YIELD MAXIMISATION OF DIRECT SOWN RICE UNDER PUDDLED CONDITION

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VELLAYANI THIRUVANANTHAPURAM
1996

.... to the famishing millions of the world

DECLARATION

I hereby declare that this thesis entitled **Yield maximisation of direct sown rice under puddled condition** *is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree diploma associateship fellowship or other similar title of any other university or society*

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CERTIFICATE

Certified that this thesis entitled **Yield maximisation of direct sown rice under puddled condition** *is a record of research work done independently by Sri Sajith Babu D under my guidance and supervision and that it has not previously formed the basis for the award of any degree fellowship or associateship to him*

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CONTENTS

	Pages
INTRODUCTION	1
REVIEW OF LITERATURE	3
MATERIALS AND METHODS	16
RESULTS AND DISCUSSION	32
SUMMARY	66
REFERENCES	71
APPENDICES	79
ABSTRACT	81

LIST OF TABLES

Table	Title	Page
1	Physico chemical properties of soil at the experimental site	17
2(a)	Effect of treatment combinations on growth characters	33
2(b)	Effect of individual factors and levels on growth characters	"
3(a)	Effect of treatment combinations on growth attributing characters	37
3(b)	Effect of individual factors and levels on growth attributing characters	"
4(a)	Effect of treatment combinations on drymatter production and nutrient uptake at 45DAS	42
4(b)	Effect of individual factors and levels on dry matter production and nutrient uptake at 45DAS	"
5(a)	Effect of treatment combinations on pest and disease occurrence	45
5(b)	Effect of individual factors and levels on pest and disease occurence	"
6(a)	Effect of treatment combinations on yield attributing characters	47
6(b)	Effect of individual factors and levels on yield attributing characters	"
7(a)	Effect of treatment combinations on yield	52
7(b)	Effect of Individual factors and levels on yield	"
8(a)	Effect of treatment combinations on nutrient concentration of grain and straw and protein content of grain	59
8(b)	Effect of individual factors and levels on nutrient concentration of grain and straw and protein content of grain	"
9 (a)	Effect of treatment combinations on total nutrient uptake at harvest (kg/ha)	61
9(b)	Effect of individual factors and levels on total nutrient uptake at harvest (kg/ha)	"
10	Available soil nutrient status before and after the experimentation	64
11	Agronomic efficiency and Apparent recovery	"

LIST OF ILLUSTRATIONS

Figure	Description	Page
I	Weather data during the cropping period	19
II	Layout plan Randomised Block Design	21
III	Total N P and K uptake as influenced by various levels of individual factors at 45 DAS	43
IV	Total N P and K uptake as influenced by various levels of individual factors at harvest	62
V	Total drymatter production at harvest	57

LIST OF ABBREVIATIONS

a i	Active ingredient
cm	Centimetre
FYM	Farmyard manure
DAS	Days After Sowing
g	Gram
ha	Hectare
Kg	Kilogram
Kg ha 1	Kilogram per hectare
NPK	Nitrogen Phosphorus Potassium
m	Metre
m^2	Square metre
mg/g	Milligram per gram

Introduction

INTRODUCTION

Rice production scenario in India is at the cross roads today Eventhough we could achieve substantial increases in rice production it is now realised that such increases were only marginal when compared with several other rice growing nations of Asia Inspite of the large acreage of rice in India grain production hardly meet our requirement Low average yield of even the improved varieties grown in diverse agro-ecosystems is held responsible for this grim situation

In India it is estimated to produce an additional 75 million tonnes of food grams to sustain self sufficiency by 2000 A D for which the share of rice would be not less than 40 percent with an annual increase of 3 3 million tonnes With no scope for expansion of area under rice the vertical yield increments from the present national average of 1 5 t ha^{1} to 2 5 t ha^{1} is the only way to achieve targeted production (Siddiq 1990)

In Kerala the area under rice cultivation is decreasing day by day A reduction of about 28 percent in the rice growing area is noticed during the period of 1984 to 1995 However a marginal increase in productivity was noticed over these years With the present improved production strategies we could produce only about 30 percent of our requirement and the situation demands more and more intensification of rice cultivation in the state

Use of chemical fertilizers alone and at increased doses lead to soil ill health and subsequent decline in productivity Today it is a well established theory that sustainable production at higher levels become possible only when the factors leading to the continued maintenance of soil health are adequately taken care of Integration of locally available organic manures in rice crop nutrition in the range of 30 50% of the total nutrients not only substitutes the costly inorganic nitrogen to some extent but also restores the physico chemical properties of the soil (Siddiq 1991)

It is observed that high yielding varieties at present used are responding to higher levels of fertilizers than what is recommended in farmers fields Also the present seed rate of 100 kg ha^{1} is found to be inadequate for many shy tillering varieties Since the number of panicles is the most important yield attributing character it is worth to try a higher seed rate inorder to have adequate number of productive tillers in direct sown rice In order to maximise the yield level in wetland rice the present investigation is carried out with the objectives of studying the efficacy of organic manure in conjunction with the varymg doses of inorganic fertilizers under different seed rates in lowland direct sown rice

Review of Literature

REVIEW OF LITERATURE

There are a lot of constraints associated with the potential yield realisation in high yielding rice varieties Among them the declining soil productivity is the most important one By incorporation of organic manure along with chemical fertilizers soil productivity could be sustained It is also found that increased dose of chemical fertilizers found to enhance the yields of high yielding rice varieties Also the present seed rate of 100 kg ha ^{1} is found to be inadequate for many shy tillering varieties A brief review on the response of rice towards high yield by varying the fertilizer dose and plant population in the presence of adequate organic manure supply is presented in this chapter

2 1 Effect of seed rate

2 1 1 *Growth yield and quality of rice*

While investigating the effect of seed rate and variety on yield and growth of rice Ghosh and Reddy (1983) observed a progressive increase in number of tillers with increased seed rates Studies conducted at CRRI (1983) Cuttack revealed that increasing plant densities would increase rice yields A seed rate of 150 kg ha ^{1} seed rate produced more number of panicles per m^2 but less number of grains per panicle (Ghobrial 1983)

Increased seed rates over 100 kg ha^{-1} was found to produce sequential increase in occurrence of sheathblight in rice (Mithrasena and Adhikari 1986)

John *et al* (1990) reported that at high plant densities the incidence of pests like yellow stemborer brown plant hopper and gall midge were higher than lower plant densities

2 2 Effect of organic manure on soil productivity and rice yield

2 2 1 *Organic manure on soil characters*

The soil physical and chemical properties including bulk density resistance to penetration infiltration rate soil pH CEC etc were improved by FYM application (Ganal and Singh 1990)

Hernandez *et al* (1991) observed an increase in soil pH after the addition of FYM in greyish brown acid soils which was later confirmed by Varghese (1992) Lungu *et al* (1994) while investigating the effectiveness of both lime and FYM on reducing soil acidity found that lime had little effect on soil pH of acid Alfisol but FYM @ 10 t ha^{-1} increased top soil pH by about one unit

While investigating the residual effects of FYM and inorganic fertilizer application Rai *et al* (1991) found that similar effects were produced at inorganic fertilizer dose of 60 35 50 Kg NPK ha or 10 t ha[1] of FYM

Effect of continuous manuring on microbial population in rice soils was studied by Nanda *et al* (1991) and studies revealed that in laterite sandy soils of rice rice rotations bacteria were the important group of microbes followed by actinomycetes and fungi Varghese (1992) found that FYM application enhanced the natural occurrence of *Azolla pinnata* in rice fields

Toyota and Kimura (1992) opined that the number and percentage of antagonistic microorganisms among total microorganisms were higher in FYM amended soil than in chemical fertilizer amended soil John *et al* (1989 c) reported that the denitrification loss of applied nitrogen is not influenced by the addition of organic manure in the form of cowpea greenmanure in wetseeded rice

2 2 2 *On nutrient status of soil*

Application of FYM @ 60kg N ha[1] increased rice yield by 37 percent in the absence of urea nitrogen (Maskina *et al* 1988) Chellamuthu *et al* (1989) observed an increase in the organic carbon available nitrogen and phosphorus of soil by FYM application The increase in total nitrogen content from 0 045 to 0 074 percent was also noticed

Soni and Sehgal (1989) suggested the application of potassium and phosphorus along with FYM during every second growing season for rice rice cropping sequences Ganal and Singh (1990) observed an increased level of available potassium after FYM addition

According to Rai *et al* (1991) it is possible to increase the organic carbon available phosphorus available pottasium soil calcium content etc by FYM application Similar results were also reported by Hernandez *et al* (1991) Dhargawe *et al* (1992) reported an increase in available phosphorus by the addition of 10 to 20 t FYM per hectare

2 2 3 *Nutrient substitution by organic manure*

Application of 30 Kg N ha^{1} in the form of FYM at puddling and 30 Kg N ha^{1} as urea at planting gave maximum grain yield comparable to that of 60 Kg N ha^{1} as urea applied in three splits (Khan *et al* 1988) While carrying out investigation on the relative effeciency of different organic materials and nitrogen fertilizers in wetland rice Chandrakar (1990) observed that 8 t ha^{1} of FYM and 40 Kg N as urea had same effect on yield as urea at 80 Kg ha^{1}

Reddy and Panda (1985) found that higher seed rates ensured good plant stand during the initial periods of rice crop

Jones and Snyder (1987) reported that increased sowing rates increased the number of panicles per m^2 Increase in seed rates from 80 to 120 kg ha^{-1} improved the growth and yield attributes The increase in grain yield by 120 kg seeds per hectare was 3 8% and 21 6% over 100 and 80 kg seeds per hectare respectively (Om Prakash Singh and Gajendra Singh 1990)

Karim *et al* (1992) observed that qualities like 1000 grain weight cooked grain length total milling recovery head rice recovery and protein content found to decrease with increase in plant density

Srivasthava and Thripathi (1993) opined that at seed rates of 100 kg ha^{-1} the weed population was reduced to the minimum and both grain and straw yields were increased as the number of effective tillers per squaremetre was high

According to Surendra Reddy and Bucha Reddy (1994) even though the grain yield per hill was low the per hectare yield was high with enhanced seed rates

Verma (1991) suggested incroporation of FYM for saving 50 percent of inorganic fertilizers in paddy crop In an experiment conducted at Ludhiana P A U Yandivar singh *et al* (1991) observed FYM @ 12 t ha^{-1} could substitute for about 40 kg N ha^{-1} as urea

Malik and Jaiswal (1993) in an experiment on integrated use of organic and inorganic nitrogen sources found that equal grain yield of rice was obtained when 58 Kg N ha^{-1} was applied as urea alone and half dose as prilled urea and half the dose as FYM It was concluded that half to two thirds of chemical nitrogen could be subtituted by fYM without any yield loss

2 2 4 *Combined use of organics and inorganics on rice nutrition*

FYM found to increase the yield of rice with graded levels and maximum yield of 6 7 t ha^{-1} was obtained when FYM was applied @ 40 t ha (Brar and Dhillon 1989) A similar increasing trend was also observed by Ohyama (1989) as average yields over a period of 20 years were increased to 6 0 and 6 6 t ha^{-1} with addition of 20 and 40 t ha^{-1} FYM respectively over 5 2 t ha^{-1} when no FYM was applied

According to Kobayashi *et al* (1989) eventhough number of grains per ear was high with application of 10 t ha^{-1} of FYM alone the highest yield of 5 92 t ha^{-1} was obtained when 10 t FYM ha^{-1} was applied along with 80 80 80 Kg NPK ha^{-1}

An increase in number of panicles per m^2 spikelets per panicle percentage of filled grains and 1000 grain weight were noticed with increasing N P and K rates and FYM application (Mondal *et al* 1990) Similar results were also observed by Prakash *et al* (1989) as field trials with 0 or 20 Kg N ha^{-1} and 0 10 or 20 t FYM ha^{-1} the highest mean rice yield was noticed in plots receiving 20 Kg N ha and 20 t FYM ha^{-1}

Sharma *et al* (1991) found an increase in yield and N P and K uptake with chemical fertilizers and FYM application at 5 t ha^{-1} In an economic analysis of organic and inorganic fertilizer combinations Tahir Hussain *et al* (1991) found the highest value of input cost for the application of 10 t FYM ha^{-1} alone than the combined application of N P and K at 60 40 30 Kg ha^{-1} and FYM at 5 t ha^{-1}

Verma (1991) pointed out a significant increase in yield with each increment in the incorporation of FYM at 50 percent and 100 percent of recommended NPK rates Banerjee *et al* (1992) obtained highest yield by the application of 10 t FYM ha^{-1} at transplanting and 10 Kg N ha^{-1} as urea at tillering and flowering stages

Varghese (1992) observed highest rice yields by the application of 80 Kg nitrogen as FYM Pooled analysis of grain yield data for 25 years generated from a permanent manurial trial indicated an yield increase of 7 6 percent by the combined application of FYM and NPK than application of NPK alone (Anila kumar *et al* 1993)

According to Sharma (1994) by the application of FYM @ 10 t ha one week prior to sowing of rice the dry weight of the plants and tiller count were increased A yield increase of over 26 percent was also noticed

2 3 Effect of inorganic fertilizers on growth and yield of rice

2 3 1 *Nitrogen*

Among the five fertilizer doses of nitrogen (0 40 80 120 and 160 Kg N ha^{-1}) tested Syed Nazeer Peeran and Anandan (1983) found the dose of 120 Kg N ha^{-1} as the best in increasing yields Thind *et al* (1983) observed a response of 180 kg N ha^{-1} applied in three splits for rice variety IR 8 in yield increase

Kaushik *et al* (1984) reported that rice plant respond ed up to 120 Kg N ha^{-1} both in the presence and absence of FYM According to Reddy (1986) increasing rates of nitrogen application to rice Cv Jaya from 0 to 180 Kg ha^{-1} increased number of tillers per hill number of filled grains per panicle and 1000 grain weight Grain and straw yields were increased from 6 99 to 8 26 t ha^{-1} and 8 91 to 11 14 t ha^{-1} respectively

Reddy and Reddy (1986) opined that increasing nitrogen rates from 40 to 80 and to 120 Kg ha^{-1} increased average paddy yields from 4 62 to 5 38 and to 5 79 t ha^{-1} respectively showing a linear response to increased doses of nitrogen fertilizers Thorat and Patil (1986) observed highest rice yields at 120 Kg ha of nitrogen

Maskina *et al* (1987) reported that the varieties PR 106 PR 108 and PR 109 responded up to 150 Kg N ha^{-1} Bacon and Heenan (1987) observed a linear response by the addition of 0 70 and 140 Kg N ha^{-1} and found that addition of each 70 Kg nitrogen increased yield by about 1 8 t ha^{-1} Yang *et al* (1987) opined that an increase of 1 Kg nitrogen increase grain yield by about 19 Kg Chavan *et al* (1989) found low grain staw ratio with increased nitrogen application rates Thakur (1989) observed a linear increase in yield by addition of 0 to 120 Kg N ha^{-1}

Number of panicles per m^2 and spikelets per panicle are increased with increase in nitrogen aplication rate (Sharma *et al* 1991) According to Singh and Bajpai (1990) paddy crop yields best at 100 Kg N ha^{-1}

Tomar and Verma (1990) observed a yield enhancement of 50% with 120 kg N ha^{-1} Pandey and Thripathy (1994) also observed high yields at 120 Kg N ha^{-1} Singh *et al* (1992) observed a significant increase in grain yield and chlorophyll content up to 150 Kg N ha^{-1} application

Ho (1983) found an increased occurrence of deadheart and white earheads in plots receiving increased dose of nitrogen fertilizers Similar trend was noticed by Saroja *et al*

(1987) John *et al* (1990) while studying the effect of increased N application on pest incidence observed that at high N application rates (120 kg or more) the plant become susceptible to many rice pests Similar results were also observed by Swaminathan *et al* (1995)

2 3 2 *Phosphorus*

Heenan and Batten (1986) observed a significant response to applied phosphorus only upto 20 kg P_2O_5 ha in terms of growth and grain yield of rice when superphosphate was applied in graded doses upto 40 kg P_2O_5 ha ^{1} However Patel *et al* (1986) reported a response upto 60 kg P_2O_5 ha ^{1} with grain yield increase from 3 44 to 3 97 t ha ^{1} While investigating the effect of rates and sources of phosphorus on wetland rice Latchanna *et al* (1989) obtained linear yield increase by the application of 20 to 80 Kg P_2O_5 ha ^{1}

Subbian *et al* (1989) observed increased NPK uptake with increased rates of phosphorus application Linear yield increases were also observed from 30 to 90 Kg P_2O_5 ha ^{1} Application of 0 40 or 80 Kg P_2O_5 ha ^{1} gave yields of 3 53 3 86 and 4 00 t ha ^{1} respectively (Singh and Bajpai 1990)

2 3 3 *Potassium*

Purohit *et al* (1986) noticed highest grain yield and net profit by the application of 80 Kg K_2O ha^{-1} Grain and straw yields were increased with increased potassium levels and highest yield obtained with 99 Kg K ha^{-1} (Singh and Singh 1987) Singh and Patiram (1987) reported that in creasing levels of potassium up to 150 Kg ha^{-1}would significantly increase the rice yield

Sakeema and Salam (1989) observed linear yield increase by the application of 17 5 to 70 Kg K_2O ha^{-1} A similar trend by the application of 30 to 90 Kg K_2O ha^{-1} was observed by Patiram and Basad (1989)

Increased rates of potassium application increased paddy yields availability of soil potassium and number of tillers per hill (Krishnappa *et al* 1990) Similar results were also noticed by Kurmi and Das (1993)

Responses of rice crop up to 300 Kg K_2O ha^{-1} was observed by Russo (1990) John *et al* (1980) observed that at high rates of potassium application there was substantial reduction in yellow stemborer infestation

2 3 4 *Fertilizer mixtures*

Lopez *et al* (1985) observed highest grain yield by the application of 156 Kg N 99 Kg P_2O_5 and 93 Kg K_2O per hectare Mondal *et al* (1987) found that increasing rates of nitrogen and/or potassium from 40 to 160 Kg ha^{-1} increased the number of panicles per m^2 percentage of filled grains and 1000 grain weight

The maximum grain yields were obtained by the application of 80 60 40 Kg NPK ha^{-1}(Thalukdar and Charkravarthy 1988) and 120 80 60 Kg NPK ha (Dwivedi and Patel 1988)

Duhan *et al* (1989) observed highest grain yields with recommended NPK rate of 120 60 60 Kg ha^{-1} and 75 and 50 percent reduction in the recommended rate caused 1 25 and 0 63 t ha^{-1} reduction in grain yield respectively

Rajkhowa and Baroova (1991) opined that rice rice is an exhaustive crop sequence and any reduction in the recommended dose of fertilizers may reduce the yield of rice crop

While investigating the efficiency of N K combination on nutrient uptake and productivity of IR 50 rice with varying population Balasubramaniyan and Palaniappan (1992) observed highest grain yield with 150 Kg N and 50 Kg K_2O ha^{-1} Among the two levels 100 50 50 and 150 75 75 Kg NPK ha[1] the latter one increased the yield of IR 64 rice signifi cantly (Channabasavanna and Shetty 1993)

The incidence of stemborer was moderate at 1 1 N K ratio (John *et al* 1990) With regard to herbivory high N or high N K ratio often stimulated insect pests in rice (Porrenoud 1976)

Materials and Methods

MATERIALS AND METHODS

An investigation was carried out with the objective of studying the effect of combined use of organic and inorganic fertilizers under different plant populations for enhancing rice yield in the lowlands of Kuttanad

The experiment was conducted during the additional crop season from June to September in 1995 The details of materials and methods adopted for the study are given below

3 1 MATERIALS

3 1 1 *Experimental site*

The experiment was conducted at Rice Research Station Moncompu The station is located at 9 5 N latitude and 76°5 E longitude and at an altitude of 1 0 m below mean sea level

3 1 2 *Soil*

The soil of the experimental site was silty clay in texture The important physico chemical properties of the soils of experimental site are given in Table 1

Table 1 Physico Chemical properties of soil at the experimental site

A Mechanical Composition

Particulars	Percentage	Method
Sand Silt Clay	42 0 20 6 30 6	Bouyoucos Hydrometer method [Bouyoucos 1962]

B Chemical Properties

Constituent	Content	Rating	Method used
Available N (kg ha⁻¹)	238	Low	Alkaline $KMnO_4$ (Subbaih and Asija 1956)
Available P205 (kg ha⁻¹)	25	Medium	Vanadomolybdo phosphoric yellow colour method (Jackson 1973)
Available K20 (kg ha⁻¹)	160	Medium	Ammonium acetate method (Jackson 1973)
Organic Carbon (%)	1 68	High	Walkley Black rapid titration method (Jackson 1973)
pH	5 5	Acidic	1 2 5 soil solution ratio using pH meter with glass electrode (Jackson 1973)

3 1 3 *Cropping history of the field*

The field was continuously cultivated with rice for two seasons per year in the previous years During the previous season a bulk crop of punja rice was raised

3 1 4 *Season*

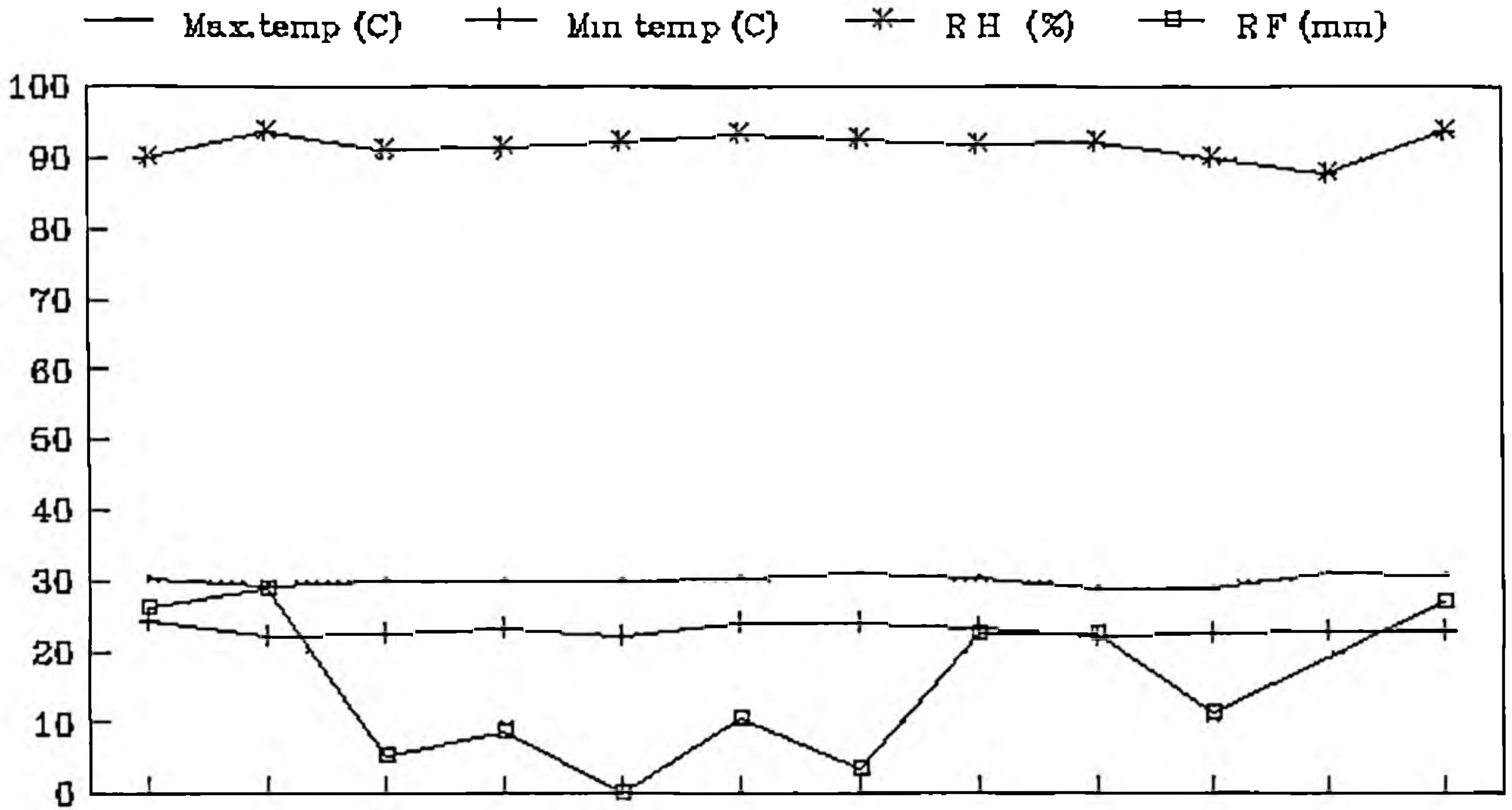
The experiment was conducted during the additional crop season coinciding with the Kharif season of 1995

3 1 5 *Weather conditions*

The location where the experiment was carried out enjoys a humid tropical climate The data on various weather parameters are graphically represented in Figure I and details are given in Appendix I

The mean maximum and mean minimum temperature during the cropping period ranged from 28 7°C to 31 2°C and 22 1 C to 24 5°C respectively The mean relative humidity ranged from 90 14 to 93 57 percent The total rainfall received during the cropping season was 167 03 mm

Fig.1 Weather Data during the Cropping Period



Standard week starting from 29-6-'96
to
20-9-'96

3 1 6 *Seed material*

The variety used for the experiment was MO 6 (Pavizham) released from Rice Research Station Moncompu which is a cross between 1R 8 and Karivennel Pavizham is a medium duration variety recommended for Kuttanad rice tracts which posses some important qualities like resistance to shattering easy to thresh fairly resistant to BPH and sheathblight It is moderately resistant to stack burn and sheathrot also

3 1 7 *Manures and fertilizers*

Dry cowdung containing 0 4% N 0 2% P_2O_5 and 0 4% K_2O was used as FYM N P and K were applied as urea (containing 46% N) Mussoriephos (22% P_2O_5) and Muriate of potash (60% K_2O)

3 2 METHODS

3 2 1 *Design and layout*

Factorial combination of two levels of FYM three levels of fertilizers and two seed rates were tried in Randomised Block Design The experiment altogether comprised of 12 treatments replicated three times The layout plan of the experiment is given in Figure II

$S_2F_0O_1$	$S_2F_1O_1$	$S_2F_0O_1$
$S_2F_0O_0$	$S_1F_0O_0$	$S_1F_1O_1$
$S_1F_0O_1$	$S_1F_1O_0$	$S_1F_2O_0$
$S_1F_2O_1$	$S_2F_2O_0$	$S_2F_2O_1$
$S_1F_0O_0$	$S_1F_2O_0$	$S_2F_0O_0$
$S_2F_2O_1$	$S_2F_1O_0$	$S_1F_2O_1$
$S_1F_2O_0$	$S_1F_0O_1$	$S_1F_1O_0$
$S_1F_1O_1$	$S_2F_0O_0$	$S_1F_0O_0$
$S_2F_2O_0$	$S_2F_2O_1$	$S_2F_1O_0$
$S_1F_1O_0$	$S_1F_1O_1$	$S_1F_0O_1$
$S_2F_1O_0$	$S_1F_2O_1$	$S_2F_2O_0$

Gross plot size
5 0x4 0 m
Net plot s ze
4 6x3 6 m

Seedrates

S_1 - 100 Kg ha ^{1}

S_2 - 133 Kg ha ^{1}

Organic manure

O_0 - 0 t ha ^{1}

O_1 - 10 t ha ^{1}

Chemical fertilizers

F_0 - 0 0 0 Kg NPK ha ^{1}

F_1 90 45 45 Kg NPK ha $^{-1}$

F2 120 60 60 Kg NPK ha ^{1}

3 2 2 *Treatments*

FACTORS AND LEVELS

Organic manure	Oo	0 t ha ^{1}
	01	10 t ha ^{1}
Seed rates	So	Normal plant stand 100 Kg ha ^{1}
	S1	Extra plant stand 133 Kg ha ^{1}
Chemical fertilizers		
	Fo	No chemical fertilizers
	F1	Fertilizer dose as per package of practices recommendation (90 45 45 Kg NPK ha ^{1})
	F2	33% increase over the package of practices recommendation (120 60 60 Kg NPK ha ^{1})

TREATMENT DETAILS

T_1 Normal plant stand without chemical fertilizer and without organic manure

T_2 33% extra plant stand without chemical fertilizer and without organic manure

T_3 Normal plant stand with normal fertilizer dose and without organic manure

T_4 33% Extra plant stand with normal fertilizer dose and without organic manure

T_5 Normal plant stand with 33% extra fertilizer dose and without organic manure

T_6 33% extra plant stand with 33% extra fertilizer dose and without organic manure

T_7 Normal plant stand without chemical fertilizer and with organic manure

T_8 33% extra plant stand without chemical fertilizer and with organic manure

T_9 Normal plant stand with normal fertilizer dose and organic manure

T_{10} 33% extra plant stand with normal fertilizer dose and organic manure

T_{11} Normal plant stand with 33% extra fertilizer dose and organic manure

T_{12} 33% extra plant stand with 33% extra fertilizer dose and organic manure

3 2 3 *Field culture*

The experimental area was puddled twice and levelled Weeds and stubbles were removed by hand picking Plots of size 5 0x4 0 m were laid out with 12 plots in each block The plots were separated with channels of 60 cm width and blocks were separated by channels of 1 m width One metre along with length and breadth in east and north side of every plot was maintained as the destructive sampling area

Cowdung was incorporated at the time of last ploughing Full dose of phosphorus was applied before last puddling and levelling Nitrogen and potassium were applied in three equal splits at 10 DAS 35 DAS and 50 DAS

Pre germinated seeds were broadcasted at the rate of 100 Kg ha^{-1} and 133 kg ha^{-1} in respective plots

2 4 D at the rate of 1 Kg a i/ha was sprayed on 21 DAS to control broad leaved weeds Two hand weedings were also done at 25 and 45 DAS

Water level was maintained at 5 to 10 cm throughout the growth period except when drained for fertilizer and herbicide application Plot bunds were strengthened when and where necessary

A number of pest and disease occurrences were noticed during the cropping period Carbofuran 3G @ 0 75 Kg a i/ha was applied against stemborer Quinalphos @ 0 05% was sprayed to control leaf roller and rice bug Sheathblight incidence was noticed for which no control measure was adopted Attack of rats which is a common menace of the locality was controlled by setting Moncompu traps

The crop was harvested at 119 DAS leaving 20 cm border on all sides The dry weight of grain (at 14% moisture) and straw were recorded

3 2 4 *Observations*

GROWTH CHARACTERS OF RICE

3 2 4 1 *Plant population at 5 DAS*

The plant stand at 5 DAS was taken from three locations randomly selected in each plot using a quadrat of 0 5 x 0 5 m

3 2 4 2 *Height of Plants*

Height of the plants (in cm) was recorded on 20 40 60 and 80 DAS Ten plants were selected randomly from each plot for measuring the height Height was measured from the base of the plant to the tip of the longest leaf or to the tip of longest earhead whichever is taller

3 2 4 3 *Vegetative tillers per unit area*

Total number of tillers per unit area was recorded on 45 DAS Three sites using a quadrat of 0 5x0 2 m was selected randomly for counting the number of tillers from each plot

3 2 4 4 *Leaf Area Index*

Plant samples were cut at the base from randomly selected three locations using 0 5x0 2m² quadrat in the destructive sampling area on 45 DAS Leaves were separated and leaf area was estimated using leaf area meter (LI COR made model LI 3100)

3 2 4 5 *Dry matter Production*

Dry matter production and uptake of nutrients by plants at 45 DAS were observed after returning the leaves to the original sample lots Samples were then dried at 70 C for 48 hours and weighed before carrying out the chemical analysis

3 2 4 6 *Chlorophyll content*

The a b and total chlorophyll content of the boot leaves collected from two locations in the destructive sampling area at panicle emergence stage was estimated using the method suggested by Arnon (1949)

3 2 4 7 *Sheath blight disease*

The incidence of the disease was scored in 0 9 scale at 80 DAS Ten observations were made randomly from each treatment plots and the mean values were expressed as the disease score

3 2 4 8 *Number of white earheads*

Number of white earheads from each plot were counted and expressed as number per 20 m^2

YIELD AND YIELD ATTRIBUTES OF RICE

3 2 5 1 *Number of panicles per square metre*

Number of panicles from four locations randomly selected in the harvest area using a 0 5x0 2 m quadrat were counted and expressed as number of panicles per m²

3 2 5 2 *Number of grains per panicle*

The number of grams in three panicles collected randomly from ten sites in each plot were counted

3 2 5 3 *Chaff percentage*

The chaff percentage was worked out by using the formula

$$Chaff\ \% \quad \frac{Number\ of\ chaffy\ grains}{Number\ of\ filled\ grains} \times 100$$

3 2 5 4 *Thousand grain weight*

One thousand grains were from the samples drawn from the cleaned produce from each plot and weights recorded in grams

3 2 5 5 *Protein content of grain*

Protein percentage was computed by multiplying the nitrogen content of the grain with factor 6 25 (Simpson et al 1965)

3 2 5 6 *Grain yield of rice*

The grains harvested from each net plot was dried cleaned and weighed and expressed as t ha^{-1} at 14 per cent moisture

3 2 5 7 *Straw yield of rice*

The straw harvested from each net plot was dried to constant weight under sun and the weight was expressed as t ha

3 2 5 8 *Harvest Index*

Harvest Index was calculated by dividing the weight of grain with the total weight of grain and straw of each plot (Sinha and Swaminathan 1984)

$$\text{Harvest Index HI} \quad \frac{\text{Economic Yield}}{\text{Biological Yield}}$$

3 2 5 9 *Agronomic efficiency*

The grain yield produced per kilogram of applied nitrogen was calculated using the formula and expressed as kg of grain per kg of nitrogen

$$\text{Agronomic efficiency} = \frac{[\text{Grain yield from N applied plot} - \text{Grain yield from control plot}]}{\text{N applied in Kg ha}}$$

3 2 4 10 *Apparent recovery*

The percentage of nitrogen absorbed by the plant of the total nitrogen applied was found out and expressed as percentage

$$\text{Apparent recovery} = \frac{[\text{Total N uptake in N applied} - \text{Total N uptake in control plot}] \times 100}{\text{N applied in Kg ha}^{-1}}$$

3 2 6 *Chemical analysis*

3 2 6 1 *Soil analysis*

Composite soil samples collected before and after the experimentation were analysed to determine the available nitrogen available phosphorus and available potassium

3 2 6 2 *Plant analysis*

N P and K of the plant samples collected at 45 DAS and harvest were analysed after drying to constant weight in an electric hot air oven at 70°c for 48 hours It was then ground and passed through a 0 5 mm mesh in a Willey mill Grains were also analysed by following the same procedure for finding out protein content of the same The required quantity of samples were then weighed accurately in an electronic balance and subjected to acid extraction The nutrient contents were determined and expressed as percentage oven dry weight basis

Total nitrogen content was estimated by modified micro Kjeldal method total phosphorus by Vanadomolybdo phosphoric yellow method and total potassium by flame photometry (Jackson 1973)

3 2 6 3 *Uptake of nutrients*

The total uptake of nitrogen phosphorus and potassium by plant at 45 DAS and at harvest were calculated as the product of content of these nutrients in the plant sample and the respective dry weight and expressed as Kg ha^{-1}

3 2 7 *Statistical analysis*

The data collected were subjected to analysis of variance (Gomez and Gomez 1976) Whenever the results were significant the critical difference (CD) was worked out at one and five percent probability

Results and Discussion

RESULTS AND DISCUSSION

The results of the field experiment conducted to determine the effects of organic manures in conjunction with chemical fertilizers at varying plant population are presented and discussed below

4 1 Growth characters

The effect of treatments in factorial combinations and at different levels of individual factors pooled over other factors at varying levels on different growth characters are presented in tables 2(a) and 2(b)

4 1 1 *Plant population*

The number of seedlings at 5 days after sowing (5 DAS) showed significant difference with varying seed rates Neither the chemical fertilizers nor the organic manure could influence the plant density as normally expected However the population in the early stages expected to have a direct influence on the growth characters such as plant height tiller number etc which in turn influenced the final yield Reddy and Panda (1985) observed good plant stand with increased seed rates at early stages of the crop growth which is subsequently found responsible for increasing grain yield

Tab 2(a) Effect of treatment combinations on growth characters

Sl no	Treatment	Plant population per m² 5 DAS	Vegetative tiller count 45 DAS	Height (cm)	
				At max tillering stage	At harvest
1	S1FoOo	452	557	53	73
2	S2FoOo	726	699	49	66
3	S1F1Oo	492	674	68	84
4	S2F1Oo	684	729	69	84
5	S1F2Oo	488	619	73	89
6	S2F2Oo	613	624	74	88
7	S1FoO1	476	586	60	81
8	S2FoO1	571	631	63	79
9	S1F1O1	487	652	76	92
10	S2F1O1	605	738	75	89
11	S1F2O1	480	708	80	94
12	S2F2O1	656	692	78	90
	F	4 241**		17 878**	18 79**
	CD	80 9	NS	3 3	2 658
	SEm±	143927 7		16 168	10 605

Tab 2(b) Effect of individual factors and levels on growth characters

Seed rates	S1	479	633		85 19
	S2	643	686		82 71
	F	33 74**	4 43*	NS	6 04*
	CD(0 05)	58 44	52 25		2 10
	SEm±	19 91	17 8		0 71
FYM	Oo	576	650	64 3	80 62
	O1	546	668	72	87 28
	F			48 50**	43 42**
	CD(0 05)	NS	NS	2 29	2 10
	SEm+			0 78	0 71
Fertilizers	Fo	556	618	56 2	74 57
	F1	567	698	72 0	87 07
	F2	559	661	76 2	90 20
	CD(0 05)			121 03**	89 30*
	SEm±	NS	NS	2 81	2 57
				0 96	0 88

S1 & S2 - Seedrates at 100 and 133 kg/ha
Oo & O1 - Organic manure at 0 and 10 t/ha
Fo, F1 & F2 - NPK at O, 90 45 45 and 120 60 60 kg/ha
* & ** - Significance at 5% and 1% respectively

4 1 2 *Vegetative tillers per square metre*

Various treatment combinations had significant influence on the vegetative tiller production during the active tillering stage of the crop Rice being very elastic in its growth habit it try to adjust the plant population in tune to the availability of space Eventhough there was increased tiller production with increased initial plant population such increases were not uniform in various treatments [Table 2(a)] This may be due to the plant density adjustment property which is very much pronounced in the case of rice Maximum number of tillers were observed in treatments receiving normal dose of chemical fertilizers with organic manure under increased seed rates Tiller production was minimum in low input situations of no organic manure no fertilizers and normal seed rates It was also observed that only in combination with organic manure the increased dose of chemical fertilizers could increase the tiller number per unit area to a considerable 14 percent According to Reddy (1986) it is possible to increase the tillers per hill with increased dose of nitrogen fertilizers Increased dose of potassium also found to increase the number of tillers per hill (Krishnappa *et al* 1990)

The vegetative tiller count was found to be increased when the seed rates were increased above normal levels However such increases were not significant at the active crop growth of 45 DAS [Table 2(b)] Increased seed rates found to maximise vegetative tiller count at the maximum tillering stage of the crop The findings of Ghosh and Reddy (1983) also stress the need of increased seed rates for enhancing tiller number in the initial stages of the crop growth

Addition of organic matter had pronounced effect on tiller production [Table 2(b)] This may also be due to the extra benefits other than the nutrient supply function of organic manures to the soil like improved physico chemical properties as observed by Rai *et al* (1991) The enhanced tiller production by organic manuring was also reported by Sharma (1994)

The effect of inorganic fertilizers pooled over other factors and levels showed significant influence on tiller production than no application [Table 2(b)] However the enhancement from moderate levels of 90 45 45 to higher levels of 120 60 60 did not yield any advantage on tiller production

4 1 3 *Plant height*

The treatments received both organic manure and fertilizer irrespective of the seed rates attained maximum heights at maximum tillering and harvest stages of the crop [Table 2(a)] against the low input situations of no manure and no fertilizers While analysing the effect of individual factors pooled over other factors and its levels the same trend hold true [Table 2(b)] Sheela *et al* (1993) reported an enhanced growth of rice in terms of tiller count and height when the nutrients were supplied in excess than that of normal rate However the height at harvest was significantly higher when the plant population was dense as a consequence to the increased seed rate The increase in height towards maturity is considered a general phenomenon in high plant density situation where competition for light naturally arises

4 1 4 *Chlorophyll content*

High level of Chlorophyll in any plant system by and large has been associated with high productivity

There w is no significant variation in chlorophyll a However chlorophyll b synthesis and there by total chlorophyll changed significantly due to the influence of different factors in their combinations Perusal of table 3(a) shows that among the factors such as seed rate organic manure and inorganic nutrients only inorganic fertilizers could significantly influence all the chlorophyll fractions much as evident from the high range of 3 07 to 3 63 mg g^{-1} plant tissue in the treatments received enhanced fertilizer doses against 2 17 to 2 51 in no fertilizer situations irrespective of seed rates and organic manure addition Rai *et al* (1991) observed that increased doses of chemical fertilizers resulted in enhanced production of chlorophyll for performing more photosynthesis

The table 3(b) confirm the effect of inorganic fertilizers in chlorophyll content Among the inorganic fertilizers nitrogen is believed to have the key role in chlorophyll

Tab 3(a) Effect of treatment combinations on growth attributing characters

Sl no	Treatments	Chlorophyll (mg/g leaf)			Leaf Area Index
		a	b	Total	
1	S1F10o	1 69	0 82	2 51	3 04
2	S2F00o	1 63	0 76	2 38	3 89
3	S1F10o	1 94	0 83	2 77	4 31
4	S2F10o	1 73	0 90	2 63	5 63
5	S1F20o	1 94	0 99	2 93	5 16
6	S2F20o	1 92	1 15	3 07	6 33
7	S1Fo01	1 50	0 80	2 30	3 92
b	S2Fo01	1 44	0 73	2 17	5 29
9	S1F101	2 03	0 87	2 90	5 47
10	S2F201	1 73	0 71	2 54	6 23
11	S1F201	2 36	1 20	3 63	6 84
12	S2F201	2 20	1 24	3 44	6 97
	F		4 48*	10 78**	44 26**
	CD(0 05)	NS	0 081	0 193	0 262
	SEm±		0 023	0 056	0 103

Tab 3(b) Effect of individual factors and levels as growth characters

	a	b	Total	Leaf Area Index
S1	2 08	0 93	2 84	4 79
S2	1 78	0 93	2 71	5 72
F				189 48**
CD(0 05)	NS	NS	NS	0 14
SEm±				0 05
Oo	1 97	0 91	2 72	4 73
O1	1 88	0 95	2 83	5 78
F				241 80**
CD(0 05)	NS	NS	NS	0 14
SEm+				0 05
Fo	1 82	0 78	2 34	4 03
F1	1 86	0 85	2 71	5 41
F2	2 10	1 16	3 27	6 32
F		68 44**	43 53	384 19**
CD(0 05)	NS	0 07	0 21	0 17
SEm±		0 02	0 07	0 06

S1 & S2 - Seedrates at 100 and 133 kg/ha
Oo & O1 - Organic manure at 0 and 10 t/ha
Fo, F1 & F2 - NPK at O, 90 45 45 and 120 60 60 kg/ha
* & ** - Significance at 5% and 1% respectively

content (Tisdale *et al* 1985)

The significant increase in chlorophyll b as against mean static level of chlorophyll a with increasing N application is indicative of the increase in the relative proportion of chlorophyll a to chlorophyll b This would mean that at lower levels of N chlorophyll a alone will develop and chlorophyll b which is believed to be derived from chlorophyll a fails to develop probably because of an inhibition in the concerned reactions (Bridgit and Potty 1992) This incidently will explain the reasons for low productivity under low nitrogen situations as chlorophyll b known to be the acceptor of radiant energy which is subsequently funneled to the real site of synthesis Mayers and French (1960) reported that photosynthetic efficiency will be maximum only in the two pigment system process A deficiency in one will bring about more than proportionate reduction in assimilation rate

Organic manuring resulted only in marginal increase while higher seed rates decreased the chlorophyll content The decreased trends in chlorophyll observed at increased plant population is attributed to the mutual shading and ineffective reception of solar radiation The improvement in chlorophyll content due to the organic manuring may be due to the enhanced availability of micro and secondary nutrients including Mg in organic manure amended soils as reported by Rai *et al* (1991)

4 1 5 *Leaf Area Index*

Watson (1952) established that leaf area is the simple and appropriate measure of plants photosynthetic potential who found it to be a more common determinant of plant growth and yield than photosynthetic capacity of individual leaves in a crop community Hence the measurement of leaf area often necessary for agronomic and physiological studies

Leaf area index at 45 DAS was significantly influenced by the individual factors such as seed rate organic manures and inorganic fertilizers and their combination as seen in table 3(a) and 3(b) The lowest LAI of 3 04 was observed in the least input situations of normal seed rate no manure and no fertilizer application The LAI attained a more than double value of 6 97 under maximum input situation Leaf area index is the product of number of tillers leaves per tiller and area of individual leaf Leaf number being a more or less constant factor for a plant type the difference in LAI is mainly due to difference in production of tillers and leaf size

The influence of organic manure seed rate and inorganic fertilizers on tiller production is already discussed Here all these factors have positively influenced the LAI as a consequent to the enhanced tiller production and leaf area

The optimum leaf area index for rice is reported to be 4 to 7 depending upon the environment it grow LAI nearing to 7 may become unfavourable for wet seeded rice in a tropical humid climate since the micro climate may favour the multiplication of pests and disease causing organisms Even the marginal increase in the LAI towards higher range may lead to a relatively thicker plant canopy which may adversely affect the grain production as discussed in section 4 1 7

4 1 6 *Drymatter production and nutrient uptake at 45 DAS*

The drymatter produced at 45 DAS was in the range of 34 to 42 percent of the total drymatter produced at harvest The percentage production at 45 DAS was lower for the high input situations than in the least input situation indicating that the drymatter accumulation was greater during the reproductive stage in the high input situations It is seen that in the presence of added organic matter and enhanced fertilizer application seed rate is not influencing the drymatter production But in the absence of organic matter and enhanced fertilizer rate increase in seed rate brought about more drymatter accumulation

Considering the individual factors organic manures definitely resulted in better drymatter production when other factors remained at same levels In the presence of organic manures only the increased dose of chemical fertilizers could produce more dry matter at normal plant population during the active tillering stage of the crop It was also observed that the drymatter production at this stage of the crop may not be influencing the yield to a considerable extent the reasons for the same are discussed elsewhere Enhancement of fertilizers from normal to higher levels did not influence the drymatter production at this stage Seed rates also did not have much influence on LAI at 45 DAS

Application of both normal and high levels of fertilizers directly influenced the uptake of nutrients at 45 DAS There was not much difference in uptake of N P and K due to the presence of organic manures But at higher levels of chemical fertilizers organic manures had significant influence on the uptake of major nutrients [Table 4(a) and 4(b)]

The uptake was not at all influenced by the plant population except at high fertility levels The increased uptake of N P and K could be attributed to the combined effect of higher content of these elements in plant parts and the increase in drymatter production at high fertilizer levels This may be due to the increased uptake and rapid translocation induced by high K levels Munda (1989) observed higher N and P uptake with increase in N levels Drymatter production at 45 DAS was not significantly influenced by the treatment combinations However a positive effect of organic manure and inorganic fertilizers were seen [Table 4(a)] The total uptake of N P and K as influenced by seed rate organic manure and inorganic fertilizers is given in Figure III

Tab 4(a) Fffect of treatment combinations on dry matter production and nutrient uptake at 45 DAS

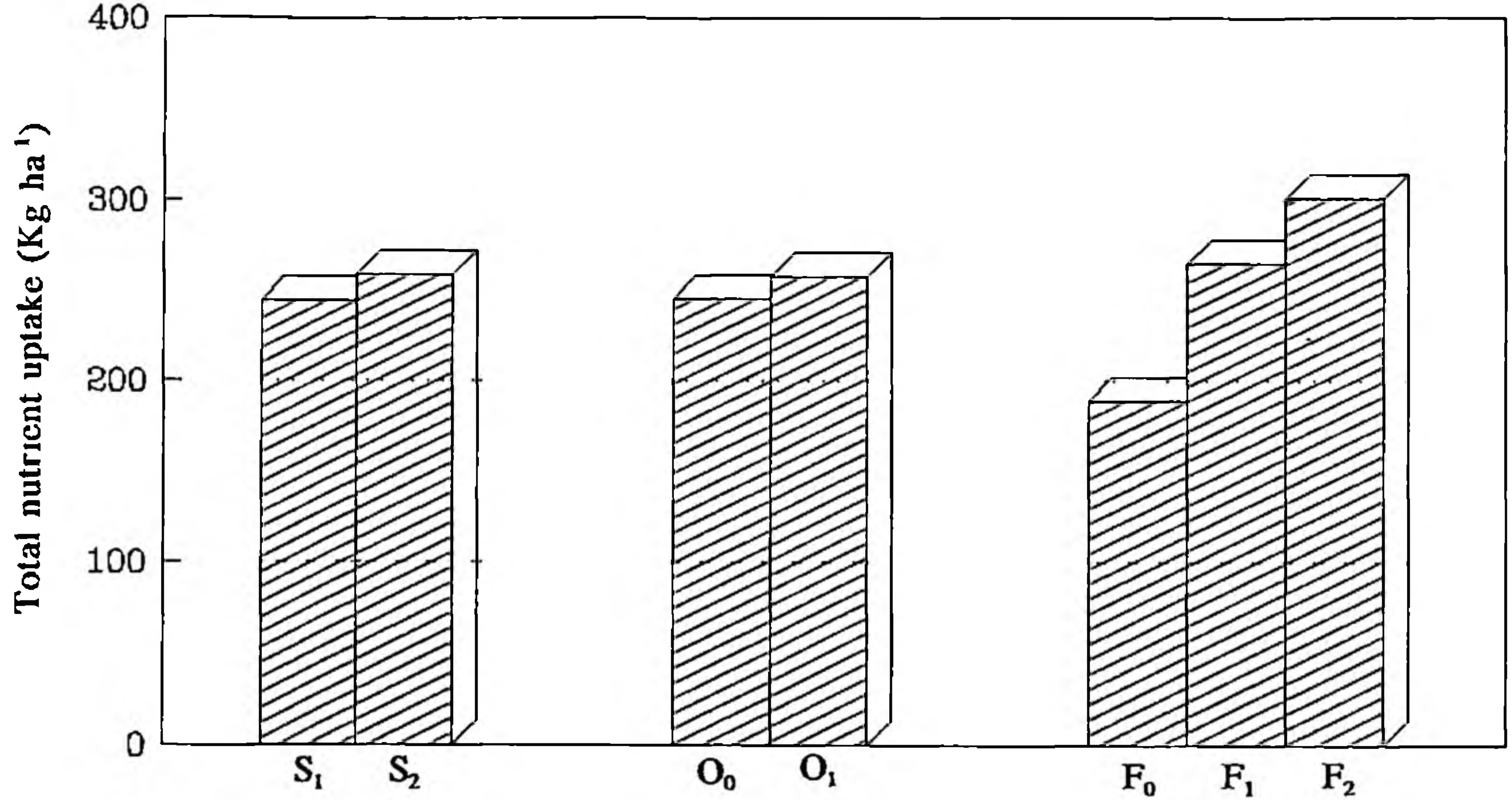
Sl no	Treatments	Dry matter production (t/ha)	Nutrient uptake (Kg/ha)		
			N	P	K
1	S1FoOo	3 4	93 5	18 6	92 0
2	S2FoOo	3 3	74 0	12 0	91 7
3	S1FoOo	4 3	111 1	24 6	130 3
4	S2F1Oo	4 3	103 2	22 6	149 7
5	S1F2Oo	3 6	89 5	17 6	135 5
6	S2F2Oo	4 8	112 1	21 7	163 4
7	S1FoOo	3 7	63 7	15 8	103 2
8	S2FoO1	3 8	69 0	16 7	106 0
9	S1F1O1	4 0	117 5	19 9	118 1
10	S2F1O1	4 1	102 5	23 1	137 5
11	S1F2O1	4 1	139 2	20 6	156 9
12	S1F2O1	4 2	154 8	23 8	159 9
	F		4 680**	2 488**	3 880**
	CD(0 05)	NS	2 922	1 25	2 976
	SEm±		12 80	2 377	13 288

Tab 4(b) Fffect of individual factors and levels on dramatter production and nutrient uptake at 45 DAS

S1	3 8	102 4	19 5	122 7
S2	4 1	104 3	20 0	134 7
F				
CD(0 05)	NS	NS	NS	NS
SEm±				
Oo	3 9	99 0	19 5	127 2
O1	4 0	107 8	20 0	130 3
F				
CD(0 05)	NS	NS	NS	NS
SEm±				
Fo	3 5	75 0	15 8	98 2
F1	4 2	108 6	22 6	134 0
F2	4 1	126 4	20 9	153 9
F	4 44*	16 58**	8 88**	18 06**
CD(0 05)	494 39	18 8	3 49	19 5
SEm±	168 39	6 4	1 19	6 64

S1 & S2 - Seedrates at 100 and 133 kg/ha
Oo & O1 - Organic manure at 0 and 10 t/ha
Fo, F1 & F2 NPK at 0, 90 45 45 and 120 60 60 kg/ha
* & ** - Significance at 5% and 1% respectively

FIG.III.TOTAL N,P AND K UPTAKE AS INFLUENCED BY VARIOUS LEVELS OF INDIVIDUAL FACTORS AT 45 DAS.



4 1 7 *Pest and Disease Occurrence*

The white earhead count showed an increasing trend with the increased dose of chemical fertilizers But in the presence of organic manures the incidence was reduced to minimum levels as evidenced from Table 5(a) and 5(b) Athisamy and Venugopal (1995) reported that by the application of organic manures along with chemical fertilizers it is possible to reduce the white earhead occurrence However the white earheads were recorded the minimum in the least input situations Enhanced seed rates increased the pest occurrence both in the presence and absence of organic manure and inorganic fertilizers

It is probable that increased doses of chemical fertilizers make the plant to grow luxuriously which succumb them to pest attack The present observation is supported by the findings of Ho (1983) and Swaminathan *et al* (1995) who noticed increased white earhead occurrence with increased dose of inorganic nitrogen fertilizer By combining with organic manures the increased incidence of white earheads resulting due to high fertilizer dose can be minimised

Sheathblight score was high at high plant densities regardless of other factors and their levels However the difference was not significant The incidence was minimum at low fertilizer situations both at normal and increased seed rates This is contradictory to the reports of Mithrasena and Adhikari (1986) who found that increased seed rates

Tab 5(a) Effect of treatment combinations on pest & Disease occurrence

Sl no	Treatments	No of white earheads	Sheath blight score
1	S1FoOo	36	0 00(1 00)
2	S2FoOo	35	0 00(1 00)
3	S1F1Oo	67	0 48(1 22)
4	S2F1Oo	82	0 64(1 28)
5	S1F2Oo	80	1 64(1 63)
6	S2F2Oo	92	1 72(1 65)
7	S1FoO1	49	0 03(1 02)
8	S2FoO1	78	0 51(1 23)
9	S1F1O1	74	1 28(1 51)
10	S2F1O1	77	1 81(1 68)
11	S1F2O1	67	2 26(1 80)
12	S1F2O1	58	3 97(2 23)
	F	4 1**	NS
	CD(0 05)	12 67	
	SEm±	240 9	(Transformed scores are given in parenthesis)

Tab 5(b) Effect of individual factors and levels on pest and disease occurrence

S1	62	0 86
S2	70	1 28
F		
CD(0 05)	NS	NS
SEm+		
Oo	65	0 68
O1	67	1 49
F		12 46**
CD(0 05)	NS	0 17
SEm+		0 06
Fo	50	0 13
F1	75	1 02
F2	74	2 34
F	10 34**	30 56**
CD(0 05)	13 16	0 20
SEm±	4 48	0 07

S1 & S2 - Seedrates at 100 and 133 kg/ha
Oo & O1 Organic manure at 0 and 10 t/ha
Fo, F1 & F2 - NPK at 0, 90 45 45 and 120 60 60 kg/ha
* & ** - Significance at 5% and 1% respectively

over 100 kg ha produced sequential increase in sheathblight occurrence In the presence of organic manure also the incidence was found to be significantly high which is contradictory to the reports of Kannaiyan and Prasad (1983) probably due to the favourable micro environment for the fungal growth generated at the high input situations imposed in the present study Significantly high incidence of sheathblight observed at increased fertilizer doses which may also be due to the above mentioned reasons further aggravated by the succulence of plant parts at higher fertilizer doses

4 2 Yield attributes and Yield

The yield is a function of number of panicles per unit area spikelets per panicle fertility percentage and test weight of grains Effect of treatments on any of these factors may have a direct bearing on yield of the crop The effect of various treatment combinations is given in Table 6(a) and 6(b)

4 2 1 *Number of panicles per unit area*

Increased seed rates and application of organic manures increased the number of panicles But only the increased seed rates could significantly influence the number of panicles per square metre This can be related to the increased tiller production at the maximum tillering stage of the crop The treatment received normal fertilizer dose at increased plant population without organic manure supply can be considered for

Tab 6(a) Effect of treatment combinations on yield attributing characters

Sl no	Treatments	Number of panicles per m²	Number of grains per panicle	chaff percentage (%)	1000 grain weight (g)
1	S1FoOo	436	63	17 83	25 4
2	S2FoOo	544	56	19 27	26 3
3	S1F1Oo	451	61	18 60	25 8
4	S2F1Oo	558	58	19 40	25 9
5	S1F2Oo	476	66	22 80	25 6
6	S2F2Oo	453	54	17 37	24 5
7	S1FoO1	460	64	16 48	27 7
8	S2FoO1	505	57	17 25	26 1
9	S1F1O1	499	67	18 87	26 5
10	S2F1O1	539	68	22 36	24 9
11	S1F2O1	437	74	16 26	25 1
12	S1F2O1	454	64	15 46	25 1
		NS	NS	NS	NS

Tab 6(b) Effect of individual factors on yield attributing characters

S1	460	66	17 14	26 0
S2	509	60	19 43	25 6
F	6 86*		5 17**	
CD(0 05)	38 88	NS	0 25	NS
SEm+	13 24		0 08	
Oo	487	60	21 60	25 7
O1	482	66	15 19	25 9
F			40 44**	
CD(0 05)	NS	NS	0 24	NS
SEm+			0 08	
Fo	486	60	19 50	26 4
F1	512	64	17 99	25 8
F2	455	65	17 33	25 3
F				
CD(0 05)	NS	NS	NS	NS
SEm+				

S1 & S2 - Seedrates at 100 and 133 kg/ha
Oo & O1 - Organic manure at 0 and 10 t/ha
Fo, F1 & F2 NPK at O, 90 45 45 and 120 60 60 kg/ha
* & ** Significance at 5% and 1% respectively

explaining the effects of early growth factors on the final yield attributes In this treatment the tiller production was high and LAI was optimum which resulted in the better performance of the crop even at later stages of its growth But at heavily fertilized situations there was luxuriant growth of the established plants and the LAI was optimum or above optimum levels which invariably resulted due to enhanced vegetative growth culminating in drastic reduction in number of panicles per m^2 The profused growth of extra fertilized plants also resulted in increased occurrence of pest and disease which caused death of many productive tillers

Increased seed rates regardless of the various levels of inputs increased the number of panicles per unit area Similar results were also reported by Ghobrial (1983) Jones and Snyder (1987) and Srivasthava and Thripathi (1993)

Mondal *et al* (1990) observed increased production of panicles after organic manuring Similar trend was observed in the present investigation also though not statistically significant Positive response with added inorganic fertilizers was found only upto the normal rate though not significant Sharma (1991) reported marginal increases in panicle production due to chemical fertilization

4 2 2 *Number of grains per panicle*

The number of grains per panicle was found to be decreased with increased seed rates Number of spikelets per panicle is decided invariably after panicle emergence A competition for nutrients at this stage may result in reduction of this parameter The increased tiller production observed at maximum tillering stage is a clear evidence for competition within the plant community High seed rates produced more number of panicles per m^2 but less number of grains per panicle (Ghobrial 1983)

The number of grains per panicle was also influenced by organic manure addition but the effect was only marginal Kobayashi *et al* (1989) observed increased number of grains per panicle with the application of 10 t ha^{-1} of FYM definitely due to the favourable nutrient availability in the soil system

Various treatment combinations could not significantly influence the number of grains per panicle An increase in number of grains per panicle was observed by Mondal *et al* (1990) after an increase in NPK and FYM application rates

4 2 3 *Chaff percentage*

The various treatment combinations could not significantly influence this yield attributing character The chaff percentage ranged from 15 4 to 22 8% which is within the reasonable level for high yield Seed rates did not influence the chaff percentage Similar result was also observed by Surendra Reddy and Bucha Reddy (1994) It was observed that a considerable reduction in chaff percentage resulted due to organic matter addition Prakash *et al* (1990) also observed similar trends In general a decrease in chaff percentage was observed in treatments receiving organic manures Increased availability of K after organic matter addition was reported by Ganal and Singh (1990) By judicious application of inorganic fertilizers especially nitrogen it is possible to reduce the chaff percentage

4 2 4 *Thousand grain weight*

Treatment combinations did not influence the thousand grain weight but it was observed that the thousand grain weight recorded the maximum in treatments receiving normal seed rate and organic manure While considering the individual factors organic manuring could increase the 1000 grain weight but not significantly Organic manuring in soil is responsible for long and sustained availability of plant nutrients Test weight of seed is benefitted by this property after organic manuring

Increased dose of chemical fertilizers decreased test weight as against the findings of Mondal *et al* (1987) But as the study was carried out at varying plant populations and at different levels of factors there may be reductions in 1000 grain weight Dinesh Chandra (1990) observed increased dose of chemical fertilizers decreased 1000 grains

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weight considerably

A slight reduction in thousand grain weight was observed with increased seed rates This may be due to the reduced uptake of major nutrients at harvest which is evidenced from Table 8(a) and 8(b) Karim *et al* (1992) observed that thousand grain weight was decreased with increased plant density

4 2 5 Grain yield

The effect of treatments in factorial combinations and at different levels of individual factors pooled over varying levels of other factors on yield and associated characters are given in Table 7(a) and 7(b)

The highest yield of 6 t ha^{-1} was recorded for both the treatments which received either an enhanced seed rate and normal fertilizer dose or a normal seed rate and enhanced fertilizer dose in the presence of added organic matter [Table 7(a)]

Enhanced seed rate with normal fertilizer dose in the absence of organic manure and normal fertilizer dose with normal seed rate in the presence of organic manure produced lower but statistically similar yields These results bring about the importance of organic manuring in relation to fertilizer use and plant density in wetseeded rice A drastic increase in the mean grain yield from 3 9 to 5 6 t ha under the similar conditions

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Tab 7(a) Fffect of treatment combinations on yield

Sl no	Treatments	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index	Grain Straw ratio
1	S1FoOo	3 92	4 1	0 49	1 97
2	S2FoOo	4 39	4 5	0 49	0 97
3	S1F1Oo	5 16	5 9	0 47	0 87
4	S2F1Oo	5 91	6 5	0 48	0 90
5	S1F2Oo	5 07	6 4	0 44	0 80
6	S2F2Oo	5 18	6 7	0 44	0 80
7	S1FoO1	5 63	6 2	0 48	0 90
8	S2FoO1	5 52	5 9	0 48	0 90
9	S1F1O1	5 81	6 0	0 49	1 00
10	S2F1O1	6 05	6 4	0 48	0 93
11	S1F2O1	5 97	6 4	0 48	0 93
12	S2F2O1	5 17	7 3	0 41	0 70
	F	9 504**	10 556**	6 01**	4 345**
	CD(0 05)	0 375	0 182	0 082	0 167
	SEm+	0 211	0 273	0 0102	6 042

Tab 7(b) Effect of individual factors and levels on Yield

	Grain yield	Straw yield	Harvest Index	Grain Straw ratio
S1	5 26	5 86	0 48	0 92
S2	5 37	6 22	0 46	0 87
F		5 27**	4 69**	
CD(0 05)	NS	0 33	0 01	NS
SEm±		0 11	0 0	
Oo	4 94	5 68	0 47	0 88
O1	5 69	6 40	0 47	0 91
F	38 53**	21 33**		
CD(0 05)	0 25	0 33	NS	NS
SEm±	0 09	0 11		
Fo	4 86	5 21	0 48	0 95
F1	5 73	6 18	0 48	0 93
F2	5 35	6 74	0 44	0 81
F	17 12**	32 43**	20 48**	13 0**
CD(0 05)	0 31	0 40	0 01	0 06
SEm±	0 11	0 14	0 01	0 02

S1 & S2 - Seedrates at 100 and 133 kg/ha
Oo & O1 - Organic manure at 0 and 10 t/ha
Fo, F1 & F2 - NPK at 0, 90 45 45 and 120 60 60 kg/ha
* & ** - Significance at 5% and 1% respectively

of normal seed rate and no inorganic fertilizer use but with the addition of organic manure at 10 t ha^{-1} also underscore the need for organic manuring particularly under no or minimum fertilizer use

The individual factor analysis for organic manure pooled over other factors such as seed rate and fertilizer dose at their different levels [Table 7(b)] clearly shows the significance of organic manure in rice manurial schedule

The yield increase observed with the addition of organic manure in the presence or absence of fertilizer dose is brought about by the appropriate positive changes occurred in the plant growth and yield attributes which have already been discussed in the previous sections The two way action of nutrient supply and enhancement of soil nutrient mineralisation of organic manures under minimum external inorganic nutrient supply and nutrient supplementation and enhancing efficiency of applied inorganic nutrients by improving biological physical and chemical characteristics of soil by organic matter application were reported by several researchers (Soni and Sehgal 1989 John *et al* 1989 b and John *et al* 1992)

Analysis on the influence of seed rates on yield showed significant effect which varied depending on the associated factors An in depth analysis of the table 7(a) showed that in the absence of organic manure and inorganic fertilizers an enhancement of seed rate from 100 to 133 kg ha^{-1} could increase the yield by 0 5 t ha^{-1} In the absence of organic manure but with normal fertilizer dose the enhanced seed rates increased the yield by 0 7 t ha^{-1} however under enhanced fertilizer doses no yield advantage was observed In the presence of organic manure at 10 t ha^{-1} the enhancement in seed rate resulted in similar yield for no or normal fertilizer application It decreased the yield when fertilizer dose enhanced from normal by 33%

Though seed rates could be instrumental in increasing the panicle number the most important yield attributing character its increase from normal recommended rate of 100 kg ha^{-1} is not appreciable in high input situations Jones and Snyder (1987) observed increased number of panicles with increased seed rates at moderate input levels The increased growth at vegetative phase and subsequent dense canopy may result in heavy diseases and pest occurrences in wetland paddy in humid tropics as discussed earlier

The effect of fertilizers on yield was significant in single factor as well as at factorial combinations In general fertilizer application increased the grain yield by about 1 t ha^{-1} upto the normal fertilizer rate irrespective of seed rates and organic manure application However their interactive effect varied with situations Under high seed rates the increase in normal fertilizer dose reduced the yield whether or not organic manuring was done Under normal seed rates the yield increase due to fertilizer application at normal and enhanced rates were similar

The yield increase observed in fertilized plots can be related to the improvement in growth characters like LAI leaf chlorophyll content nutrient uptake during active tillering stage etc But at added rates of chemical fertilizer particularly under thick plant density and with addition of organic manure it may negatively influence the yield by way of creating mutual shading of leaves lodging pest and disease occurrence and increasing sterility of spikelets

4 2 6 *Straw yield*

Straw yield was significantly influenced by various factors and their combinations [Table 7(a) and 7(b)] The response was more or less similar to the grain yield except for the enhanced fertilizer rates where straw production was considerably higher Highest straw production was in the treatment with organic manure addition enhanced seed rate and fertilizer use This would normally be due to the higher growth as evidenced by characters mentioned in sections 4 1 However grain production in this treatment was relatively lower for which the reasons were explained elsewhere Similarly the treatments received high dose of inorganic fertilizers irrespective of the seed rates and without organic manure also produced high straw yield

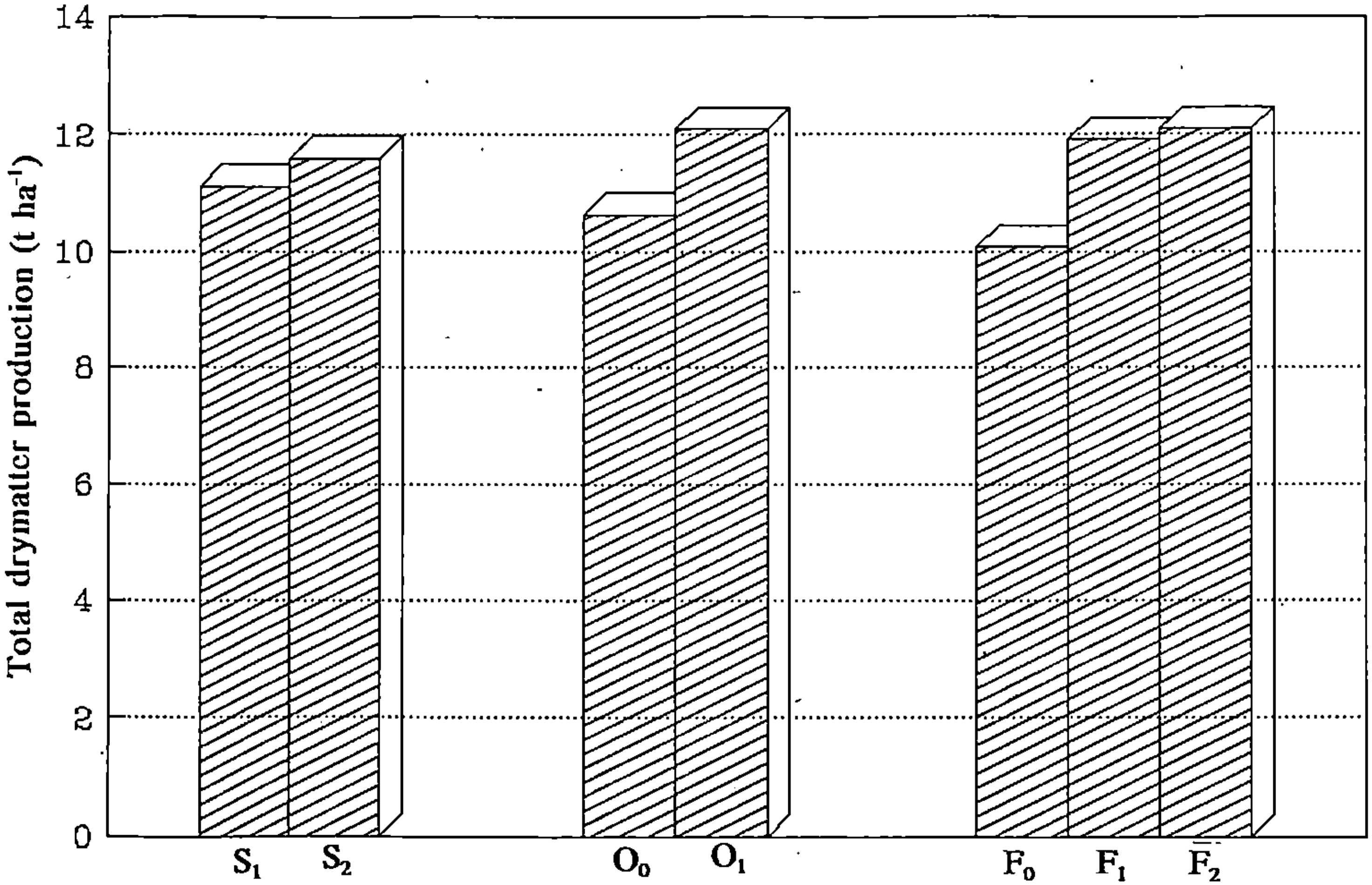
Reddy (1986) reported greater production of straw with increased chemical fertilizer Higher seed rates found to increase the straw yield significantly over the normal seed rates Lowest straw yields were produced by the treatments without organic or inorganic fertilizers and having normal seed rate Which is definitely due to the lower growth and drymatter accumulation in the active growth stage of the crop The total drymatter production (Fig V) also pronouncedly showed the benefit of organic manure and moderate fertilizer use in enhancing biomass yield

4 3 Harvest Index and grain straw ratio

A harvest index of 0 5 is believed to be ideal for high yielding rice varieties to achieve potential production For varieties with potential production of more than 12 5 t ha ^{1} targeted harvest index is 0 6 (I R R I 1994) None of the treatment combinations could achieve such a favourable harvest index in the present study The treatment combinations with enhanced seed rates fertilizer application and organic manuring resulted in a poor harvest index of 0 41 Reducing any one of the above factors to the normal level could improve the harvest index to 0 49 which have the highest yields [Table 9(a)] Similarly the treatments with enhanced fertilizer dose even in the absence of organic manure had relatively lower harvest indices

Similar to the harvest index the grain straw ratio of 1 1 is believed to be favourable for high yielding varieties and is recorded for treatment received organic manure normal seed rate and normal dose of fertilizer A very low grain straw ratio of 0 7 1 was noticed in treatment which had received organic manure normal seed rate and normal dose of fertilizer Chavan *et al* (1989) observed low grain straw ratio with increase in nitrogen application rates A very low grain straw ratio of 0 7 1 recorded by the high input situations was not qualified to be considered for yield maximisation

FIG.V. TOTAL DRYMATTER PRODUCTION AT HARVEST



4 4 Nutrient concentration in grain and straw

The N content of grain averaged over different seed rates and organic manure showed significant increases with increasing rates of fertilizer application [Table 8(b)] However their significance levelled off when compared among combination treatments [Table 8(a)] N content in straw was found to be significantly different both at combined as well as individual factor levels The treatments alone or in combinations did not influence the P content in grain or straw Though P concentration did not differ in grain, substantial variation was observed in straw due to different treatments and attained significance when compared at the different fertilizer levels

The higher N and K content in straw with fertilizer increments could be related to the corresponding higher straw yield and N and K removal and similar grain yield and grain N content in different treatments The N and K mobilization from straw to grain may not significantly increase at a more than optimum level when other factors such as plant population etc are interacting However P with its main role in the initial growth stages is not expected to cause much difference in its concentration in grain or straw

4 5 Protein content of grain

The various treatment combinations could not significantly influence the protein content of the grain obviously due to similar nitrogen concentration in grain [Table 8(a)] However an increase of about 10% in grain protein was noticed at treatment combinations receiving normal seed rates and increased dose of chemical

Tab 8(a) Effect of treatment combinations on nutrient concentration of grain and straw and protein content of grain

Sl no	Treatments	Grain			Straw			Protein of grain (%)
		N	P	K	N	P	K	
1	S1FoOo	1 16	0 273	0 559	0 495	0 366	2 503	7 25
2	S2FoOo	1 21	0 282	0 560	0 518	0 283	2 517	7 56
3	S1F1Oo	1 24	0 276	0 569	0 573	0 300	2 730	7 75
4	S2F1Oo	1 24	0 273	0 570	0 632	0 308	3 273	7 75
5	S1F2Oo	1 27	0 282	0 576	0 483	0 300	3 573	7 94
6	S2F2Oo	1 24	0 266	0 569	0 518	0 300	3 297	7 75
7	S1FoO1	1 17	0 273	0 572	0 329	0 300	2 460	7 31
8	S2FoO1	1 26	0 273	0 566	0 337	0 216	2 637	7 89
9	S1F1O1	1 21	0 273	0 573	0 436	0 300	2 653	7 56
10	S2F1O1	1 23	0 276	0 572	0 360	0 269	3 207	7 69
11	S1F2O1	1 27	0 276	0 583	0 615	0 267	3 253	7 94
12	S2F2O1	1 24	0 273	0 575	0 690	0 316	3 100	7 75
	F				4 85**			
	CD (0 05)	NS	NS	NS	0 076	NS	NS	NS
	SEm±				0 009			

Tab 8(b) Effect of individual factors and levels on nutrient concentration of grain and straw and protein content of grain

	Grain N	Grain P	Grain K	Straw N	Straw P	Straw K	Protein of grain (%)
So	1 22	0 28	0 57	0 49	0 30	2 86	7 66
S1	1 24	0 27	0 57	0 51	0 28	3 01	7 74
F							
CD (0 05)	NS	NS	NS	NS	NS	NS	NS
SEm±							
Oo	1 23	0 28	0 57	0 54	0 31	2 98	7 70
O1	1 23	0 27	0 57	0 46	0 27	2 89	7 70
F				5 97*			
CD (0 05)	NS	NS	NS	0 06	NS	NS	NS
SEm±				0 02			
Fo	1 20	0 28	0 56	0 42	0 28	2 53	7 51
F1	1 23	0 27	0 56	0 50	0 29	2 97	7 75
F2	1 26	0 27	0 57	0 58	0 30	3 31	7 85
F	5 98**			8 60**		28 46**	5 55*
CD(0 05)	0 03	NS	NS	0 08	NS	0 21	0 22
SEm±	0 01			0 03		0 07	0 07

S1 & S2 - Seedrates at 100 and 133 kg/ha
Oo & O1 Organic manure at 0 and 10 t/ha
Fo, F1 & F2 NPK at 0 90 45 45 and 120 60 60 kg/ha
* & ** - Significance at 5% and 1% respectively

fertilizers in the presence of organic manure Brar and Dhillon (1989) observed an increased N content of grain with organic manure application along with inorganic fertilizers

4 6 Nutrient uptake at harvest

The effect of individual treatments and combinations on grain, straw and total drymatter are given in Table 9(a) and 9(b) and Figure IV Nutrient uptake is a function of drymatter production and nutrient concentration in plant parts The effect of treatments on grain and straw drymatter and nutrient concentration were discussed in sections 4 5 5 4 5 6 and 4 6

Though the nutrient concentration did not significantly vary the N, P, K uptake by grain and N K uptake by straw were found to be much differed at treatment combinations and individual factor levels mainly due to the influence of the varying drymatter production The total uptake followed the similar trend The plant density effected difference only in the case of straw and total K uptake However the application of organic manure significantly influenced the grain NPK and straw K content The fertilizer application from zero level to the higher level significantly increased the uptake of all the three nutrients in grain and straw

4 7 Available soil nutrient status before and after experimentation

The mean available nutrient in the soil before the experiment estimated and pooled over three replications did not show any significant difference and it indicates the uniformity of the plots in which various treatments were imposed

Tab 9(a) Total ntrient uptake at harvest (kg/ha)

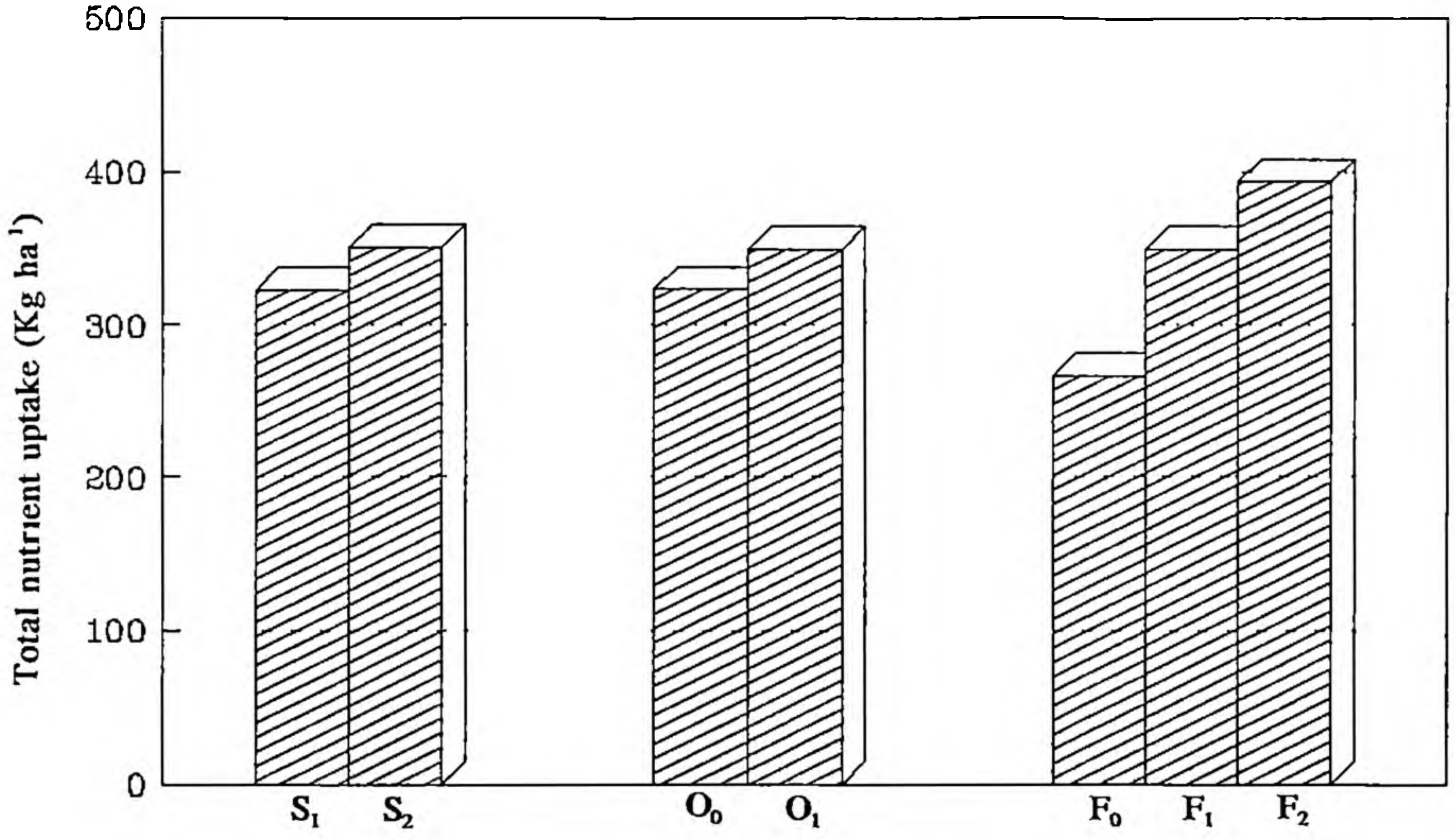
	Grain			Straw			Total		
Treatments	N	P	K	N	P	K	N	P	K
S1FoOo	45 6	10 8	21 9	20 2	15 1	102 9	65 8	25 9	124 8
S2FoOo	53 2	12 1	24 6	21 5	12 9	114 7	76 8	25 0	139 3
S1F1Oo	63 9	14 2	29 4	33 4	17 8	160 0	97 3	32 0	189 4
S2F1Oo	73 3	16 2	34 0	40 9	19 9	211 7	114 2	36 1	245 7
S1F2Oo	64 3	14 1	29 3	31 0	19 4	228 7	95 3	33 5	258 0
S2F2Oo	64 4	13 7	28 3	35 0	19 9	220 3	99 4	33 6	248 6
S1FoO1	65 9	15 4	32 2	20 3	13 6	153 0	86 2	29 0	185 2
S2FoO1	69 3	15 1	31 3	20 2	12 8	157 3	89 5	27 9	188 6
S1F1O1	70 5	16 3	33 5	26 9	19 1	165 3	97 4	35 4	198 8
S2F1O1	74 7	16 8	34 6	23 1	17 8	203 0	97 8	34 6	237 6
S1F2O1	76 3	16 7	34 8	33 6	17 4	213 0	109 9	34 1	247 8
S2F2O1	64 1	14 3	29 8	50 8	22 9	226 0	114 9	37 2	255 8
F	10 53**	10 27**	48 45**	3 94*		17 15*	4 697**		7 767*
CD (0 05)	1 348	0 655	0 958	1 785	NS	2 646	10 514	NS	22 231
SEm+	2 724	0 644	1 378	4 788		10 507	165 83		741 41

Tab 9(b) Effect of individual factors and levels on nutrient uptake at harvest

S1	61 6	14 6	30 2	28 7	17 1	170 5	90 48	31 65	201 52
S2	66 6	14 7	30 5	32 7	17 7	188 8	98 40	33 39	219 28
						9 09**			7 49*
CD(0 05)	NS	NS	NS	NS	NS	12 59	NS	NS	13 47
SEm+						4 29			4 59
Oo	60 8	13 5	27 9	30 69	17 5	173 1	91 52	32 08	200 96
O1	67 4	15 7	32 7	30 26	17 3	186 33	97 56	33 04	219 84
F	5 15*	37 34**	36 14**			4 80*			8 48**
CD(0 05)	6 01	0 77	1 65	NS	NS	12 59	NS	NS	13 47
SEm+	2 04	14 6	30 2			4 29			4 59
Fo	58 5	13 4	27 5	21 1	13 6	132 0	78 91	23 95	159 46
F1	66 6	15 8	32 9	31 0	18 6	185 0	97 63	35 96	217 88
F2	67 3	14 7	30 6	39 3	19 9	221 1	106 82	34 05	253 86
F	3 76*	14 91**	15 37**	15 02**	4 22*	74 31**	16 11**	6 63**	71 89**
CD(0 05)	7 35	0 95	2 03	6 91	4 79	15 42	10 40	5 55	16 50
SEm+	2 51	0 32	0 69	2 35	1 63	5 25	3 54	1 89	5 62

S1 & S2 - Seedrates at 100 and 133 kg/ha
Oo & O1 - Organic manure at 0 and 10 t/ha
Fo F1 & F2 - NPK at O, 90 45 45 and 120 60 60 kg/ha
*&** - Significance at 5% and 1% respectively

FIG.IV. TOTAL N,P AND K UPTAKE AS INFLUENCED BY VARIOUS LEVELS OF INDIVIDUAL FACTORS AT HARVEST.



There was considerable reduction in the available nitrogen after experimentation in all the treatments obviously due to the substantial removal by the crop Such a great difference was not observed with available P_2O_5 content of the soil The reason mainly attributed to low P requirement by rice and the quantity removed, peak P absorption stage of the crop phosphorus dynamics in submerged wetlands and source of P applied

As against the nitrogen uptake pattern extended even upto the flowering stage of rice the P uptake almost stop during maximum tillering stage Thus there is enough time for the soil P to get mineralised and accumulate in soil The response of applied P in wetlands of Kuttanad is lower and the P deficiency symptoms initiate only after eight to ten seasons of continuous skipping of P from fertilizer schedule (John *et al* 1996) The phosphorus applied through rock phosphate which is slowly available for a long period is also responsible for maintenance of available P towards harvest of the crop A substantial reduction in available K content in soil after the harvest of the crop was found only in plots received no chemical fertilizer in all other plots it was relatively maintained The above reduction is primarily due to the uptake of K by the crop But in fertilized plots the uptake was from both soil pool and applied fertilizer and the quantity was thus maintained Also the potassium equilibrium in soil between slowly readily and non available forms of K are readily maintained

4 8 Agronomic efficiency and Uptake efficiency

The utilization efficiency of applied nitrogen in terms of grain production per kg of N applied was greater when organic manure and fertilizers were jointly applied (Table 11) Enhancing the efficiency of inorganic fertilizers particularly ab 10 Soil nutrient status before and after experimentation

1 o	Treatments	N(Kg/ha)		P2O5(Kg/ha)		K2O(Kg/ha)	
		before	after	before	after	before	after
	S1FoOo	199 8	61 4	43 0	46 2	128 7	91 2
	S2FoOo	107 5	92 2	41 9	42 2	107 5	61 7
	S1F1Oo	143 4	102 4	41 8	44 8	126 9	113 6
	S2F1Oo	194 9	81 9	38 1	39 7	146 7	86 5
	S1F2Oo	179 7	81 9	39 1	51 5	147 1	115 5
	S2F2Oo	169 1	76 8	40 8	50 8	138 1	157 3
	S1FoO1	186 0	66 5	33 0	33 7	135 4	68 4
	S2FoO1	138 2	71 7	30 9	46 5	159 0	84 8
	S1F1O1	117 8	66 6	44 8	43 4	150 8	158 1
0	S2F1O1	122 9	56 3	40 3	32 4	132 5	119 6
1	S1F2O1	171 0	66 5	44 8	44 7	119 4	122 9
2	S2F2O1	172 5	71 7	39 6	53 5	143 2	118 3
	F		3 081*				4 931*
	CD	NS	2 238	NS	NS	NS	1 732
	SE		7 515				13 64

ab 11 Agronomic efficiency and Apparent recovery

1 o	Treatments	Agronomic efficiency (Kg grain/kg of N)	Apparent recovery (%)
	S1FoOo	--	--
	S2FoOo	--	--
	S1F1Oo	14 4	35
	S2F1Oo	22 2	54
	S1F2Oo	10 0	25
	S2F2Oo	10 8	28
	S1FoO1	--	--
	S2FoO1	--	--
	S1F1O1	22 2	35
0	S2F1O1	23 3	36
1	S1F2O1	17 5	37
2	S2F2O1	10 83	41

nitrogen by organic manure was reported by several researchers (John *et al* 1989 a d Mondal *et al* 1990 and Verma *et al* 1991) The seed rates did not have much influence on the agronomic efficiency However the enhancement of the fertilizer dose from normal to higher dose decreased it considerably John *et al* (1991) have reported decreasing N use efficiency with increased nitrogen fertilization in wetland rice

The apparent recovery of applied nitrogen varied from 25 to 54 per cent In the absence of organic manure the recovery of N at normal rate of application was greater than that at higher rates But in the presence of organic manure this difference was levelled off

Summary

SUMMARY

An experiment entitled Yield maximisation of direct sown rice under puddled condition was carried out to study the effect of combined use of organic manures and inorganic fertilizers under different plant populations for enhancing rice yield in the lowlands of Kuttanad during the Kharif season of 1995

Observations on the vegetative and productive aspects of rice nutrient uptake by the plant and the nutrient status of the soil before and after the experimentation were studied The results obtained were statistically analysed

The increased seed rate of 133 kg ha^{-1} resulted in a corresponding increase in the initial plant population Neither the normal/increased dose of chemical fertilizers nor the presence/absence of organic manure could influence the initial plant population Initial plant density greatly influenced the other growth characters like plant height tiller number etc in the later stages of crop growth However maximum number of tillers were observed in treatments receiving normal dose of chemical fertilizers in the presence of organic manure at increased seed rate

A considerable 14 percent increase in tiller count was noticed when the normal dose of 90 45 45 kg NPK ha was enhanced to 120 60 60 kg ha^{-1} when applied along with organic manure at 10 t ha and at normal seed rate At least input situations the tiller count was minimum

Irrespective of the seed rates the treatments received both organic and inorganic fertilizers could influence the plant height positively throughout the growth period of the crop Increased plant density resulted in height increments at harvest stage of the crop Application of organic manure or enhanced seed rate did not influence any of the leaf chlorophyll fractions Increase in inorganic fertilizer rate significantly increased chloro phyll b and thereby total leaf chlorophyll content

Leaf area index was high when inorganic fertilizers were applied in combination with organic manure increased plant densities The high input situations almost doubled the LAI than that at low input situations

The drymatter production at 45 DAS was in the range of 34 to 42 percent of the total drymatter produced at harvest At low-input situations the drymatter production during the active tillering stage of the crop was minimum Addition of organic manure or successive increase in seed rate and fertilizers enhanced drymatter accumulation At higher levels of chemical fertilizers organic manure had significant influence on the uptake of major nutrients at 45 DAS

Increased dose of chemical fertilizers along with organic manure at higher plant densities increased sheathblight and white earhead occurrence

Seed rate independently increased number of panicles per m² but in combination with other factors the increase was nullified At increased plant densities the number of grains per panicle was low Test weight of seed was maximum when organic manure was applied at normal plant densities but increased dose of chemical fertilizers and seed rates decreased it

Organic manuring @ 10 t ha significantly increased the grain yield by 0 75 t ha $^{-1}$ Fertilizer application increased the grain yield by about 1 t ha $^{-1}$ upto the normal fertilizer rate irrespective of seed rates and organic manure application

Highest grain yield of 6 t ha $^{-1}$ was recorded for the treatments receiving either an enhanced seed rate and normal fertilizer dose or a normal seed rate and enhanced fertilizer dose in the presence of organic manure Enhanced seed rates with normal fertilizer dose in the absence of organic manure and normal fertilizer dose with normal seed rate produced low but statistically similar yield in the presence of organic manure In the absence of organic manure and inorganic fertilizers an enhancement of seed rate from 100 to 133 kg ha $^{-1}$ could increase the yield by about 0 5 t ha In the absence of organic manure but with normal fertilizer dose the enhanced seed rates increased the grain yield by about 0 7 t ha $^{-1}$ In the presence of organic matter @ 10 t ha the enhancement in seed rate resulted in similar yield for no or normal fertilizer application rates Increased seed rates at increased fertilizer doses decreased the yield in the absence of organic manure

Maximum straw yields were recorded at high input situations Increased seed rates increased straw yield significantly and lowest straw yield was recorded at least input situations

Reducing any one of the factors like seed rate organic manure and inorganic fertilizers to the normal levels could improve the harvest index to a near optimum 0 49 where the treatments produced higher yields Grain Straw ratio was optimum when normal dose of chemical fertilizers were applied along with organic manures at normal seed rate Inorganic fertilizers in combination with organic manures increased the grain N Straw N ratio over no manauring situations Organic manures significantly increased the NPK uptake at harvest A 10 per cent increase in grain protein was observed at increased dose of chemical fertilizers and normal seed rates in the presence of organic manure over the least input situations Nitrogen uptake was increased by 43% in maximum input situations over the least input situa tions during the harvest stage of the crop Increased seed rates enhanced the nutrient uptake at harvest due to higher drymatter production

The available soil nitrogen content after harvest was significantly reduced from the content prior to experimentation in all the treatments and at different levels of individual factors The available potassium status was reduced only in the non fertilized plots Available P status was maintained at the initial level in all the treatments

The efficiency of applied N in terms of grain production/kg of N applied was greater when organic manure was applied along with inorganic fertilizers In the absence of organic manure the apparent recovery of N at normal rates of application was greater than that at higher levels

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** *Originals not seen*

Appendices

Appendix I

Weekly weather data during the cropping period from 29 6 95 to 20 9 95

Particulars	Max temp C	Min temp °C	R H %	R F mm
Starting from 29 6 95	30 4	24 5	90 14	26 34
	29 2	22 1	93 57	28 97
	30 0	22 3	91 00	5 41
	30 1	23 1	91 43	8 74
	30 1	22 1	92 14	0 09
	30 3	24 0	93 29	10 69
	31 2	24 1	92 43	3 37
	30 4	23 4	91 71	22 41
	28 7	22 1	92 13	22 43
	29 0	22 3	90 14	11 47
	31 1	20 9	87 57	
to 20 9 95	30 7	23 0	93 57	27 11

Appendix II

Plant height at various stages of crop

Treatments	20 DAS	40 DAS	60 DAS	80 DAS
T_1	33 5	52 8	66 1	72 6
T_2	33 5	48 7	65 1	66 0
T_3	35 9	68 5	80 5	83 7
T_4	36 1	68 9	80 9	84 2
T_5	37 5	73 4	84 2	88 8
T_6	36 1	73 5	84 0	88 3
T_7	35 8	60 2	75 8	80 9
T_8	36 3	63 3	79 1	78 7
T_9	38 8	75 7	86 7	91 5
T_{10}	37 1	74 9	87 3	88 9
T_{11}	38 4	79 9	91 3	93 6
T_{12}	39 5	77 8	89 2	90 1

YIELD MAXIMISATION OF DIRECT SOWN RICE UNDER PUDDLED CONDITION

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ABSTRACT OF THESIS
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ABSTRACT

An experiment entitled Yield maximisation of direct sown rice under puddled condition was conducted at Rice Research Station Moncompu Kerala Agricultural University during the additional crop season (Kharif) of 1995 to study the effect of combined use of organic manures and inorganic fertilizers under different plant population for enhancing rice yield in the lowlands of Kuttanad using the variety Pavizham

Factorial combinations of two levels each of organic manure and seed rate and three levels of chemical fertilizers were tried in Randomised Block Design with three replications

Organic manure addition @ 10 t ha^{-1} was found to have pronounced effect on various growth and yield attributing characters of rice when applied alone and/or in combination with chemical fertilizers at recommended dose of 90 45 45 kg NPK ha^{-1} and at increased seed rate of 133 kg ha^{-1} At normal seed rate also organic manuring resulted in higher yields in combination with chemical fertilizers at the higher level of 120 60 60 kg NPK ha^{-1}

The available soil N content after harvest was significantly reduced from the content prior to experimentation in all the treatments The available K status was related only in the non fertilized plots Available P status was maintained at the initial level in all the treatments

The efficiency of applied N in terms of grain production/kg of N applied was greater when organic manures were applied along with inorganic fertilizers In the absence of organic manure the apparent recovery of N at normal rates of application was greater than that at higher levels