density in the case of short duration varieties of paddy. Sasak et al. (1966) showed that grain yield increased with increase in seed rate.

The grain yield recorded indicated that it was not significantly influenced by methods of sowing. But higher grain yield of 3381 kg ha^{-1} was obtained from broadcast method as against 3287 kg ha^{-1} obtained from pinch method. Eventhough broadcast method of sowing registered higher establishment rate (Table 2) in the initial stages of crop growth it was nullified at subsequent stages of growth, as the pinch method made up the loss by producing larger number of productive tillers. As such the yield remained almost on par with

each other. From these observations, it may be concluded that broadcasting in puddle soil is preferable over pinch method in terms of monetary benefit compared to pinch method which requires a higher labour in put. Rao (1976) obtained similar yield from broadcasting and sowing in rows, in puddled soil. Dixit and Singh (1973) observed no significant advantage of dibbling over broadcasting in respect of grain yield. But studies conducted C.R.R.I. Cuttack (1984) showed that grain yield was higher with sowing of farm yard manure coated seeds than uncoated seeds with a short duration variety of rice (105 days) CR. 222 MT 10. Nair (1971) also reported that dibbling of sprouted seeds gave higher yield than broadcasting. Gupta et al. (1976) reported higher yield with transplanted rice.

The effect of levels of nitrogen showed that grain yield progressively increased with increase in the rate of nitrogen applied from 50 to 90 kg ha^{-1}, though the increase was not significant. The highest yield of 3416 kg ha^{-1} was obtained with 90 kg ha^{-1} while lowest yield of 3293 kg ha^{-1} was obtained with 50 kg ha^{-1}. This may be because of the fact that native fertility of the experimental area which was medium with reference to available nitrogen and the crop might have utilised this nitrogen also for its growth and development resulting in lack of response to added nitrogen. The general recommendation of N for a short duration variety is 70 kg ha^{-1}. But from the present investigation it is evident that in soils having medium available nitrogen even 50 kg N ha^{-1} is more than sufficient to produce maximum yield of grain. This again

that weight of panicle decreased with increase in seed rate, but methods of sowing and levels of nitrogen did not significantly affect the panicle weight, though the increase was linear.

An increase in seed rate decreased the panicle weight. The maximum weight (2.02g) was obtained with 60 kg ha^{-1} seed rate and it decreased to 1.33g with 120 kg ha^{-1}, the highest seed rate tried in the experiment. Dawood et al. (1976) obtained a decreased panicle weight with increasing seed rate from 40 to 80 kg ha^{-1}. Prasad and Misra (1981) and Reddy and Ghosh (1983) also reported similar results. But Subbiah et al. (1977) found that panicle weight was not influenced significantly by seeding rates.

Regarding the methods of sowing it showed no influence on panicle weight. Experiments at C.R.R.I. Cuttack (1984) showed no significant difference in panicle weight between two methods of sowing viz. broadcasting and dibbling farm yard manure coated paddy seeds. The result of the study conducted by Singh (1973) is also in conformity with this finding.

An increasing trend in weight of panicle with increase in the nitrogen levels was noticed though the increase was not significant. At the highest nitrogen rate of 90 kg ha^{-1} the panicle weight was the highest (1.69g) and at the lowest nitrogen rate of 50 kg ha^{-1} the panicle weight recorded the lowest weight of 1.52g. According to Vaijayanthi (1986) the panicle weight showed no significant difference due to different doses of nitrogen. But Pillai (1971), Dixit and Prasad (1979), Sushamakumari (1981) showed an increase in panicle weight with increase in the level of nitrogen applied.

shows the importance of soil analysis for fertiliser application.

Pillai et al. (1975) pointed out that the rate of increase of grain yield beyond 80 kg N ha^{-1} was not significant in the case of variety Annapurna one of the parents of the variety Triveni, tested in the experiment. Wells and Faw (1978) reported that nitrogen rate was weakly correlated with yield except at high seed rates.

II.8 Straw yield

The yield of straw computed per hectare presented in Table 9, shows significant increase at each successive increament of seed rate tried in the present investigation. Highest straw yield (6688 kg ha^{-1}) was obtained with 120 kg ha^{-1} seed rate which was significantly higher than the lowest of (4933 kg ha^{-1}) 60 kg ha^{-1}. When the seed rate was increased from 60 to 90 kg ha^{-1} the straw yield increased by 970 kg which is 16% increase over 60 kg ha^{-1} the straw yield increased by 1765 kg which is 27% increase over 60 kg ha^{-1}. Though the increase in straw yield for 120 kg ha^{-1} seeding was fairly higher than 90 kg ha^{-1} seeding rate, it was not statistically significant. The increase in straw yield with increase in seed rate may be due to higher plant population, increased tiller production per unit area. According to Lal et al. (1982) increasing plant density increase straw yield due to increased plant population per unit area. Enyi (1965) reported that higher plant population resulted in higher yield of straw. H ten Have (1970) observed that the straw yield increased with rate of seeding and nitrogen levels. Verma (1972) also reported that higher plant population brought

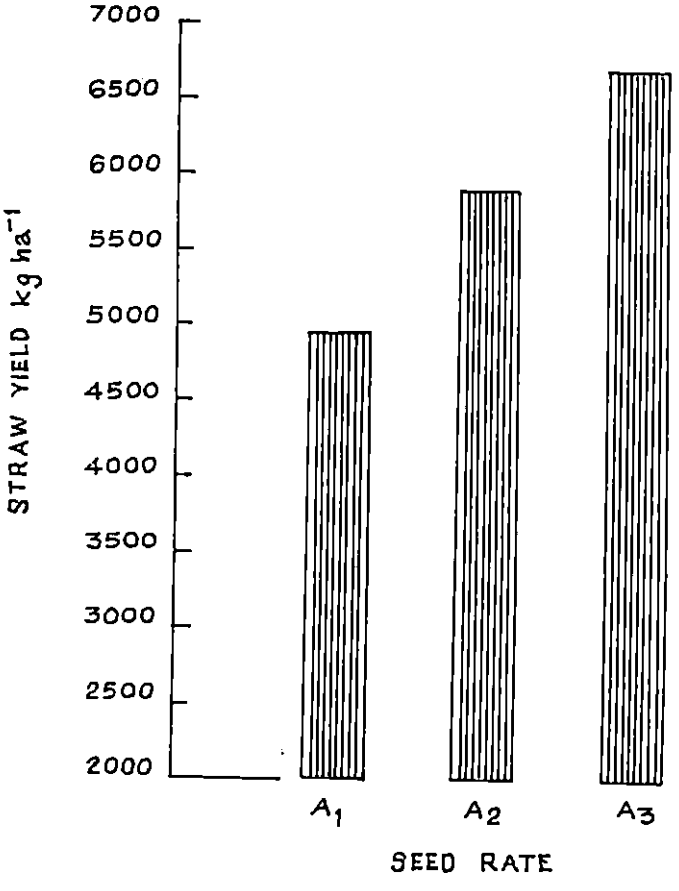


FIG. 5. STRAW YIELD AS INFLUENCED BY SEED RATES.

about significant improvement in straw yield.

Although broadcast method of sowing recorded higher straw yield than pinch method, it was not significant. Chandramohan and Mohammadali (1976) reported that direct sown crop recorded 14.7% increase in straw yield over transplanted crop partially support the present finding. However studies at C.R.R.I. Cuttack (1984) recorded higher straw yield from FYM coated seeds than broadcasting of uncoated seeds. (Dinesh Chandra 1985)

The data obtained showed a progressive increase in straw yield with successive increase in nitrogen application. Though this increase was linear it was not significant. Highest straw yield of 5987 kg ha^{-1} was obtained with 90 kg N ha^{-1} and lowest (5684 kg ha^{-1}) with 50 kg ha^{-1}. The beneficial effect of nitrogen in increasing straw yield has been reported by many workers like Sahu and Lenka (1967), Venkiteswaralu (1978), Nair (1976), Vaijayanthi (1986), Babu mathew (1987).

No interaction effect was seen between various treatments.

II.9 Harvest index

The results obtained (table 9) indicated that the seed rates, methods of sowing and levels of nitrogen did not influence the harvest index.

Harvest index for the different seed rates viz. 60 and 120 kg ha^{-1} remained almost constant. The findings reported by Verma (1972) that harvest index was higher as number of plants/unit area increased also do not support the present results. The seeding methods also did not affect the harvest index.

The influence of levels of nitrogen did not alter the harvest index, which indicates that the incremental levels of nitrogen both economic yield and biological yield increased tending to keep the index to remain almost constant. Babu mathew (1987) did not find any influence of nitrogen on harvest index. Contrary to this decrease in harvest index with increase in the level of nitrogen has been reported by Prasad (1981), Sreekumaran (1981), Surendran (1985).

The interaction among the treatments was also not significant.

III Economics of rice production

The relative economics of seed rates and nitrogen fertilisation of Triveni variety of rice under pinch and broadcast in puddled soil in terms of grain and straw returns worked out on the basis of expenditure and returns are presented in table 10.

III.1 Net return and cost-benefit ratio.

The seed rates significantly influenced the net return and cost-benefit ratio. A highest net return (Rs.5175/-) was recorded with 120 kg ha^{-1}, the highest seed rate tried in the experiment, and it was significantly superior to 90 kg and 60 kg ha^{-1}. But 90 and 120 kg ha^{-1} recorded almost similar cost benefit ratio and they were significantly superior to 60 kg ha^{-1}. With 120 kg seed rate the additional net income over and above 90 kg ha^{-1} was Rs.565/-(by investing an additional amount of Rs.120/-

per hectare). But the additional net income obtained with 90 kg ha^{-1} by investing an additional amount of Rs.120/- per hectare over and above 60 kg ha^{-1} was Rs.1391/-. So 90 kg seed rate is more economical than 120 kg ha^{-1}. The cost benefit ratio recorded also showed that 90 kg was significantly superior to 60 kg ha^{-1} and it was on par with 120 kg ha^{-1}.

The net return and cost benefit ratio obtained showed no significant difference with regard to methods of sowing. But broadcasting recorded higher net return and cost benefit ratio than pinch method. This shows that broadcasting is more economical than pinch method because the pinch method always require more labour input, which is becoming more and more expensive nowadays.

The levels of nitrogen did not showed significant difference on the net return obtained and cost benefit ratio worked out. This again substantiate that under conditions of medium soil nitrogen status a nitrogen level of 50 kg ha^{-1} is sufficient to produce economic yield from rice variety Triveni.

IV Chemical studies

IV.1 Nitrogen uptake

The data in table 11 revealed that the seed rate exerted significant influence on nitrogen uptake. Nitrogen uptake increased with increase in seed rates in all 3 stages except at the initial stage (20 DAS). At 20 DAS the uptake was not found to be not significant which may be due to

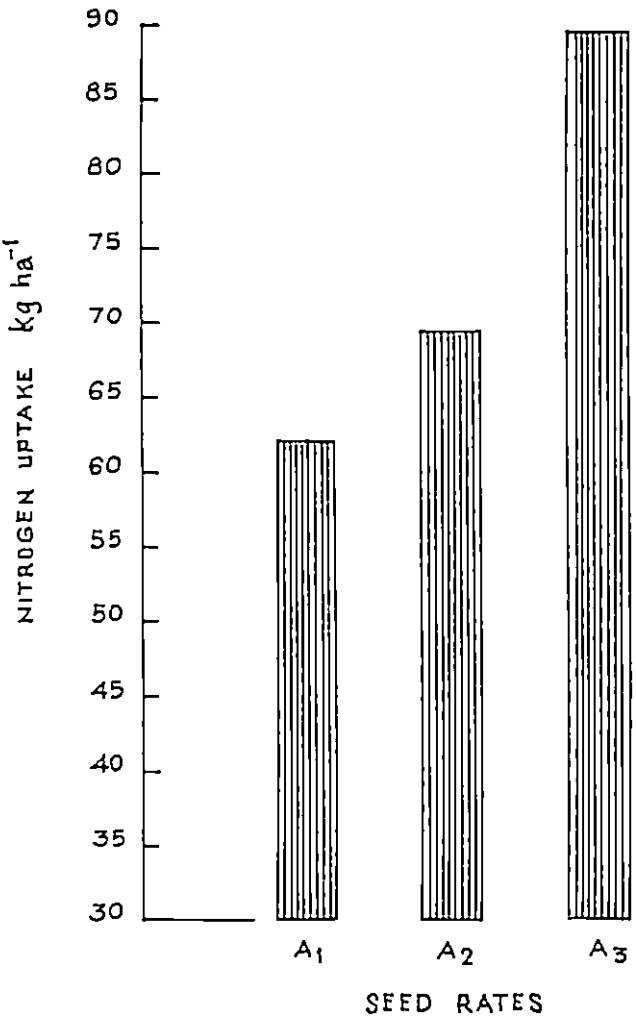


FIG. 6. NITROGEN UPTAKE AT HARVEST AS INFLUENCED BY SEED RATES.

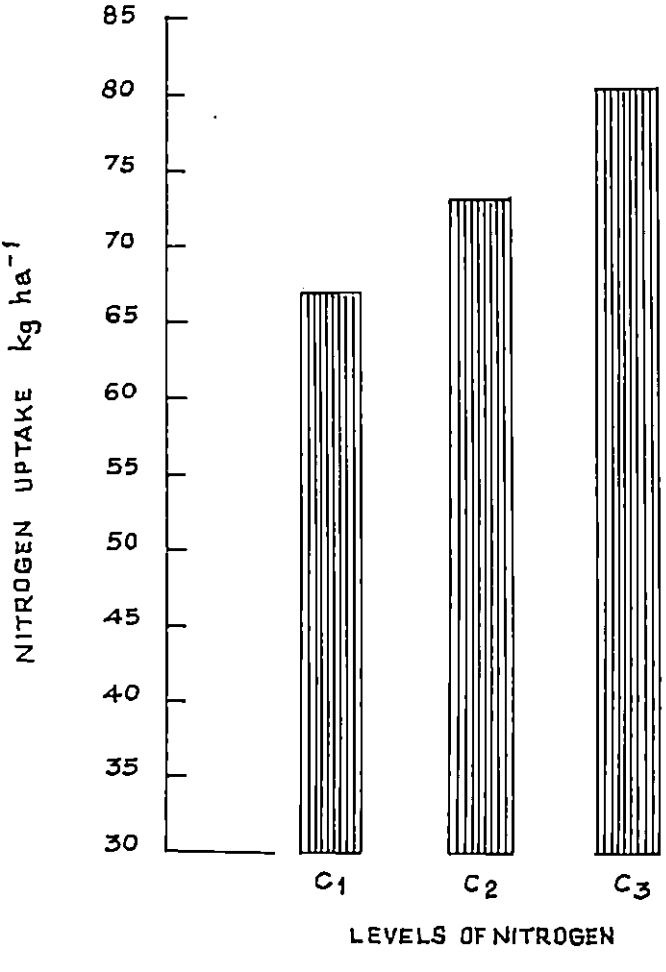


FIG.7. NITROGEN UPTAKE AT HARVEST AS INFLUENCED BY LEVELS OF NITROGEN.

slower absorption of nitrogen in the initial stages of crop growth. Ramkumar reddy et al. (1978) reported that nitrogen uptake increased with increased rate of seeding. Verma (1972) pointed out that nitrogen uptake increased with decreased seed rate explaining that greater feeding zone available perclumb possibly affected the uptake and affected translocation of nutrients. There was numerical increase of nitrogen uptake by "pinch" method though the increase was not statistically significant. Studies at C.R.R.I., Cuttack (1984) indicated that better uptake of nitrogen was recorded from sowing of FYM coated seeds dibbled than uncoated seeds broadcasted. This is in confirmity with the present finding.

The nitrogen uptake was not altered by the levels of nitrogen. But the uptake was found to increase with levels of nitrogen at harvest. At harvest highest level of 90 kg ha^{-1} recorded highest uptake value of 80.3 kg ha^{-1}. According to Abraham (1976) nitrogen levels exerted profound influence on nitrogen uptake by Triveni and found that nitrogen uptake pattern showed an increasing trend from maximum tillering to harvest. Gopalaswamy (1977) reported that increase in the rate of applied nitrogen from 0 to 200 kg ha^{-1} produced linear increase in the uptake of nitrogen. Sivappah et al (1969), Rai and Murthy (1979), Sushamakumari (1981), Rao (1983), Surendran (1985) have also reported similar results.

IV.2 Nitrogen content of soil experiment

The results obtained revealed that various treatments

did not alter the residual nitrogen content of the soil after the experiment. This indicates that some quantity of the applied and soil nitrogen was absorbed by the plants and the rest of the soil nitrogen and applied nitrogen might have lost by various means like leaching etc.

SUMMARY

VI SUMMARY

A trial was undertaken at the Instructional farm, College of Agriculture, Vellayani in Trivandrum District during the viruppu season (first crop) of 1986-87 to study the merits and demerits of an age old local practice of "pinch" method of sowing rice in certain specific locations of the state, over the common broadcast method of sowing in puddled soil. The cultivar used for the investigation was Triveni, a short duration photoinsensitive variety evolved at the Central Rice Research Station, Pattambi of the Kerala Agricultural University. The treatments included three rates of seeding (60, 90 and 120 kg ha^{-1}) two methods of sowing ("Broadcast" and "pinch" methods) and three levels of nitrogen (50, 70 and 90 kg ha^{-1}). The experiment was laid out as 3x2x3 split plot experiment in Randimised Block Design with three replications. The results of the study are summarised below:

1. The different rates of seeding significantly influenced the crop establishment per unit area. The crop establishment was found to be higher for broadcast method of sowing. The levels of nitrogen tried in the experiment did not influence crop establishment.

2. The various treatment studied in the trial viz. rates of sowing, method of sowing and levels of nitrogen did not influence plant height at any stages of growth. The plant height is more a genetical phenomenon than influenced by external factors.

3. The number of tillers produced increased significantly with increased seed rates from 60 to 90 kg ha^{-1}. The methods of sowing did not influence the tiller production. The number of tillers produced at the incremental levels of applied nitrogen was linear though the effect due to nitrogen at 90 and 70 kg ha^{-1} was on par.

4. The leaf area index was not influenced by the various treatments.

5. An increase in seed rate from 60 to 120 kg ha^{-1} gave a progressive and significant increase in dry matter production at all stages of growth. But the dry matter production was not altered by method of sowing. However dry matter production was significantly influenced by increments of applied nitrogen and it was evidenced at the flowering and harvest stages only.

6. The most important yield attribute viz. the number of productive tillers per unit area increased with increase in seed rate up to 90 kg ha^{-1}. With higher sowing rate of 120 kg ha^{-1} the effect was quadratic. Similarly highest tiller production was observed with highest level of nitrogen 90 kg ha^{-1} applied. Of the methods of sowing, the pinch method produced more number of productive tillers numerically, though it was not statistically significant over broadcasting.

7. The other yield attribute such as spikelets/panicle, length of panicle, percentage of unfilled grains

and thousand grain weight were not influenced significantly by the treatment viz. seed rates, methods of sowing and nitrogen levels.

8. Increased rate of seeding decreased the mean weight of panicle. Highest panicle weight (2.02g) was obtained with lowest seed rate (60 kg ha^{-1}). The weight progressively decreased to 1.33 g for the highest seed rate of 120 kg ha^{-1}. The weight of panicle progressively increased with incremental levels of nitrogen. But the difference between the levels was not significant. The methods of sowing also showed no significant influence on the panicle weight.

9. Enhancement of seed rate enhanced grain production. An increase in rate of seeding progressively increased grain yield. Although highest grain production was registered with highest rate of seeding viz. 120 kg ha^{-1} tried in the experiment, it was on par with grain yield obtained with 90 kg ha^{-1}. Enhancing rate of seeding by 30 kg ha^{-1} from 60 to 90 kg ha^{-1} increased grain yield by about 28%. Grain yield was not changed either by the methods of sowing or levels of nitrogen.

10. An increase in seed rate increased the straw yield progressively, highest straw production (6688 kg ha^{-1}) was obtained with highest seed rate (120 kg ha^{-1}) and lowest with lowest seed rate (4923 kg ha^{-1}). But the difference between the highest rates viz. 90 and 120 kg ha^{-1} was not significant. Highest straw production was obtained with broadcast method. But the difference between broadcast and pinch method was not significant. Successive increment of nitrogen from 50 kg ha^{-1}

brought about a progressive increase in straw yield but the increase between levels was not significant.

11. The influence of various treatments on the harvest index was not significant.

12. Nitrogen uptake was significantly influenced by seed rate. Nitrogen uptake increased with increase in seed rate. The methods of sowing did not influence nitrogen uptake. The nitrogen levels showed significant influence on the nitrogen uptake. At harvest highest value was recorded as 80.3 kg ha^{-1} with 90 kg N ha^{-1}.

13. Nitrogen content of the soil after experiment was not influenced significantly by the various treatments.

14. For economical rice production in Triveni variety of rice, 90 kg ha^{-1} seed rate and 50 kg ha^{-1}_{N} in broadcast in puddled soil were found to be optimum.

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APPENDICES

APPENDIX I

Weather data during the cropping period (June-Oct. 1986)

Standard week number	Date	Rain-fall	Temperature Max.	Temperature Min.	Relative humidity(%)
2 June	8-14	70.1	31.21	22.96	79.86
3 June	15-21	83.8	30.25	22.69	85.21
4 June	22-28	23.6	30.24	23.25	81.57
5 June	29-5	--	30.74	22.99	80.93
6 July	6-12	10.6	31.21	22.25	80.29
7 July	13-19	69.4	30.7	23.36	82.86
8 July	20-26	14.4	31.3	22.81	75.50
9 July	27-2	11.6	31.17	21.9	76.93
10 August	3-9	337.4	28.51	22.99	83.29
11 August	10-16	111.9	29.51	22.11	75.93
12 August	17-23	--	31.25	23.00	71.00
13 August	24-30	--	31.44	23.00	69.07
14 August	31-6	3.6	31.72	21.17	73.64
15 Sept.	7-13	6.2	31.11	21.89	72.43
16 Sept.	14-20	52.4	30.91	22.42	76.21
17 Sept.	21-27	8.6	30.38	22.27	73.29
18 Sept.	28-4	42.4	29.87	22.98	69.43
19 October	5-11	7.0	30.59	22.59	79.10

APPENDIX II

Weather data during the last 25 years

Month	Rainfall mm	Temperature °C		Relative humidity (%)
		Max.	Min.	
January	34.62	30.93	22.46	79.88
February	36.00	31.34	22.87	82.05
March	35.00	32.17	24.00	81.36
April	89.16	32.27	25.02	83.29
May	197.70	30.42	24.92	85.07
June	292.20	29.72	23.95	85.13
July	220.90	29.77	23.46	87.18
August	138.63	30.12	23.22	86.02
September	150.28	29.70	23.36	85.77
October	264.14	29.91	23.76	87.41
November	208.05	30.66	23.81	86.97
December	71.85	30.00	23.26	84.28

APPENDIX III

Average value of various observations

No.	Treatments	Crop.establishment (number/m^2)			
		3 DAS	5 DAS	7 DAS	9 DAS
1	a_1 b_1 c_1	11.67	15.27	18.10	23.25
2	a_1 b_1 c_2	11.22	16.83	20.41	25.45
3	a_1 b_1 c_3	13.51	16.54	18.98	24.44
4	a_1 b_2 c_1	5.87	9.34	12.90	16.21
5	a_1 b_2 c_2	6.90	9.75	16.40	20.78
6	a_1 b_2 c_3	4.43	6.44	8.98	11.15
7	a_2 b_1 c_1	11.69	15.13	18.79	24.28
8	a_2 b_1 c_2	16.66	18.59	23.82	29.28
9	a_2 b_1 c_3	12.76	16.59	22.03	25.10
10	a_2 b_2 c_1	6.12	8.38	12.23	22.95
11	a_2 b_2 c_2	4.26	8.14	15.05	21.82
12	a_2 b_2 c_3	5.37	10.08	18.11	24.09
13	a_3 b_1 c_1	13.61	17.78	23.94	28.62
14	a_3 b_1 c_2	15.77	21.42	24.40	27.34
15	a_3 b_1 c_3	12.14	17.05	22.30	27.22
16	a_3 b_2 c_1	7.01	12.59	20.27	26.33
17	a_3 b_2 c_2	6.10	9.79	16.27	23.48
18	a_3 b_2 c_3	7.54	11.97	19.96	24.67

APPENDIX IV

Average value of various observations

No.	Treatments	Height of plants at harvest (cm)	Number of tillers at 20 DAS	Number of tillers at 45 DAS	Number of tillers at 70 DAS
1	a_1 b_1 c_1	72.93	141.33	269.00	359.33
2	a_1 b_1 c_2	64.80	162.00	260.33	326.00
3	a_1 b_1 c_3	69.13	158.67	370.67	448.00
4	a_1 b_2 c_1	67.27	114.33	294.33	345.33
5	a_1 b_2 c_2	70.73	183.33	284.67	330.33
6	a_1 b_2 c_3	67.97	163.67	277.00	331.00
7	a_2 b_1 c_1	67.87	236.67	336.00	396.33
8	a_2 b_1 c_2	65.87	197.67	311.33	347.67
9	a_2 b_1 c_3	69.80	240.00	487.67	563.33
10	a_2 b_2 c_1	67.73	287.33	413.33	491.33
11	a_2 b_2 c_2	65.87	130.00	271.00	324.00
12	a_2 b_2 c_3	73.93	285.00	571.00	682.67
13	a_3 b_1 c_1	67.53	177.00	400.33	484.67
14	a_3 b_1 c_2	67.70	156.67	312.33	378.67
15	a_3 b_1 c_3	67.93	177.00	381.33	467.33
16	a_3 b_2 c_1	73.53	170.33	342.67	421.67
17	a_3 b_2 c_2	69.20	160.67	333.33	392.00
18	a_3 b_2 c_3	67.20	161.33	373.33	443.33

APPENDIX V

Average value of various observations

No.	Treatments	Dry matter production at harvest (kg)	LAI at flowering	Number of productive tillers/ m^2	No.of spikeletes per panicle
1	a_1 b_1 c_1	7250	4.62	209.67	86.00
2	a_1 b_1 c_2	7250	4.69	139.33	82.67
3	a_1 b_1 c_3	6458	4.78	249.67	82.33
4	a_1 b_2 c_1	6055	4.48	205.67	78.00
5	a_1 b_2 c_2	6125	4.37	206.00	77.67
6	a_1 b_2 c_3	6125	4.05	217.33	71.67
7	a_2 b_1 c_1	6583	4.68	321.00	70.67
8	a_2 b_1 c_2	8208	5.04	247.33	64.33
9	a_2 b_1 c_3	7292	4.58	346.67	86.33
10	a_2 b_2 c_1	7500	4.32	341.33	83.67
11	a_2 b_2 c_2	9542	4.84	224.00	79.67
12	a_2 b_2 c_3	9333	4.79	465.33	88.00
13	a_3 b_1 c_1	7875	4.68	323.67	79.33
14	a_3 b_1 c_2	7292	4.59	243.67	87.33
15	a_3 b_1 c_3	10792	4.65	344.00	86.67
16	a_3 b_2 c_1	6792	5.04	289.33	84.33
17	a_3 b_2 c_2	7475	5.03	262.33	83.33
18	a_3 b_2 c_3	9718	4.61	332.00	76.00

APPENDIX VI

Average value of various observations

No.	Treatments	Length of panicle (cm)	Weight of panicle (g)	Percentage of unfilled grain	Thousand grain weight (g)
1	a_1 b_1 c_1	19.82	1.84	26.09	25.69
2	a_1 b_1 c_2	19.19	2.36	24.18	27.33
3	a_1 b_1 c_3	19.18	2.31	28.58	20.98
4	a_1 b_2 c_1	20.60	2.51	33.00	18.72
5	a_1 b_2 c_2	20.52	1.13	21.76	18.72
6	a_1 b_2 c_3	21.08	1.99	30.91	18.72
7	a_2 b_1 c_1	19.63	1.34	30.39	18.72
8	a_2 b_1 c_2	19.60	1.15	20.78	23.12
9	a_2 b_1 c_3	20.01	1.03	26.51	21.06
10	a_2 b_2 c_1	19.33	1.26	23.33	24.18
11	a_2 b_2 c_2	19.25	2.14	21.64	23.98
12	a_2 b_2 c_3	20.58	1.67	26.06	27.71
13	a_3 b_1 c_1	19.09	1.06	27.54	23.86
14	a_3 b_1 c_2	18.71	1.21	28.69	22.16
15	a_3 b_1 c_3	20.15	1.52	22.09	21.47
16	a_3 b_2 c_1	20.16	1.10	28.98	20.05
17	a_3 b_2 c_2	19.39	1.48	26.34	25.63
18	a_3 b_2 c_3	19.42	1.65	24.13	23.98

APPENDIX VII

Average value of various observations

No.	Treatments	Grain yield (kg)	Straw yield (kg)	Harvest index
1	a_1 b_1 c_1	3236	5897	0.35
2	a_1 b_1 c_2	2669	4641	0.36
3	a_1 b_1 c_3	3009	5296	0.36
4	a_1 b_2 c_1	2499	4477	0.35
5	a_1 b_2 c_2	2555	5241	0.33
6	a_1 b_2 c_3	2555	3986	0.39
7	a_2 b_1 c_1	3180	5441	0.37
8	a_2 b_1 c_2	3691	5733	0.38
9	a_2 b_1 c_3	3407	5897	0.36
10	a_2 b_2 c_1	3521	5296	0.40
11	a_2 b_2 c_2	3748	6279	0.38
12	a_2 b_2 c_3	3691	6716	0.35
13	a_3 b_1 c_1	3577	6224	0.36
14	a_3 b_1 c_2	3634	6607	0.35
15	a_3 b_1 c_3	4032	7371	0.35
16	a_3 b_2 c_1	3748	6770	0.36
17	a_3 b_2 c_2	3464	6497	0.36
18	a_3 b_2 c_3	3804	6661	0.36

APPENDIX VIII

Average value of various observations.

No.	Treatments	Net return (000 rupees)	Cost-benefit ratio
1	a_1 b_1 c_1	4.403	1.99
2	a_1 b_1 c_2	2.659	1.59
3	a_1 b_1 c_3	3.509	1.75
4	a_1 b_2 c_1	3.210	1.55
5	a_1 b_2 c_2	3.403	1.76
6	a_1 b_2 c_3	2.124	1.48
7	a_2 b_1 c_1	3.997	1.88
8	a_2 b_1 c_2	5.196	2.08
9	a_2 b_1 c_3	4.432	1.93
10	a_2 b_2 c_1	4.730	1.20
11	a_2 b_2 c_2	3.966	2.21
12	a_2 b_2 c_3	5.338	2.13
13	a_3 b_1 c_1	4.835	2.02
14	a_3 b_1 c_2	5.006	1.36
15	a_3 b_1 c_3	6.011	2.20
16	a_3 b_2 c_1	5.365	2.11
17	a_3 b_2 c_2	4.591	1.93
18	a_3 b_2 c_3	5.248	2.04

APPENDIX IX

Average values of various observations

No.	Treatments	N uptake at harvest (kg)	N content of soil after experiment (kg)
1	a_1 b_1 c_1	63.83	54.00
2	a_1 b_1 c_2	57.88	98.67
3	a_1 b_1 c_3	67.28	99.33
4	a_1 b_2 c_1	63.68	94.67
5	a_1 b_2 c_2	68.69	123.33
6	a_1 b_2 c_3	52.39	88.00
7	a_2 b_1 c_1	57.79	109.33
8	a_2 b_1 c_2	70.54	91.33
9	a_2 b_1 c_3	53.93	79.33
10	a_2 b_2 c_1	60.60	96.00
11	a_2 b_2 c_2	87.76	58.00
12	a_2 b_2 c_3	84.97	74.00
13	a_3 b_1 c_1	66.12	82.66
14	a_3 b_1 c_2	76.59	50.00
15	a_3 b_1 c_3	129.89	102.00
16	a_3 b_2 c_1	91.32	126.00
17	a_3 b_2 c_2	77.76	104.67
18	a_3 b_2 c_3	93.35	47.33

APPENDIX X

Abstract of Analysis of variance table on growth characters Crop.establishment (number/m^2)

Source	d.f	M.S.S.			
		3 DAS	5 DAS	7 DAS	9 DAS
Replication	2	29.43	39.96	216.90	347.40
Seed rate (A)	2	9.36	38.68	123.30	176.16
Methods of sowing (B)	1	713.22	787.38	460.55	315.31
Seed rate and Methods of sowing (A&B)	2	5.10	0.43	4.31	41.43
Error - I	10	15.97	12.06	19.80	43.23
Levels of nitrogen (C)	2	4.23	5.93	12.94	16.55
Methods of sowing & Levels of N (B x C)	2	9.07	16.49	4.39	5.65
Seed rate & Levels of N and methods of sowing	4	1.03	2.94	29.32	19.77
A&B&C	4	14.22	9.43	16.68	22.46
Error 2	24	5.78	8.30	13.66	16.29

APPENDIX XI

Abstract of Analysis of variance table on growth characters, Height of plant (cm) at different stages.

Source	d.f.	M.S.S:			
		20 DAS	45 DAS	70 DAS	Harvest
Replication	2	36.43	134.96	5.20	2.14
Seed rate (A)	2	12.02	65.06	14.48	0.58
Methods of sowing (B)	1	1.48	26.48	41.60	16.17
A & B	2	19.61	43.16	106.46	7.55
Error I	10	9.43	55.43	43.29	38.42
Levels of nitrogen (C)	2	3.59	68.85	0.03	25.07
B & C	2	0.49	15.35	35.15	6.98
A & C	4	5.10	21.09	10.83	26.80
A & B & C	4	3.29	71.39	44.30	35.40
Error-2	24	4.73	18.34	24.54	22.90

APPENDIX XII

Abstract of Analysis of variance table on growth character, number of tillers/m^2 at different stages of growth

Source	d.f	M.S.S.		
		20 DAS	45 DAS	70DAS
Replication	2	3659.06	9520.25	11088.00
Seed rate (A)	2	22816.38	51118.00	57537.50
Method of Sowing (B)	1	280.13	167.00	15.00
A & B	2	65.13	4519.00	14448.5
Error - I	10	2536.23	7088.60	8920.00
Levels of Nitrogen (C)	2	4789.63	59794.75	87628.00
B & C	2	874.88	513.00	199.50
A & C	4	7279.00	18846.13	26917.25
A&B&C	4	2504.69	8088.25	8591.75
Error - 2	24	3967.57	15714.44	21801.63

APPENDIX XIII

Abstract of Analysis of variance on growth characters, Dry matter production (kg/ha) at different stages and Leaf Area Index at flowering (LAI)

Source	d.f	M S S				
		LAI at flowering	Dry matter production			
			20 DAS	45 DAS	70 DAS	Harvest
Replication	2	7.14	142746.0	3248768.0	5986432.0	518144.0
Seed rates(A)	2	0.35	92432.0	4857216.0	1.8	2.1
Methods of sowing (B)	1	0.10	198500.0	2604800.0	1457280.0	462080.0
A & B	2	0.49	53606.0	781952.0	1392768.0	6133888.0
Error -I	10	0.23	34749.6	880307.2	2191770.0	171315.2
Levels of Nitrogen (C)	2	0.15	872.0	143552.0	1689536.0	4174080.0
B & C	2	0.03	21164.0	556384.0	2143360.0	9984.0
A & C	4	0.13	19457.0	568480.0	1107840.0	7124224.0
A&B&C	4	0.17	42622.0	1726464.0	2445888.0	1168960.0
Error-2	24	0.13	29510.3	633528.0	1170069.0	176597.3

APPENDIX XIV

Abstract of Analysis of variance on yield components of rice.

Source	d.f	M S S		
		Productice tillers number/m^2	Length of panicle (cm)	Weight of panicle (g)
Replication	2	5170.3	1.09	7.35
Seed rate (A)	2	71817.00	1.53	2.49
Method of sowing (B)	1	2360.0	4.05	0.21
A&B	2	2596.5	2.23	0.74
Error - I	10	5609.9	2.65	8.89
Levels of N (C)	2	50329.0	1.76	0.14
B&C	2	1268.0	2.93	4.67
A&C	4	5010.0	0.36	0.40
A&B&C	4	5793.0	1.12	0.88
Error -2	24	11995.6	1.62	8.80

APPENDIX XIV(a)

Abstract of Analysis of variance on yield components of rice.

Source	d.f	M S S		
		Number of spikelets/ panicle	Percentage of unfilled grain	Thousand grain weight (g)
Replication	2	229.06	77.06	2.14
Seed rate (A)	2	81.06	31.34	10.47
Method of sowing (B)	1	1.84	0.29	1.22
A&B	2	387.47	22.83	122.19
Error - I	10	75.23	97.50	4.39
Levels of N(C)	2	32.17	84.65	12.59
B&C	2	130.80	7.93	22.95
A&C	4	195.72	54.47	11.58
A&B&C	4	27.07	30.16	15.42
Error - 2	24	74.29	31.37	6.67

APPENDIX XV

Abstract of Analysis of variance on yield of rice, grain yield (kg/ha) straw yield (kg/ha) Harvest index

Source	d.f.	M.S.S. Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest Index.
Replication	2	745248.0	1.0	1.10
Seed rates (A)	2	4678752.0	1.4	1.67
Methods of sowing (B)	1	120832.0	233088.0	1.85
A & B	2	495008.0	1408064.0	2.46
Error-I	10	186659.2	1187955.0	1.29
Levels of N(C)	2	90688.0	414720.0	5.01
B&C	2	4928.0	772416.0	6.36
A&C	4	215008.0	948704.0	1.21
A&B&C	4	122448.0	1062816.0	7.49
Error-2	24	337207.7	1077248.0	1.02

APPENDIX XVI

Abstract of Analysis of variance table on economics of rice production ('000 rupees)

Source	d.f	Economic of rice production	
		Net return	Cost-benefit ratio
Replication	2	7052192	0.2724762
Seed rate (A)	2	1.826192	0.3476257
Methods of sowing (B)	1	718912	2.896118
A&B	2	628000	0.1558228
Error-I	10	48172.8	0.1067551
Levels of N (C)	2	528576	8.339691
B&C	2	233696	0.4616776
A&C	4	1283488	0.4894715
A&B&C	4	2316240	0.1310158
Error-2	24	1966771	0.2167842

APPENDIX XVII

Abstract of Analysis of variance table on N uptake (kg ha^{-1}) at different stages of growth, and N content of soil after experiment (kg ha^{-1})

Source	d.f	M.S.S.				
		20 DAS	45 DAS	70 DAS	HARVEST	N content of soil after experiment
Replication	2	98.02	917.59	1287.66	25.13	2109.84
Seed rate (A)	2	60.11	1814.95	4723.28	3502.13	381.41
Method of sowing (B)	1	138.28	5.70	177.97	223.91	342.50
A&B	2	44.54	122.88	263.13	570.38	1703.19
Error-I	10	32.85	173.53	198.02	47.8	489.85
Levels of Nitrogen (C)	2	3.11	38.88	270.22	771.81	660.06
B&C	2	15.58	363.18	625.55	399.20	2878.31
A&C	4	10.15	244.30	277.73	1062.40	2219.41
A&B&C	4	48.14	467.07	1140.15	801.05	1959.63
Error-2	24	23.83	137.13	224.91	55.92	956.52

RESPONSE OF RICE TO METHODS OF SOWING UNDER VARYING SEED RATES AND LEVELS OF NITROGEN

By
ANIL KUMAR, N.K., B.Sc. (Ag.)

ABSTRACT OF THE THESIS
Submitted in partial fulfilment of the
requirement for the degree
MASTER OF SCIENCE IN AGRICULTURE
Faculty of Agriculture
Kerala Agricultural University

Department of Agronomy
COLLEGE OF AGRICULTURE
Vellayani – Trivandrum

1989

ABSTRACT

To find out advantages and disadvantages of a popular method of sowing rice viz. "pinch" method over common method of broadcast sowing of rice in puddled soil, an experiment was conducted at Instructional farm, college of Agriculture, Vellayani, Trivandrum District during the first crop season of 1986-87. The treatments consisted of three rates of sowing (60, 90 and 120 kg ha^{-1}) two methods of sowing (broadcast and pinch) and three levels of nitrogen (50, 70 and 90 kg ha^{-1}). The experiment was replicated thrice in split splot in Randomised Block Design. Triveni variety of rice was used for the experiment.

The establishment rate was highest with a seed rate of 120 kg ha^{-1} in broadcast method. The growth characters such as plant height and leaf area index were un affected by the treatments. Highest dry matter were obtained with highest seed rate and level of nitrogen. The maximum number of tillers were obtained with medium seeding rate of 90 kg ha^{-1} and a rate of 70 kg N ha^{-1} gave the tiller count similar to 90 kg ha^{-1}.

The spikelet number, length of panicle, thousand grain weight and percentage of unfilled grains were not altered by the treatments, but the weight of panicle was significantly influenced by seed rates. The number of productive tillers were altered by the rates of seeding and levels of nitrogen. Highest tiller count was recorded with

seed rate of 90 kg ha^{-1} and a nitrogen level of 90 kg ha^{-1}.

Grain and straw yield were highest with a seed rate of 90 kg ha^{-1}. The harvest index was not affected by the treatments.

Nitrogen uptake was highest with highest seed rate 120 kg ha^{-1}. The other treatments showed no effect on N uptake.

A seed rate of 90 kg ha^{-1} and a nitrogen level of 50 kg ha^{-1}_{N} in broadcast in puddled soil were found to be optimum in Triveni rice variety for economic rice production.

KERALA AGRICULTURAL UNIVERSITY

No.Agr.5/89

College of Agriculture,
Vellayani - 695 522,
Dated 18.10.1989

From

Dr.K. Pushpangadan,
Professor of Agronomy,
Chairman, Advisory Committee

To

The Registrar,
Kerala Agrl. University,
Vellanikkara, Trichur.

Sir,

Sub:- M.Sc.(Ag.) - Final Examination of Sri.N.K. Anilkumar (84-11-16) - copy of thesis - forwarded - reg.

Ref:- Acd.C2/84-11-16/89 dated 1.8.1989 of Registrar, KAU.

***

As per the reference cited above, the M.Sc.(Ag.) final examination of Sri.N.K. Anilkumar (84-11-16) was conducted on 18.10.1989. As per the regulation 34 e of the KAU Academic Hand Book, I am enclosing herewith a copy of the thesis entitled "Response of rice to methods of sowing under varying seed rates and levels of nitrogen" for favour of necessary action.

Yours faithfully,

(K PUSHPANGADAN) 18/10

Encl: One copy of the thesis mentioned above.