

**STUDIES ON AGRONOMIC EFFECTIVENESS OF
GREEN MANURES AND SOURCES OF NITROGEN
ON THE PERFORMANCE OF CROPS IN RICE-BASED
CROPPING SYSTEM UNDER TANK IRRIGATION**

SHARANAPPA

Thesis submitted to the
University of Agricultural Sciences, Bangalore
in partial fulfilment of the requirements
for the award of the Degree of

Doctor of Philosophy

IN

AGRONOMY

BANGALORE

JULY 1992

ಕೃಷಿ ವಿಶ್ವವಿದ್ಯಾನಿಲಯ
ವಿಶ್ವವಿದ್ಯಾನಿಲಯ ಗ್ರಂಥಾಲಯ
ಗಾ.ಕೃ.ವಿ.ಕೆ., ಹೊಸಕೋಟೆ-65.

29 SEP 1992

ಅನುವೃತ್ತಿ ಸಂಖ್ಯೆ **Th. 2820**
ಬಿ.ಸಂ.

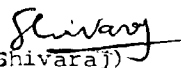
To My Lovely
DAUGHTER NAGASRI

DEPARTMENT OF AGRONOMY
UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

CERTIFICATE

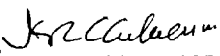
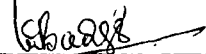
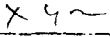
This is to certify that the thesis entitled "STUDIES ON AGRONOMIC EFFECTIVENESS OF GREEN MANURES AND SOURCES OF NITROGEN ON THE PERFORMANCE OF CROPS IN RICE-BASED CROPPING SYSTEM UNDER TANK IRRIGATION" submitted by Mr. SHARANAPPA for the degree of DOCTOR OF PHILOSOPHY in Agronomy of the University of Agricultural Sciences, Bangalore, is a record of research work done by him during the period of his study in this University under my guidance and supervision and the thesis has not been formed previously the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

Bangalore
July 22, 1992


(B. Shivaraj)
Chairman
Advisory Committee

APPROVED BY:

Chairman : 
(B. Shivaraj)

- Members: 1. 
(K. R. Kulkarni)
2. 
(M. Udayakumar)
3. 
(M. K. Badigar)
4. 
(S. Thimme Gowda)

ACKNOWLEDGEMENT

I wish to express my deep sense of gratitude to the Chairman of my advisory committee, Dr.B.Shivaraj, Associate Professor of Agronomy, UAS,Bangalore for his persistent guidance and untiring supervision during all the stages of this investigation, I am very grateful to him for the care and concern he always bestowed on me.

I am equally grateful to Dr.M.K.Badigar, Retd. Professor of Chemistry and Soils, Dr.K.R.Kulkarni, Retd. Director of Research, Dr.M.Udaya Kumar, Professor and Head, Department of Crop Physiology, Dr.S.Thimme Gowda, Associate Professor of Agronomy, University of Agricultural Sciences, Bangalore for their valuable suggestions right from planning of this experiment till the preparation of the thesis.

I sincerely acknowledge the help and co-operation received from the staff members of the Department of Agronomy University of Agricultural Sciences,Bangalore.

I express my deep sense of gratitude to the staff members of the National Demonstration Scheme, UAS,GKVK, Bangalore, for kind co-operation rendered during the period of study.

I acknowledge sincerely the authorities of the University of Agricultural Sciences,Bangalore for granting me study leave to pursue the Ph.D programme.

(ii)

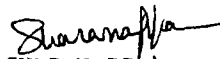
I express my heartfelt gratitude to my mother-in-law, father-in-law, my younger brother Mr. Shivashankarappa and also my wife Mrs. Kalavathy for their constant encouragement and support besides enduring hardships caused by me during the course of study.

It also gives me pleasure to place on record my gratitude to Mr. G. E. Hornappa for neat typing of thesis.

Lastly, I thank and express my gratitude to all those who have helped and encouraged me during the course of study.

Bangalore

July 22, 1992


(SHARANAPPA)

CONTENTS

<u>Chapter</u>	<u>Title</u>	<u>Page</u>
I	INTRODUCTION	... 1
II	REVIEW OF LITERATURE	
2.1a	Choice of crops and their productivity in rice based cropping systems	... 5
2.1b	Residual effects of legumes on succeeding crops	... 11
2.2	Biomass production and nitrogen contribution of green manures	... 14
2.3	Sources of nitrogen and their residual effects on the succeeding crop	... 20
2.4	Yield response and residual effects of green manures	... 25
2.5	Soil fertility changes(NPK) due to green manuring	... 35
III	MATERIAL AND METHODS	
3.1	Location of the experimental site	... 43
3.2	Soil characteristics of the experimental site	... 43
3.3	Climate during the crop growth period	... 45
3.4	Quality of irrigation water used	... 48
3.5	Experimental details	... 50
3.6	Crops and varieties	... 56
3.7	Cultural operations	... 57
3.8	After care	... 61
3.9	Harvesting	... 62
3.10	Collection of experimental data	... 62
3.11	Soil analysis	... 71
3.12	Statistical analysis	... 72

Contd...

CONTENT
(Continued)

<u>Chapter</u>	<u>Title</u>	<u>Page</u>
IV	EXPERIMENTAL RESULTS	
4.1	Experiment 1a: Performance of pre-monsoon fodder maize and green manure crops in tank irrigated areas...	73
4.2	Experiment 1b: Effect of premonsoon fodder maize and in situ grown manures on the succeeding rice crop under two levels of nitrogen	... 81
4.3	Experiment 1c: Residual effect of treatments to <u>kharif</u> rice on the succeeding sunflower	... 119
4.4	Experiment 2a: Effect of sources of nitrogen on the growth and yield of rice	... 163
4.5	Experiment 2B: Residual effect of treatments of <u>kharif</u> rice on the growth and yield of succeeding sunflower under two levels of nitrogen	... 180
4.6.1	Economics of the premonsoon crops, rice and sunflower crops grown in sequence under two levels of nitrogen	... 220
4.6.2	Economics of the rice-sunflower sequence as influenced by sources and levels of nitrogen	... 225
V	DISCUSSION	
5.1	Influence of weather on crop growth	... 229
5.2	Status of the quality of irrigation water	... 230
5.3	Experiment 1 : Effect of premonsoon crops grown and levels of N on growth, yield, economics and soil fertility status of rice-sunflower sequence	... 230

Contd...

CONTENTS
(Continued)

<u>Chapter</u>	<u>Title</u>	<u>Page</u>
5.4	Experiment-2: Effect of sources of nitrogen and levels of nitrogen on the growth, yield, economics and soil fertility status of rice_sunflower sequence	... 253
5.5	Future line of work	... 265
VI	SUMMARY	... 266
VII	REFERENCES	... 274
	APPENDICES	... i - vii:

LIST OF TABLES
(Continued)

<u>Table</u>	<u>Title</u>	<u>Page</u>
4.9	Distribution of drymatter of rice at harvest as influenced by crops grown and nitrogen levels (g/hill)	... 93
4.10	Plant height(cm) and leaf area index of rice as influenced by crops grown and nitrogen levels	... 96
4.11	Influence of crops grown and nitrogen levels on the number of tillers per hill at different growth stages of rice	... 98
4.12	Interaction effects of crops grown and nitrogen levels for rice crop on the number of tillers at 60 days after planting rice	... 100
4.13	Yield parameters of rice as influenced by crops grown and nitrogen levels	... 103
4.14	Interaction effects of crops grown and nitrogen levels on the panicle length of rice(cm)	... 104
4.15	Grain and straw yields, total biomass of rice as influenced by crops grown and nitrogen levels	... 107
4.16	Interaction of crops grown and nitrogen levels on the grain yield of rice (kg per ha) during 1989-90	... 109
4.17	NPK uptake by rice(kg/ha) as influenced by crops grown and nitrogen levels	... 113
4.18	Interaction effects of crops grown and nitrogen levels on the nitrogen and phosphorus uptake by rice crop (kg/ha)	... 116
4.19	Interaction effects of crops grown and nitrogen levels on potassium uptake by rice crop (kg/ha)	... 118
4.20	Influence of premonsoon cropping and residual fertility status of kharif rice crop on the total drymatter production and its distribution in sunflower crop at 50 days after sowing(g/plant)	... 120

Contd.

LIST OF TABLES
(Continued)

<u>Table</u>	<u>Title</u>	<u>Page</u>
4.21	Influence of premonsoon cropping and residual fertility status of <u>kharif</u> rice crop on the total drymatter production and its distribution in sunflower crop at harvest (g/plant)	... 122
4.22	Interaction of the residual effects of premonsoon cropping and N levels for <u>kharif</u> rice on the total drymatter production at different growth stages of sunflower(g/plant)	... 124
4.23	Interaction of the residual effects of premonsoon cropping and N levels for <u>kharif</u> rice on the drymatter distribution in the succeeding sunflower crop(g/plant)	... 127
4.24	Influence of premonsoon cropping and residual fertility status of <u>kharif</u> rice crop on the plant height and leaf area index of sunflower	... 131
4.25	Yield parameters of sunflower as influenced by residual fertility status of rice	... 133
4.26	Interaction of the residual effects of premonsoon cropping and N levels for <u>kharif</u> rice on the diameter of the disc, and per cent filled seeds per head of the succeeding sunflower crop	... 136
• 4.27	Seed and stalk yield and total biomass production of sunflower as influenced by premonsoon cropping and residual fertility status of <u>kharif</u> rice crop	... 140
4.28	Interaction of the residual effects of premonsoon cropping and N levels for <u>kharif</u> rice on the stalk yield and total biomass production of succeeding sunflower crop	... 142
• 4.29	Harvest index, oil content and oil yield of sunflower as influenced by premonsoon cropping and residual fertility status of <u>kharif</u> rice	... 147

Contd...

LIST OF TABLES
(Continued)

<u>Table</u>	<u>Title</u>	<u>Page</u>
4.30	Cumulative yield of biomass production by sequence of crops as influenced by different crops grown, with nitrogen levels and on residual fertility status of rice(t/ha) ...	149
4.31	NPK uptake by sunflower as influenced by premonsoon cropping and residual fertility status of <u>kharif</u> rice crop(kg per ha) ...	151
4.32	Interaction of the residual effects of premonsoon cropping and N levels for <u>kharif</u> rice on the nitrogen and phosphorus uptake by the succeeding sunflower crop (kg/ha) ...	154
4.33	Interaction of the residual effects of premonsoon cropping and N levels for <u>kharif</u> rice on the potassium uptake by the succeeding sunflower crop (kg/ha) ...	156
4.34	Fertility status of soils after harvest of premonsoon crops rice and sunflower ...	158
4.35	Total drymatter and its distribution at different stages of growth of rice as influenced by sources of nitrogen ...	164
4.36	Number of leaves, leaf area and leaf area index of rice as influenced by sources of nitrogen ...	168
4.37	Plant height(cm) of rice at 60 DAP and at harvest as influenced by sources of nitrogen ...	170
4.38	Number of tillers per hill at different growth stages of rice crop as influenced by sources of nitrogen ...	172
4.39	Yield parameters of rice as influenced by the sources of nitrogen ...	174
4.40	Grain and straw yield, total biomass and harvest index of rice as influenced by sources of nitrogen ...	177

Contd

LIST OF TABLES
(Continued)

<u>Table</u>	<u>Title</u>	<u>Page</u>
• 4.41	NPK uptake by rice as influenced by sources of nitrogen (kg/ha)	... 179
4.42	Total drymatter(g/plant) at 50 DAS and at harvest of sunflower as influenced by residual fertility status of rice and nitrogen levels	... 181
4.43	Interaction effect of residual fertility status of kharif rice and nitrogen levels on the total drymatter of sunflower(g/plant) at harvest during 1990-91	... 183
4.44	Drymatter distribution(g/plant) in sunflower as influenced by the residual fertility status of <u>kharif</u> rice and nitrogen levels at 50 days after sowing	... 185
4.45	Interaction effects of residual fertility status of rice and nitrogen levels on the drymatter accumulation in stem(g/plant) of sunflower at 50 days after sowing	... 187
4.46	Drymatter distribution of sunflower at harvest as influenced by residual fertility status of rice and nitrogen levels(g)	... 189
4.47	Plant height and leaf area index of sunflower as influenced by residual fertility status of rice and nitrogen levels	... 191
4.48	Yield parameters of sunflower as influenced by residual fertility status of rice and by nitrogen levels	... 193
4.49	Interaction effects of residual fertility status of <u>kharif</u> rice and nitrogen levels on the number of filled seeds and per cent filled seeds per head of sunflower during 1990-91	... 195
• 4.50	Seed and stalk yields, total biomass and harvest index as influenced by residual fertility status of <u>kharif</u> rice with nitrogen levels	... 199

Contd...

LIST OF TABLES
(Continued)

<u>Table</u>	<u>Title</u>	<u>Page</u>
4.51	Interaction effect of residual fertility status of <u>kharif</u> rice and nitrogen levels on the <u>seed</u> yield and total biomass of sunflower	... 201
4.52	Oil per cent and oil yield of sunflower as influenced by the residual fertility status of rice with nitrogen levels	... 205
4.53	Interaction effects of residual fertility status of <u>kharif</u> rice and nitrogen levels on the oil yield of sunflower (kg/ha)	... 207
4.54	Total biomass production of rice-sunflower sequence as influenced by sources and levels of nitrogen	... 209
4.55	Interaction effect on mean total biomass production as influenced by residual effect of sources and levels of nitrogen (t/ha)	... 211
4.56	NPK uptake by sunflower as influenced by residual fertility status of <u>kharif</u> rice and nitrogen levels for sunflower(kg/ha)	... 213
4.57	Interaction effects of residual fertility status of rice and nitrogen levels on the NPK uptake by sunflower(kg/ha)	... 215
4.58	Organic carbon(%) and available nutrient status of soils after harvest of rice and sunflower	... 219
4.59	Economics of the premonsoon crops-rice-sunflower sequence as influenced by the crops grown and levels of nitrogen	... 221
4.60	Economics of the premonsoon crops-rice-sunflower sequence as influenced by the interaction effects of crops grown and N levels	... 223
4.61	Economics of the rice-sunflower sequence as influenced by the sources of N for rice and levels of N for sunflower	... 226
4.62	Economics of rice-sunflower sequence as influenced by the the sources and levels of N	... 227

LIST OF FIGURES

<u>Figure</u>	<u>Title</u>	<u>Between pages</u>
3.1	Normal and actual weather data during the crop growth period	... 47 - 48
3.2	Normal and actual weather data during the crop growth period	... 47 - 48
3.3	Normal and actual weather data during the crop growth period	... 47 - 48
3.4	Plan of layout of Experiment - 1a	... 50 - 51
3.5	Plan of layout of Experiment - 1b	... 51 - 52
3.6	Plan of layout of Experiment - 1c	... 52 - 53
3.7	Plan of layout of Experiment - 2a	... 54 - 55
3.8	Plan of layout of Experiment - 2b	... 55 - 56
4.1	Yield parameters of rice as influenced by the crops grown in the premonsoon season	...103- 104
4.2	Grain yield of rice as influenced by crops grown in premonsoon season	...107 - 10
4.3	Yield parameters of sunflower as influenced by the residual effect of <u>kharif</u> rice treatments	...133 - 13
4.4	Seed and oil yield of sunflower as influenced by the residual effect of <u>kharif</u> rice treatments	...140 - 14
4.5	Yield parameters of rice as influenced by sources of nitrogen	...174 - 17
4.6	Grain yield of rice as influenced by sources of nitrogen	...175 - 1
4.7	Yield parameters of sunflower as influenced by the residual effect of <u>kharif</u> rice treatments and nitrogen levels for sunflower	...193 - 1

Contd...

LIST OF FIGURES
(Continued)

<u>Figure</u>	<u>Title</u>	<u>Between pages</u>
4.8	Seed and oil yield and oil per cent of sunflower as influenced by the residual effect of <u>khariif</u> rice treatments and nitrogen levels for sunflower	... 199 - 200
4.9	Gross and net income of ~~Rice-Sunflower~~ sequence as influenced by the interaction effect of crops grown and nitrogen levels	... 223 - 224
4.10	Gross and net income of rice-sunflower sequence as influenced by sources and levels of nitrogen	... 227 - 228

LIST OF PLATES
(Continued)

<u>Plate</u>	<u>Title</u>	<u>Between pages</u>
14	Sunflower grown under residual fertility status of <u>kharif</u> rice treatments viz. <u>Sesbania rostrata</u> green manure along with 50 kg fertilizer N per ha	... 138 - 139
15	Sunflower grown under residual fertility status of <u>kharif</u> rice treatment viz. premonsoon fallow and 50 kg fertilizer N per ha	... 138 - 139
16	<u>Kharif</u> rice grown with green leaf manure at 10 t per ha and 75 kg N per ha through urea	... 174 - 175
17	<u>Kharif</u> rice grown with 100 kg N per ha through urea super granules	... 174 - 175
18	<u>Kharif</u> rice grown with 100 kg N per ha through urea alone in three splits	... 174 - 175
19	Sunflower crop grown under the residual fertility status of <u>kharif</u> rice treatment viz. green leaf manure at 10 t per ha + 75 kg N per ha through urea	... 197 - 198
20	Sunflower crop grown under the residual fertility status of <u>kharif</u> rice treatment viz. 100 kg fertilizer N per ha through urea	... 197 - 198

INTRODUCTION

I INTRODUCTION

Land is the gift of nature to mankind. In recent past the agricultural land is increasingly becoming limited due to its increasing varied uses other than agriculture. It has become inevitable to use available land resource with great care to produce enough food, fibre, fuel and other requirements for teeming population. The main thrust in the present day system of farming is aimed to maximise the productivity of crops per unit area per unit time. This can only be achieved through judicious cropping system approach by efficient utilization of scarce resources of land, water, inputs and labour. Rice is an important staple food crop of our country. In rice based cropping system, rice is the base crop endorsed with most favourable growing conditions.

Rice is the World's most versatile cereal crop, grown under varied agroclimatic conditions. Over 90 per cent of the world over rice is grown and consumed in Asia covering 58 per cent of the world's population. In India, rice cultivation covers an area of 41.0 million ha with annual production of 101.95 million tonnes (FAO, 1988). In Karnataka, the rice growing area amounts to 10.51 lakh ha with an annual production of 19.08 lakh tonnes (Anon., 1989). The average

productivity of rice in the state is 1815 kg per ha as compared to 2487 kg per ha in the country.

In these days of edible oil crisis in the country sunflower occupies a unique place among oilseed crops owing to its year long adaptability, drought resistance and short duration. In addition it can successfully be grown under varied soil and climatic conditions. Sunflower oil is noted for high quality for edible purposes as it contains high degree of poly unsaturated fatty acids (PUFA) with anticholesterol properties. In India the coverage under sunflower accounts to 1.66 million ha with a total production of 0.61 million tonnes (FAO, 1988) and an average productivity of 368 kg per ha. In Karnataka, it is grown over an area of 4.62 lakh ha with an annual production of 1.98 lakh tonnes (Anon., 1991a).

In the eastern dry zone of Karnataka State rice occupies an area of 0.70 lakh ha under tank irrigation. The rainfall in this zone ranges from 679 to 889 mm. More than 50 per cent of the rainfall occurs from May to August with a peak period during May and another peak rainfall during September/October. Water is usually limited under tank irrigation and its availability to cover the complete crop growing period is quite uncertain. The existing cropping

system in this zone is characterised by single crop of rice which is generally late planted. Short duration rice cultivars are grown under late planted situations and their yields are low (1490 kg per ha). Further seldomly utilize the full potential of the applied nutrients.

Besides water and other plant nutrients nitrogen supply is the most critical and is a costly nutrient required in large quantities by the crops. Inefficient management of nitrogen for rice leads to losses amounting more than 50 per cent through leaching, runoff, denitrification and volatilization. Loss of nitrogen is greater when supplied through high analysis inorganic sources. Hence an integrated nitrogen management through incorporation of green manures or green leaf manures often acts as a slow release source of nitrogen and helps in sustaining the soil fertility and protecting the environment. It also reduces the dependence on inorganic nitrogen sources to some extent.

In tank irrigated areas of eastern dry zone of Karnataka there is greater scope for raising green manures or a short duration fodder crop for efficient utilization of premonsoon showers. In the years when tank filling rains occur early in the season, medium duration rice cultivars could be grown successfully and the productivity of the crop could be enhanced through efficient nitrogen management.

Several researchers have demonstrated the feasibility of ^{grow} a number of short duration crops after kharif rice. To mitigate the present day edible oil shortages, a short duration oil seed crop like sunflower can be fitted with advantage after kharif rice with protective irrigation. Hence there is greater scope for examining the feasibility of including a premonsoon green manure/fodder crop followed by a short duration oil seed crop after kharif rice. With this in view the studies were initiated with the following objectives:

1. To fit in a green manure/fodder crop to utilize early monsoon rains in tank irrigated areas,
2. To assess the contribution of nitrogen through green manures to the succeeding crops,
3. To study the direct effect of premonsoon green manures and fodder maize on the kharif rice and their residual effect on the succeeding crop after rice.
4. To findout the efficient source of nitrogen for rice and their residual effect on the succeeding crop and
5. To study the changes in soil fertility status due to inclusion of green manures with varying levels and sources of N in rice based cropping system.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

The pertinent literature in the management of rice-based cropping system through the use of green manures and sources of inorganic nitrogen and their residual effect on succeeding crops and changes in soil fertility status is included in this chapter.

2.1a Choice of crops and their productivity in rice based cropping systems

A wide range of crops can successfully be grown under limited moisture conditions after rice (Sadanandan and Mahapatra, 1974; Hukkeri et al., 1978 and Kulkarni, 1979).

Yadahalli et al. (1975) reported that soybean, cowpea and blackgram could successfully be grown in tank and canal irrigated areas after rice. Reddy et al. (1976) found that after harvesting of rice in October groundnut, finger millet or cowpea can be grown successfully during October-January.

Prasad and Rao (1976) reported that rice following fodder cowpea out yielded all other rotations. But from the point view of monetary returns rice-mustard-green gram and rice-niger-horsegram were paying. Balachandran et al. (1977) obtained highest return in rice-rice-groundnut sequence. The beneficial effects of groundnut in the rotation were reported by

Subbaiah and Sreerangaswamy (1978). They opined that groundnut in the rotation serves not only as a cash crop but also as a fertility restoring crop. In addition, groundnut in the rotation economises water. In irrigated belts rice-rice-rice sequence can be adopted under adequate water supply throughout the year. Total yield of 13.93 t of rice per ha was obtained with water use efficiency 39.79. Under limited water availability, rice-rice-greengram/blackgram found to give higher yields (Palaniappan et al., 1978).

Arwooth Nalampang (1978) contended that there is greater advantage of growing several upland crops preceeding or following the main rice crop. It is realised that growing rice continuously year round is often undesirable from soil fertility point of view.

Rice followed by upland crops like soybean was found to be preferable over two crops of rice-rice (Anon., 1978; Mandal and Rao, 1979; Beltrane et al., 1981) in many areas.

Misra (1978) demonstrated that Linseed, mustard and safflower were promising crops after rice in lateritic soils of Bhubaneswar. Among the different crops tested in Rabi season, wheat gave significantly more grain yield per hectare (12.54 q per ha) than rest of the Rabi crops except gram (10.67 q per ha) (Patil and Thakre, 1978). Wal safflower and

sunflower gave comparable yields of 7.8, 7.2 and 7.1 q per hectare respectively. The returns per rupee investment was maximum in case of Wal (Rs. 2.75) followed by safflower (Rs. 2.27), Sunflower (Rs.2.15), wheat (Rs.2.08) and gram(Rs.2.06).

Rice-sorghum/maize for fodder/India fodder bear/ lab lab bean/bengal gram/cowpea/sunflower/safflower are the suggested crops after rice in rainfed uplands in Maharashtra (Anon., 1979 and Patel, 1979).

The maximum biomass production was obtained in the multiple cropping sequence with two crops of rice and one crop of legume viz., groundnut/cowpea (Sasidhar and Sadanandan, 1980).

A study of farming systems in Philippines showed that many farmers were benefitted most economically from mungbean grown after rice; yet the average yield of mungbean grown after rice was less than 300 kg per ha (Flinn et al., 1981). Another study showed that garlic and tobacco grown after rice were lucrative to farmers (Paris and Price, 1979).

At CRRI Cuttack, blackgram produced highest yield (865 to 887 kg per ha) followed by safflower (775 kg per ha) and tobacco (728 kg per ha) after rice (Anon., 1980). Under

residual moisture, crops like gram, lentil, linseed, niger, barley and safflower could be grown after rice (Anon., 1983b), Zandstra (1980) reported that dibbling soybean in rice fallows with no tillage yielded maximum (1.38 and 1.90 t per ha with no mulch and with mulch respectively).

Cropping sequence involving a short duration rice-medium duration rice-green gram produced maximum grain yield (17 tons) in 257 days (Subbarayalu, 1980).

During the years of deficit rainfall horse gram proved superior as second crop (Jha, 1980). In tribal areas of Orissa, rice-niger is as promising sequence (Sreenivasulu, 1980). Rice-safflower and rice-mustard-green gram are the suggested cropping sequences for coastal Orissa (Moorthy and Jha, 1980; Prasad and Rao, 1980).

Mahapatra et al. (1981) opined that rice-wheat-rice and rice-rice-rice are the promising sequences in India at different centres.

The cropping sequences rice-potato-wheat or rice-potato-rice produced 10-12 t per ha of grain and 15 to 17 t per ha of potato. The rice-rice-cowpea rotation in Mangalore resulted in total production of 12.9 t per ha in addition to mean yield of 2.4 t per ha of cowpea (Anon., 1983a).

Jain and Ramasubba Reddi (1981) obtained maximum income of Rs.2989 per ha with greengram as succeeding crop after rice while cowpea gave an income of Rs.2388 per ha.

In studies on soybean-rice, rice-soybean and rice-rice cropping systems practiced at Hunan, China, the best results were obtained with rice-soybean system (Guo, 1982).

Gomez and Zandstra (1982) reported that under zero tillage cowpea (1033 kg per ha) mungbean (260 kg per ha), soybean (342 kg per ha) performed better after rice using residual moisture.

Khan (1983) studied the performance of various upland crops viz. Barley, lentil, pea, linseed, mustard and sunflower. Maximum yields were obtained with barley followed by peas.

Rice-rice-fallow, rice-ragi or rice-pulses are the major cropping patterns in the states of Kerala and Karnata (Mahapatra, 1985).

Mungbean, cowpea, pigeonpea and soybean entries performed better under residual moisture in rice fallows (Anon., 1984b). Joy et al. (1986) found the superiority of grain legumes in relay cropping following kharif rice.

Among the grain legumes blackgram relay cropped with rice produced significantly high grain yield (0.92 t per ha). Rajagopalan and Panalisamy (1986) reported that dibbling blackgram, soybean seeds under no tillage gave 0.53 and 0.41 t per ha respectively.

Sorghum, chickpea and pigeonpea proved better after rice with one irrigation, and with two irrigations groundnut performed better (Anon., 1986c).

Patra and Barik (1988) obtained most economic yields from rice-field bean sequence (5.2 and 2.9 t per ha rice and field pea respectively) and a net return of Rs.11,627 per ha.

Among the various rice based cropping systems tested at Parabani, rice-sunflower sequence gave yields of 2098 kg per ha of rice and 915 kg per ha sunflower (Anon., 1987a). But during the year 1986-87 the yields of both the crops were slightly lower (1939 and 788 kg per ha) (Anon., 1990a). Cropping sequences viz. rice-sunflower, greengram-rice-sunflower and rice-sunflower-greengram were tested at Kathalagere, Coimbatore and Rajendranagar respectively. At Kathalagere the gross returns was Rs.12,857 per ha with production of 3854 kg per ha rice and 1521 kg per ha sunflower during 1987-88 (Anon., 1990b). While during the

year 1988-89, rice-sunflower sequence gave maximum gross returns (Rs.19,062 per ha). The productivity of rice and sunflower was 6164 and 1839 kg per ha. At coimbatore greengram-rice-sunflower produced 908, 6200 and 1838 kg per ha respectively with a gross return of Rs.22,029 per ha (Anon., 1990b). At Rajendranagar rice-sunflower-greengram sequence gave maximum return of Rs.12,757 per ha with a productivity of 3952, 697 and 601 kg per ha of rice, sunflower and greengram respectively (Anon., 1991b).

The beneficial effects of cropping system involving green manures were reported by Bantilan et al. (1989), Garrity et al. (1989). Indigo (Indigofera tinctoria L.) was inter cropped with food or cash crops. After harvest of food or fodder crop, Indigo grows and is incorporated for wet season rice in Philippines. Similarly in China S.cannabina is transplanted as an intercrop in rice and is incorporated for the second season rice crop (Chen, 1988). Carangal et al. (1988) also suggested inter cropping of food, forage and green manure crops in rice.

2.1b Residual effects of legumes on succeeding crops

Higher rice yields resulted when it was preceeded by legumes in the system (Sasidhar and Sadanandan, 1980). Prasad and Rao (1976) also reported high yields of rice grown after legumes than when grown after cereals.

Misra and Misra (1975) opined that mung crop benefitted the following cereal crop of rice in sequence and the yield of rice increased by two to four q per ha. Similarly, Singh and Singh (1975) found that introduction of legumes as summer crops resulted in improved yield of kharif rice.

Inclusion of legumes in the cropping system improved the soil N status, thus reducing the N application to the succeeding crop (Palaniappan et al., 1976). Further, legumes when included in the intercropping or in sequential cropping system can mitigate nutrient deficiency besides smothering weeds and increasing total yield per unit area (Nutman, 1976). Pereira et al. (1979) reported that paddy grown after four years continuous crop of soybean yielded equally as the nitrogen fertilized crop even without fertilization indicating that soybean organic matter left in the soil was sufficient to supply the nitrogen needs of the crop.

Growing cotton and greengram in summer increased the yield of the following rice but on the other hand cereal particularly sorghum and maize as preceeding crops had adverse effect on rice yield (Purushothaman, 1979).

Inclusion of legumes in the system was found to restore the N, improved the physical properties of the soil and found efficient in residual moisture utilization (Chatterjee et al., 1978; Okhuba, 1980; Barlow et al., 1981; Flin et al., 1981).

Jakhro and Faroque (1982) reported further that the number of tillers, per cent nitrogen at 30 DAT and grain yield of rice increased significantly after gram and lucerne.

Incorporation of summer greengram haulms in soil as green manure after harvesting of pods resulted in substantial N economy in the succeeding rice (Meelu, 1981).

In Phillippines, farming studies indicated that including mungbean in the rice based rotation increased the rice yield by one t per ha (Barlow et al. , 1981; Flin et al., 1981).

Studies of Hamid et al. (1981) showed that rice grain yield responses to the three legumes as preceeding crops (Vigna radiata, V. unguiculata and soybean) were identical, highest grain yields were obtained with moderate N rates (80 kg N per ha), higher N rates tended to depress yields and LAI, drymatter accumulation and spikelet number were increased linearly with increase in leaf N content.

De et al. (1983) from the studies on different preceeding legumes reported that mungbean (Vigna radiata), cowpea (Vigna unguiculata) and blackgram (Vigna mungo) increased the grain and straw yields of subsequent rice relative to fodder maize or guar bean (Cyamopsis tetragonoloba) or a grain crop

of phaseolus bean (Phaseolus vulgaris). The benefits from the preceeding crops of mungbean, cowpea or blackgram were equivalent to 36 to 67 kg N per ha applied through chemical fertilizer to rice following a cereal crop. The preceeding legumes improved the number of productive tillers per sq.m., panicle length and number of grains per panicle. The yield increase from the preceeding legumes was noted even when the rice crop was given 90 kg N per ha. Palaniappan (1985), Roger and Watanabe (1986a), Prasad and Palaniappan (1987) were also of the view that legumes included in intensive cropping systems maintain soil fertility and economise fertilizer use. Grain yield and N uptake of rice were higher when rice was grown after dhaincha followed by moong (Antil et al., 1988).

2.2 Biomass production and N contribution of green manures

In India, China and Japan green manure crops had been recognised as an important source of N for wet land rice much before the advent of modern agriculture technology (Bin, 1983; Singh, 1984 and Watanabe, 1984).

2.2a Biomass production

The biomass production in most of the green manures ranged from four to five t per ha in 50 to 60 days. Biomass yield was maximum with Sesbania, sunhemp, cowpea and least

with cluster bean (Singh et al., 1981a and Beri et al., 1989). Sesbania sesban produced leaf yield of 542 to 683 g per plant in wet season and 167 to 377 g per plant in dry season and was more productive than S.formosa and S.grandiflora (Arunin et al., 1988).

Dry matter production of sunhemp ranged from 3.4 to 8.1 t per ha and N accumulation from 68 to 149 kg per ha in 50 to 60 days (Bharadwaj et al., 1981; Meelu and Mossis, 1988; Sharma and Mittra, 1988; Beri et al., 1989 and Salam et al., 1989).

Watanabe (1984) opined that the biomass production of soybean was 11 to 30 t per ha (fresh weight) and N accumulation was 64 to 174 kg per ha at flowering stage. Meelu et al. (1985) reported that biomass production of green manures varied from 12 to 46 t per ha and N accumulation ranged from 50 to 224 kg per ha. Among the Sesbanias N accumulation and total dry matter production was highest with S.rostrata (Anon., 1986e).

Meelu and Morris (1988) opined that soybean accumulate 6.4 t of biomass in 60 days with N accumulation of 138 kg per ha. Morris et al. (1989) found that biomass production 6.7 tons per ha in 60 days old S.rostrata with N accumulation

of 157 kg per ha. Drymatter yield of S.rostrata ranged from 2.1 to 5.1 t per ha with N accumulation ranging from 48 to 116 kg per ha (Herrera et al., 1989). Salam et al. (1989) opined that the drymatter production of S.rostrata in 50 days was 5.0 t per ha and in 60 days 6.1 t per ha. The N accumulation was 96 and 145 kg per ha in 50 and 60 days respectively.

2.2b Nitrogen contribution

Sahu and Nayak (1971) reported that application of green manure or farm yard manure were as effective as application of 22.5 kg fertilizer N per ha. Similar results were obtained by Su (1983).

Khare and Rai (1968) compared the effect of phosphorus on N fixation by leguminous crops and found that maximum N was excreted by Sesbania followed by soybean, cowpea and greengram. The contribution of Sesbania to soil N is actually more than what is added as roots and tops.

Chatterjee et al. (1979) reported that green leaf manures of Sesbania and Ipomea applied before transplanting rice released more N than farm manure and yielded as much as rice with 40 kg N per ha.

Khind et al. (1982) opined that green manures such as dhaincha, cowpea and gaur contributed 120, 73 and 56 kg N per ha to the soil respectively. Green manures with 60 kg inorganic N gave higher yields.

Bhardwaj et al. (1981) reported that green manures such as sunhemp, Sesbania and Ipomea when added to the soil, the N equivalents were 74.5, 49.9 and 25.3 kg per ha which were reflected in the rice yield of 4.96, 4.66 and 4.22 t per ha respectively, compared with 3.40 t per ha without green manuring.

Dreyfus and Dommergues (1980 and 1981) and Dreyfus et al. (1983) reported two unique properties of S.rostrata viz. high N₂ fixing potential (fixes 200 kg N₂ per ha in 50 days) and the ability to nodulate and fix N even with high rates of combined N in the soil.

Meelu and Rekhi (1983) from the studies on N management in a wheat-mungbean-rice sequence found that incorporation of mungbean straw resulted in a saving of 60 kg inorganic N per ha

Singh (1984) reported that Sesbania and sunnhemp when incorporated at 56 days added 100 kg N per ha through their top growth.

Studies from Meelu and Morris (1984) on integrated management of plant nutrients in rice showed that the contribution of N from green manuring ranged from 45 to 80 kg per ha. Mungbean as a green manure for rice was as effective as 80 kg inorganic N per ha (Morris et al., 1984).

Rice yield with green manure application was comparable to rice yield obtained with 100 kg N per ha after maize fodder and 50 kg N per ha following the treatments mungbean-rice, fallow (FYM)-rice, fallow(weedy)-rice. Therefore 50-100 kg N per ha can be saved by adopting green manure-rice cropping pattern without reducing rice yield (Anon., 1984c).

Nitrogen accumulation at 45 days in Sesbania acculeata, Crotalaria juncea, soybean and mungbean was 143, 120, 67 and 115 kg per ha respectively. At 60 days N accumulation was 173, 144, 134 and 136 kg per ha for S. acculeata, C. juncea soybean and mungbean respectively (Anon., 1986e).

Ghai et al. (1985) reported that N content of different green manures (8 week old) ranged from 1.5 to 4.85 per cent). Roger and Watanabe (1986b) reported that N content in legumes varies from 0.2 to 0.6 per cent on fresh weight basis. Further, they found that incorporation of a legume crop is equivalent to applying 30 to 80 kg fertilizer N per ha for rice.

Sesbania and Crotalaria accumulated maximum N between 45 to 55 days after establishment. S.rostrata adds more than 200 kg N per ha when incorporated at 58 days after establishment (Anon., 1986d).

Narasa Reddy et al. (1987) reported that incorporation of five t per ha of either Eichornia crassipes or Ipomea reptans gave the same yield and were comparable with that of 40 kg per ha of fertilizer N. Soybean, Vigna radiata and S.cannabina accumulated 290 to 360, 80 to 130 and 110 to 180 kg N per ha respectively in the tops at maturity. Rice yields and N uptake were highest after S.cannabina and lowest after wet season cereal. Soybean at early flowering stage (110 days) fixed 124 to 167 kg N per ha (Chapman and Myers, 1987).

Rinaudo and Moudiongui (1987) estimated that S.rostrata could fix 300 kg N per ha at the age of 53 days. Nitrogen recovery in green manured plot was higher (71.3 per cent) compared to without green manure (56.5 per cent). Rinaudo et al. (1988a) reported that S.rostrata has high N₂ fixation potential, fast growth and tolerance for flooding.

Antil et al. (1988) computed optimum N rates for wet land rice as 152, kg each after fallow and maize, 74 and 66 kg per ha after S.aculeata and sunnhemp respectively.

Palaniappan et al. (1990) also reported that S. aculeata and S. rostrata accumulated 185 and 219 kg N per ha respectively at 45 days after seeding.

2.3 Sources of nitrogen and their residual effects on the succeeding crop

The efficiency of N_2 utilization for grain production in the tropics is about 50 kg rice per kg N. Recovery of applied N is about 30 to 50 per cent. To produce six tons of rice 120 kg N is required (Prasad and De Datta, 1979). In an intensive cropping system N uptake is estimated at 500 kg per ha per year (Tandon, 1978).

Reddy and Prasad (1977) reported higher grain yield of rice and wheat by the use of slow release N fertilizers and nitrification inhibitors.

Pillai and Vamdevan (1978) found that use of urea supergranules (USG) and mudball techniques showed increasing trend in the yield of rice and N recovery percentage.

De Datta (1978) opined that the use of urea super granules or slow release fertilizers in the form of sulphur coated urea are generally effective in increasing the yield of wet land rice.

Application of USG/urea briquettes after planting rice in between the four hills at 38 kg N per ha or application of sulphur coated urea (SCU) or neem cake coated urea (NCCU) offered promising results (Patel and Mishra, 1979; Rao, 1979; Reddy and Ghosh, 1979). Similarly USG or prilled urea applied behind plough in the moist soil was also reported to perform well (Reddy and Ghosh, 1979).

Sulphur coated urea gave the highest residual effect on succeeding wheat, which produced seven q per ha more grain yield than ordinary urea. The net returns were highest with urea briquettes in rice-wheat rotation (Mangal Prasad and Rajendra Prasad, 1980).

USG proved to be more effective than three split application of urea at levels of 27 and 87 kg N per ha (Anon., 1980). Root zone placement of USG gave significantly higher grain yields over prilled urea split application (Pratap Reddy et al 1981).

Meelu et al. (1983) from the field study on modified urea materials on rice found that USG resulted in lower yields than three split applications of prilled urea and SCU on a rapidly percolating soils. The poor result was attributed to the leaching of urea beyond the root zone in the percolating

water. But on a slow percolating loamy soil at Gurudaspur there was little difference between the various sources of N.

Singh et al. (1984) reported that the new nitrogen carriers were superior to ordinary urea. Placement of USG produced maximum yields of 3.5 and 3.7 t per ha at 39 and 58 kg N per ha. USG was found to produce significantly more yield (5.76 t per ha) when compared to other N sources (Anon., 1984a). Rao (1984) reported USG was superior to best split urea, because N loss was minimum and flood water contained minimum N concentration.

USG was superior to dicyandiamide (DCD) blended as well as neem-cake coated urea (Singh and Prasad, 1985). It was also found from the trials conducted under AICARP at various centres that the USG as a source of N gave better results in rice-wheat rotations (Anon., 1985). Thirty kg N per ha can be reduced for wheat due to N supply through USG for rice in rice-wheat rotation (Anon., 1985-86).

The results of AICARP experiments conducted at Siruguppa in Karnataka indicated residual effect of coal tar treated urea and urea rock phosphate (URP) on the second rice crop. The residual effect of N was noticed when it was supplied through USG and mussurielphos coated urea (MPCU) at Honnaville, Karnataka (Anon., 1985). Placement of USG gave higher yields

in trials of AICARP at Bhubaneswar, Rajendranagar, Thanjavur and Bavanisagar in rice-rice sequence. Residual effect of N was also noticed on the succeeding crop. In rice-wheat sequence USG performed better at various centres, through higher wheat yields compared to prilled urea. At some locations there was no significant difference between 56 and 112 kg N per ha (Anon., 1986a).

Sharma et al. (1985) found more number of panicles per hill, spikelets per panicle and yield resulting from placement of USG as compared to other sources of N. USG placement for rice coupled with foliar application of urea could save 33 per cent of N.

Padalia and Manna (1986), Sharma and Subbaiah (1986) reported maximum yield of rice when N was supplied through USG. Basal application of USG (30.8 q per ha), gypsum coated urea (GCU) (29.9 q per ha), rock phosphate coated urea (29.06 q per ha) were found better than prilled urea or ammonium sulphate in three splits (Anon., 1986b).

Root zone placement of USG at 29 kg N per ha performed better at Pattambi, Mohanpur and Chhangraghat. The response was 30.7 kg grain per kg N with USG followed by 24.5 kg grain per kg N with SCU, while split application of prilled urea (PU) gave only 9 to 16 kg grain per kg N (Anon., 1986c).

Velu et al. (1987) reported 26.3 per cent increase in grain yield of rice with 75 kg N per ha as USG over split application of 100 kg N as urea. The available N status of the soil was markedly increased by the application of USG;

Shetty et al. (1987) found greater N use efficiency when N was supplied through USG or SCU. Singh and Sangliena (1987) also reported beneficial effects of USG placement in the reduced zone after transplanting rice. The leachate from the USG applied plot contained less concentration of N indicating less loss of applied N through USG (Anon., 1987c).

DuraiSwamy and Palaniappan (1988) noticed highest residual effect in wet season rice-dry season rice sequence. Plant height, leaf area index, drymatter production and number of tillers per hill were highest with USG. They attributed this for the slow solubility and retention of NH_4^+ ion in soils which have high CEC due to placement of USG in reduced zone.

Sharma and Roy (1988) noticed the superiority of USG over other sources of N like prilled urea, GCU, NHCU and MPCU. The rice and succeeding wheat yields were maximum with USG. The number of panicles per hill and filled spikelets per hill were also higher. But Subbaiah and Sharma (1988) reported

that there was no significant difference in grain yield among USG, neem cake coated USG and USG with new coating material.

Kulhare (1991) found that USG, neem seed cake coated urea, sal seed cake coated urea and nitrohumic acid coated urea were better than conventional urea. USG and nitrification inhibitor treated urea gave high values of urea equivalents, harvest index, yard stick value and returns. Hundred kg N through USG gave higher return than 150 to 200 kg N per ha through conventional urea.

The experiments conducted under AICARP from 1985-86 to 1988-89 revealed that in rice-wheat sequence, USG was superior to other N sources in majority of the locations and gypsum coated urea was found superior in some locations. Residual effect of USG and GCU on the succeeding wheat was also noticed (Anon., 1987a, 1990a, 1990b and 1991b).

2.4 Yield response and residual effects of green manures

In India green manure is followed in different forms viz. incorporating a legume crop in situ before planting a next crop, simultaneous cultivation of green manure and main crop and adding leaves and cuttings of annual and perennial plants and trees growing else where before planting a crop. Yield responses and residual effects of green manures and green leaf manures is presented below.

Tiwari and Bisen (1971) reported that green manuring wheat with sunhemp and cowpea gave significantly higher grain yield than no green manure. Green manure + 17 kg N + 17 kg P_2O_5 per ha was equal to no green manure + 34 kg N and 34 kg P_2O_5 per ha.

Singh et al. (1971) from green leaf manuring of differer wild legumes (35 t per ha) obtained increased yield from 17 to 59 per cent over no green leaf manure treatment.

Reddi et al. (1972) reported higher grain yield of rice (6.58 t per ha) with 15 t of glyricidia green leaf manures per ha (28.5 t per ha) plus 120 kg N, 60 kg P_2O_5 and 60 kg K_2O per ha as compared to NPK alone (5.5 t per ha) or green leaf manuring alone. The increase in grain yield was attributed to increase in total and productive tillers per hill, test weight, number of filled grains per panicle and test weight. The soil physical, chemical and biological conditions were also improved by green manuring.

Williams et al. (1972) opined that with green manuring vetch produced rice yields equivalent to 50 kg fertilizer N per ha. Bredero (1973) also revealed that incorporation of green manures (legumes) increased the grain yields of rice.

Lin (1975) reported that the rice yields with 16 t green manure per ha was maximum (2.79 t per ha) compared to 95.3 kg NPK per ha (2.5 t per ha), while with no fertilizer rice yield was 1.05 t per ha. Majumdar and Chakraborty (1977) reported higher yields of IR-8 cultivar of rice when 100 kg P in the form of basic slag was supplied along with green vegetation.

Beri and Meelu (1979) reported highest grain yield of rice when Dhaincha(S. aculeata) was incorporated which was equivalent to application of 120 kg N per ha. Chatterjee et al. (1979) reported that incorporation of green leaf manures of Ipomea carnea and S.bispinosa (10 t per ha on dry weight basis) gave rice yield equivalent to 40 kg N per ha as urea applied at the time of transplanting.

Beri and Meelu (1981), Meelu and Rekhi (1981) also showed that burrying Sesbania one day before transplanting gave significantly higher yield and were equivalent to the yield obtained with the application of 90 kg N per ha. Green manures when buried just before planting act as slow release fertilizers and also create reduced conditions which help in mobilizing several other nutrient elements.

Shchashchenko and Belous (1980) concluded that cultivation of rice with green manure applied periodically and NPK applied each year improves the physical characters and chemical composition of rice grain grown in both rotation and monoculture.

Tiwari et al. (1980b) reported significantly higher grain yield of rice and plant NPK uptake by green manuring. Application of 40 kg N per ha along with green manuring compared well with application of 120 kg N per ha without green manuring.

Rice yields were significantly higher with sunhemp and Sesbania green manuring than with no green manure. The net income with sunhemp and dhaincha green manuring was Rs.1504 and Rs.1121 per ha per year (Bharadwaj et al., 1981). Bharadwa (1982) reported that transplanting rice immediately after incorporation of 65 day S.aculeata gave higher yields of rice. Incorporation of mungbean with 80 kg fertilizer N per ha gave three times higher yields obtained with no mungbean incorporation and no fertilizer N (Anon., 1982).

Nagarajiah and Nizar (1982), Rekhi and Meelu (1983), Khind et al. (1985), Joseph (1986), Rana et al. (1988), Mahapatra and Sharma (1989), Kalidurai and Kannaiyan (1990)

reported that green manure plus 50 per cent of the recommended fertilizer N gave higher rice yields than recommended fertilizer N alone.

Khind et al. (1983) opined that the rice yields with the incorporation of 60 day old Dhaincha were equivalent to yields obtained with 120 kg N per ha. Studies of Rinaudo et al. (1983) showed that green manuring with S.rostrata increased the grain yield by 3.72 t per ha and N uptake by the crop (135 ± 46 kg per ha). The N content of the soil was also increased by 444 ± 266 kg N per ha.

De et al. (1983) obtained higher grain yield of rice following the leguminous crops like cowpea, mungbean and blackgram (Vigna mungo) than after maize-fodder crop.

Maximum increase in grain yield (2.7 t per ha) and N uptake (68 kg per ha) was noticed with the incorporation of 62 day old S.rostrata which accumulated 219 kg N per ha (Anon., 1986e).

Rajendra Prasad (1985) reported that incorporation of residues remaining after harvest of soybean pods increased rice yields. On the contrary Morris and Meelu (1985) in a seven year rice-rice-soybean rotation did not notice increase in rice yield

Bhatti et al. (1985) obtained additional yield of 1.0 t per ha with fertilizer along with green manure (4.0 t per ha) than fertilizer alone (3.0 t per ha).

Takahashi et al. (1986) reported higher plant height, tiller number, leaf area index and dry weight per plant of rice following Sesbania sp. (5.2 to 8.4 t per ha) and soybean (4.5 to 5.1 t per ha). Sesbania accumulated maximum biomass at 65 days age upon incorporation improved plant height and tiller number (Anon., 1987b).

Soundarpandian and Lakshminarayanan (1986) concluded the application of green leaf manuring in a permanent amanurial trial during June-September and urea in October-January was beneficial for rice. This was attributed to the favourable environment for the humidification and mineralization of green manure during the first year.

Diack (1986) concluded that green manure had a more marked effect on rice yields than organic matter. Fertilizer N to the extent of 50 per cent can be saved with S. rostrata (Camara and Diara, 1986).

Grain yield of rice was higher by incorporating 45 or 60 days aged S. rostrata than those obtained by fertilizer nitrogen at 60 or 105 kg per ha respectively (Anon., 1986d).

Morris et al. (1986a and 1989) obtained 16 to 24 kg grain per kg N through green manuring rice.

The results of the AICARP experiments in majority of the locations revealed that integrated supply of nutrients was found to have better residual effect in rice-rice and rice-wheat sequences. When 50 per cent of the nitrogen to the kharif crop was applied in the form of green manure followed by recommended level of fertilizer to the Rabi crop the total yield of the sequence was higher than 100 per cent recommended fertilizer N for both the crops (Anon., 1985 and 1986a).

Alazard and Becker (1987) also reported that green manuring rice fields with stem nodulating Aeschenomene afraaspera and A.nilotica increased grain yield by more than 80 per cent over control and the nitrogen content of grain and straw was significantly higher in treatments with Aeschenomene green manure than in other treatments.

Singh et al. (1987) observed that rice yields were enhanced from seven to nine tons per ha when 120 kg N per ha was applied along with incorporation of Sesbania sp. as compared to incorporation of Sesbania sp. alone. Use of S.rostrata has significantly increased rice grain and straw yields and N content of both grain and straw (Rinaudo and Moudiongui, 1987).

Mahapatra et al. (1987) reported that bio-organics (Azolla and Dhaincha) in combination or with chemical N resulted in more N uptake. Ninety kg fertilizer N per ha can also be substituted by dhaincha plus Azolla (6 t per ha). Bio-organics in combination or with chemical N applied had significant residual effect on the succeeding wheat crop. Swarup (1987) and Ghai et al. (1988) obtained rice yields by incorporation of 40 to 50 days old S.rostrata equivalent to 80 to 120 kg fertilizer N per ha. Susbania rostrata at 45 to 60 days accumulated 60 to 90 kg N per ha. Rice yields with the incorporation of S.rostrata increased by 3.7 t per ha while 60 kg N per ha increased the yields by 1.7 t per ha (Ranvir Singh et al., 1988).

Green manuring with sunhemp (Crotalaria juncea) and dhaincha (S.aculeata) significantly improved the growth and yield of rice. Fertilizer N to the extent of 45 to 60 kg per ha can be replaced by incorporating green manure. Residual fertility in terms of organic carbon and available N, P, K increased under green manured plots. Grain yield of wheat/gram increased when grown after rice in plots in which green manure crops were grown (Sharma and Mittra, 1988). On coarse textural soils incorporation upto 35 t per ha (fresh weight) of

S.aculeata the rice yields were progressively increased (Singh et al., 1988). Ishikawa (1988) reported that combined use of green manure and fertilizer N in 56:38 proportion resulted in greater rice yields than fertilizer N alone.

Grain yield, N uptake and agronomic efficiency of rice was higher with basal incorporation of Sesbania green manure and 30 kg fertilizer N five to seven days before panicle initiation stage (Biswas, 1988). Similarly, Ravindra et al. (1989) reported higher rice yield and N uptake with green manure plus 30 per cent fertilizer N than 100 kg fertilizer N alone.

Sesbania green manure to supply 60 kg N per ha gave 25 kg grain per kg N as compared to 18 kg per kg of fertilizer N at 90 kg per ha (Shukla et al., 1989).

Residual effect of green manure on succeeding wheat in rice-wheat rotation was observed by Mahapatra and Sharma (1989). Rice supplied with 80 kg N per ha through urea had no residual effect on the succeeding wheat. While 40 kg N per ha as S.aculeata combined with 40 kg N per ha as urea increased wheat yield by 0.7 and 0.6 t per ha in two years. The residual effect was attributed to more hydrolyzable

and non hydrolyzable organic N in the treatment receiving green manure (Chakraborty et al., 1988) and also due to slowly decomposable component of green manures (Bouldin, 1988).

Mahapatra and Pradhan (1990) also reported that green leaf manuring with 30-30 kg P and K per ha gave higher yields than 60-30-30 kg NPK per ha through fertilizers. Sesbania green leaf manuring gave double the profit of where NPK alone used through fertilizers.

The results of AICARP experiments conducted at different centres viz., Pantnagar, Kalyani, Ludhiana, Kanpur, Varanasi, Faizabad, Navasari, Jabalpur, Kharagpur, Raipur and Rudrur on integrated nutrient supply in rice-wheat sequence it was found that 25-50 per cent of NPK needs of kharif rice can be substituted through green manures. Residual effect of green manures on the succeeding wheat was also observed at some locations (Anon., 1990b and 1991b).

Greengram when included as preceeding crop in the sequence there was slight increase in the rice yields (4065 to 4165 kg per ha) in rice-wheat rotation at Kharagpur. At Ludhiana when cowpea was used as green manure crop in summer there was considerable increase in rice yield (7074 kg per ha) with recommended fertilizer as compared to no green manuring (6494 kg per ha). When cowpea was raised for fodder purpose

there was slight increase in rice yield. The succeeding wheat yield was unaffected by green manuring to rice (Anon., 1990b).

Residual effect of green manure on the second crop of rice in rice-rice sequence was observed by Morris et al. (1989) and Diekmann et al. (1991).

2.5 Soil fertility changes (NPK) due to green manuring

2.5a Organic carbon

Singh and Verma (1969) observed higher soil organic carbon content when green manuring was practiced every year.

Intensive rice-based tripple cropping system would like to add five to six tons of residues per ha per year. After leguminous crop there was slight improvement in organic matter content and available N and P of the soil (Nair et al., 1973). The quantity of the residues added ranged from 3.1 to 3.6 t per ha per year through roots and stubbles of rice in intensive rice-rice sequences. Addition of residues coupled with minimum tillage and slow decomposition of organic residues resulted in increase of organic carbon content of the soil.

Capuna et al. (1980) reported a positive balance of organic matter when sorghum was green manured by berseem, mung and soybean. In cereals, oilseeds and legumes as rotation crops with rice, Tyagi et al. (1982) found that maximum increase of organic carbon with rice-berseem followed by rice-sunflower while in rice-wheat rotation organic carbon remained unchanged.

Green manuring considerably improved organic carbon, available NPK status of the soil and enhanced the uptake of N, P, Ca, Mg, S, Fe, Mn and Zn (Swarup, 1987).

Ishikawa (1988) observed in long term (10 to 51 years) application of milk Vetch green manure increased organic matter and N content of soils. Sahu et al. (1988) also reported higher organic carbon (0.43 per cent) in rice-cowpea rotation as compared to initial soil test values (0.25 per cent)

Organic wastes namely Lantana Litter, rice husk and saw dust markedly increased the organic carbon, the increase being in the order of 29, 19 and 18 per cent respectively over the control. Organic wastes also improved the N status of soil. Available phosphorus content increased by about 20 per cent which was attributed to release of P during decomposition and solubilization of P compounds by organic acids (Sharma et al., 1988).

2.5b Available nitrogen

Crop removal of nitrogen in intensive cropping sequence could exceed 500 kg N per ha through wetting and drying cycles of rainfed wet lands after harvest of rice resulting in considerable loss of available N. In addition to this incorporation of residues of high C:N ratio immobilize nitrogen during decomposition.

Sadanandan and Mahapatra (1973a) reported that inclusion of legumes in the cropping pattern decreased excessive removal of soil N as compared to cereal-cereal rotation.

Nair et al. (1973) from the studies on NPK balances in five rice based cropping systems reported that cropping patterns involving legumes the removal of N was greater (119 and 155 per cent rice-wheat-green gram and rice-Indian rape-soybean respectively). Though there was excess removal of N in cropping patterns involving legumes the soil N status did not show any decline.

Meelu et al. (1979) reported that the available nitrogen status of the soil was considerably lower in rice-wheat-mung rotation. This was due to unfavourable conditions during the growth of rice which has slowed down the mineralization process. Secondly there was spurt in bacterial

population during the initial growth stages of wheat which immobilized the mineral nitrogen. This adversely affected the availability of nitrogen for the succeeding crop.

Purushothaman (1979) studied different cropping sequences and reported positive balance when full recommended dose of N was supplied and it was negative when half the recommended dose of N was supplied. Chakravorti *et al.* (1980) observed a net grain of N where cowpea (forage) was introduced in rice rotation. Rinaudo *et al.* (1988b) also reported greater soil N following *S.rostrata*-rice sequence than fallow-rice sequence under water logged conditions.

Thimmegowda (1985) reported positive N balance in rice-groundnut and rice-finger millet sequence with combined use of organic and inorganic N sources.

Nagarajiah(1988) reported that part of the increase in rice yield following the addition of leguminous green manures and residues was due to increase in soil available N.

2.5c Available phosphorus

Green manuring helps in the increased utilization of fertilizer P by crops (Venkata Rao and Govindarajan, 1960).

Rao et al. (1961), Subbiah and Manikar (1964) have shown that green manure taps, sub soil P and makes it available to the shallow rooted crops. Upon mineralization organically bound P becomes available to crops.

In the field studies Martin et al. (1971) found that poor growth of safflower after continuous cropping of rice is associated with acute phosphorus deficiency. Another study in California (Petersen et al., 1972) showed that sorghum production after rice was improved by phosphorus addition and effect was more evident when wet land rice was grown continuously for four years. Sadanandan and Mahapatra (1973b) reported loss of available P. This was mainly due to the fixation of added P.

Nair et al. (1973) from the studies on five rice based cropping systems found that the P removal ranged from 96-113 per cent of the addition.

During the rainfed post monsoon growing season the wet land soils change from a reduced state to an oxidised state. The active iron ratio is higher after wet land rice than after upland crops. Hence there is fixation of available P leading to lower phosphorus availability (Melhuish et al., 1976). Willet et al. (1977) suggested that soils previously

grown with wetland rice required more P than soils grown with upland crops.

Legume plants have the ability to utilize insoluble phosphates through the well developed root system. When they are used as green manures upon mineralization release P in the available forms (Gu and Wen, 1981; Singh, 1984). Changes in soil pH due to green manuring can influence solubility of P (Singh et al., 1981b).

2.5d Available potassium

Increased availability of K in soil due to green manuring was reported by Kute and Mann (1969), Debnath and Hajra (1972), Katyal (1977); Tiwari et al. (1980a), Nagarajiah et al. (1989) and Swarup (1987). Gu and Wen (1981) found that the legumes have strong ability to absorb inaccessible K in the soil.

Nair et al. (1973) from the studies on five rice based cropping patterns reported that the removal of K exceeded two to three times of the addition. But there was no change in available K when compared to initial status. This was due to continuous replenishment of K from reserved K in K rich Tarai soils. Sadanandan and Mahapatra (1976) reported that in continuous cropping of rice there was decrease in exchangeable K. This was due to removal of K by rice straw.

Dev et al. (1978) reported that 2.1, 0.33 and 3.66 kg NPK each are required to produce 100 kg rice. Hence K is required in larger quantity.

Rice-wheat rotation producing 50 q per ha rice and 38 q per ha wheat removed 150 to 160 kg N, 20 to 25 kg P and 160 to 200 kg K per ha per year. Hence adequate and balanced fertilization is essential in rotations depleting heavy NPK (Sharma and Prasad, 1980).

Narang et al. (1990) reported that in rice-wheat rotation, rice-crop producing 9.5 t per ha of rice and wheat producing 5.9 t per ha of wheat removed 198, 31, 230 kg NPK per ha by rice and 132, 25 and 97 kg NPK per ha by wheat. Soil nutrient status shows that soil fertility with respect to NPK was either maintained or improved. Available P ranged from 16.2 to 20.8 kg per ha and available K ranged from 112-134 kg per ha as against initial soil values of 13.8 and 110 kg P and K per ha respectively. This was partly due to increased fertilizer used and contribution through root biomass

In brief, there is ample literature on sequence of crops in rice based system under adequate resource conditions. But research is scanty on the efficient utilization of early rains

in the tankried areas where 50-60 days are available to raise a crop. Beneficial effects of preceeding legumes and green manures on the rice crop has been well documented. Adequate information is lacking on the residual effects of in situ green manuring on the succeeding crops after rice. Information available on the feasibility of intercropping green manure crops in food or fodder crops is meagre. Urea super granules among the different sources of N was found better by many workers. But there was divergent opinion on the efficiency of residual effects of USG. There is need to strengthen research in these areas.

MATERIAL AND METHODS

III MATERIAL AND METHODS

The material used and methods adopted in the present study conducted during the years 1989-90 and 1990-91 at the University Farm at Main Research Station, Hebbal, Bangalore are described below.

3.1 Location of the experimental site

The field experiments were conducted in plot numbers 17, 18 and 19 of the 'A' range of wet land, Main Research Station, Hebbal, Bangalore-24. It is located at a latitude of 12°58' N, longitude 77°35' E and at an altitude of 899 m above mean sea level.

3.2 Soil characteristics of the experimental site

Composite soil samples from experimental sites were drawn from 0-15 cm soil depth and analysed for physical and chemical properties (Table 3.1).

The soil was sandy clay loam in texture. The bulk density was 1.34 g per cc at site I and 1.45 g per cc at site II. The soil pH was 8.2 at site I and 7.5 at site II. The soluble salt content of the experimental site (0.78 and 0.55 mmhos per cm at site I and site II respectively) was in

Table 3.1 Physical and chemical properties of the soil of the experimental site at Main Research Station, Hebbal, Bangalore-24

	Site I	Site II
A. Physical properties		
1. Mechanical composition (Per cent)		
a) Sand	60.62	52.53
b) Silt	15.10	13.20
c) Clay	24.28	34.27
Textural class		
	Rhodic Paleustalfs	
2. Bulk density (g/cc)	1.34	1.45
B. Chemical properties		
1. pH (1:2.5)	8.20	7.50
2. Electrical conductivity (m mhos/cm)	0.78	0.55
3. Organic carbon (Per cent)	0.44	0.60
4. Cation exchange capacity (me/100g)	9.57	10.89
5. Total nitrogen (kg/ha)	918	1053
6. Available nitrogen (kg/ha)	256	266
7. Available phosphorus (kg P_2O_5 /ha)	56	23
8. Available potassium (kg K_2O /ha)	218	229
9. Exchangeable calcium (me/100 g)	4.30	4.10
10. Exchangeable magnesium (me/100 g)	3.16	3.26
11. Available sulphur (ppm)	20.80	15.12
12. Exchangeable sodium (me/100g)	1.85	0.87

International Pipette Method (Piper, 1966)

Core sampler (Piper, 1966)

Glass electrode method (Jackson, 1973)

Conductivity bridge (Jackson, 1973)

Walkely and Black's Wet oxidation method (Piper, 1966)

Ammonium saturation with neutral normal NH_4OAC (Jackson, 1973)

Jackson (1973)

Alkaline permanganate method (Subbiah and Asija, 1956)

Olsen's extraction with stannous chloride (Jackson, 1973)

Neutral normal Ammonium acetate extraction and Flame photometry (Jackson, 1973)

Versenate method (Jackson, 1973)

Versenate method (Jackson, 1973)

(Chesnin and Yelin, 1950)

Neutral normal Ammonium acetate extraction and Flame photometry (Jackson, 1973)

acceptable limits. The organic carbon per cent of the soil was low (0.44 per cent) at site I and was medium (0.60 per cent) at site II. The available nitrogen was low at both the sites (256 and 266 kg per ha at site I and site II respectively). Total nitrogen content of the soil was 918 kg per ha at site I and 1053 kg per ha at site II. Available phosphorus content of the soil was high at site I (56 kg P_2O_5 per ha) and medium at site II (23 kg P_2O_5 per ha), while available potassium content of the soil was medium at both the sites (218 and 229 kg K_2O per ha at site I and site II respectively). The cation exchange capacity of the soil was 9.57 me per 100 g of soil at site I and 10.89 me per 100 g of soil at site II. The exchangeable calcium was 4.30 me per 100 g soil at site I and 4.10 me per 100 g soil at site II. The exchangeable magnesium was 3.16 me per 100 g soil at site I and 3.26 me per 100 g soil at site II. The sodium content of the soil was 1.85 and 0.87 me per 100 g of soil at site I and site II respectively.

3.3 Climate during the crop growth period

The normal and actual weather data on mean monthly maximum and minimum temperature, mean rainfall, mean relative humidity, mean evaporation, mean wind velocity and daily

sunshine hours during the crop growth period (May 1989 to April 1991) are presented in the table 3.2 and depicted in Fig. 3.1, 3.2 and 3.3.

The maximum temperature 1989-90 ranged from 26.5°C (December) to 33.9°C (May), while during 1990-91, it was from 26.7°C (December) to 33.3°C (March). The minimum temperature during the first year ranged from 12.4°C (January) to 22.3°C (April) and from 15.5°C (February) to 21.4°C (April) during the second year.

The total rainfall during 1989-90 was higher (826 mm) than the normal (819.01 mm). Thus excess rain of 6.99 mm occurred during 1989-90. During the year 1990-91, there was deficit of 413.62 mm than the normal one. The rainfall during October 1989-90 was fairly higher (253.60 mm) than the normal (84.97 mm). In the month of July also excess rainfall occurred. The normal and actual rainfall during July were 94.56 and 182.20 mm respectively. The rainfall during 1990-91 was lower than the normal ones except during April.

The mean relative humidity ranged from 59.00 (March) to 83.50 (July) per cent during the year 1989-90, while it increased from 54.00 (March) to 81.50 (August) per cent during the year 1990-91.

Table 3.2 Meteorological data indicating monthly normal (1979-88) actual 1989-90 and 1990-91 and deviation for the growth period at the Main Research Station, Hebbal, Bangalore

Months	Maximum temperature (°C)				Minimum temperature (°C)				Rainfall (mm)						
	1989-90		1990-91		1989-90		1990-91		1989-90		1990-91				
	N	A	D	A	N	A	D	A	N	A	D	A			
May	33.95	33.90	-0.05	31.70	-2.25	20.78	21.40	+0.62	21.30	+0.52	96.82	47.40	-49.42	67.60	-27.22
June	30.65	30.30	-0.35	30.20	-0.45	20.37	20.00	-0.37	20.10	-0.27	74.85	51.50	-23.35	29.70	-45.15
July	29.83	28.00	-1.83	29.10	-0.73	19.87	19.90	+0.03	19.50	-0.37	94.56	182.20	-87.64	17.70	-76.86
August	28.34	28.30	-0.04	27.70	-0.64	19.63	19.40	-0.23	19.70	+0.07	101.96	47.10	-54.86	69.40	-32.56
September	28.56	28.70	+0.14	31.30	+2.74	19.54	19.50	-0.04	19.90	+0.36	243.80	215.60	-28.20	72.70	-171.10
October	28.41	28.90	+0.49	28.30	-0.11	18.77	18.60	-0.17	19.50	+0.73	84.97	253.60	+168.63	53.70	-31.27
November	26.96	27.10	+0.14	27.10	+0.14	16.85	16.00	-0.85	17.40	+0.55	43.11	9.00	-34.11	16.40	-26.71
December	26.34	26.50	+0.16	26.70	+0.36	15.58	16.10	+0.52	15.60	+0.02	12.18	0.00	-12.18	5.00	-7.18
January	27.28	27.60	+0.32	28.90	+1.62	14.69	12.40	-2.29	15.70	+1.01	5.07	8.20	+3.13	0.00	-5.07
February	29.88	30.70	+0.82	30.70	+0.82	15.99	15.00	-0.99	15.50	-0.49	11.69	0.00	-11.69	0.00	-11.69
March	32.48	32.70	+0.22	33.30	+0.82	18.43	20.10	+1.67	19.90	+1.47	26.13	2.60	-17.53	0.00	-26.13
April	34.13	34.90	+0.77	32.60	-1.53	21.29	22.30	+1.01	21.40	+0.11	29.87	8.80	-21.07	73.20	+43.33
											819.01	826.00	+6.99	405.40	+413.62

Months	Mean Relative Humidity (%)				Evaporation (mm)				Sunshine (hours)				Wind velocity (km/hr)							
	1989-90		1990-91		1989-90		1990-91		1989-90		1990-91		1989-90		1990-91					
	N	A	D	A	N	A	D	A	N	A	D	A	N	A	D	A				
May	61.01	65.50	+4.49	72.00	+13.99	6.85	7.30	+0.45	5.00	-0.85	9.3	9.00	-0.23	7.40	-1.83	8.03	9.40	+1.37	9.50	+1.67
June	72.35	75.00	+2.64	75.00	+2.64	5.51	6.10	+0.59	5.20	-0.31	6.03	6.60	+0.57	6.10	+0.07	14.05	13.20	-0.85	13.30	-0.75
July	71.73	83.50	+9.77	77.00	+3.27	5.31	4.20	-0.93	5.40	+0.09	5.37	5.50	+0.13	4.90	-0.47	12.02	10.70	-2.32	14.00	+0.98
August	76.16	81.00	+4.84	81.50	+5.34	4.40	4.30	-0.10	4.30	-0.10	5.44	5.90	+0.46	4.20	-1.24	12.44	11.00	-1.44	11.20	+0.78
September	75.96	79.00	+3.04	73.00	-2.96	4.23	4.30	+0.07	4.50	+0.27	6.15	6.70	+0.55	6.90	+0.75	7.65	7.20	1.45	7.00	+0.15
October	72.37	75.00	+2.63	77.00	+4.63	4.24	3.50	-0.74	3.90	-0.34	7.27	6.00	-1.27	6.00	-1.27	5.30	5.00	1.70	4.40	+1.10
November	71.76	72.50	+0.74	75.50	+3.74	3.48	4.10	+0.62	3.30	-0.18	7.20	8.20	+1.00	8.40	+0.90	5.48	5.20	0.70	4.40	+1.00
December	59.92	75.00	+5.08	73.00	+3.08	3.76	3.84	+0.08	3.60	-0.16	7.67	8.10	+0.43	8.30	+0.63	6.17	5.89	0.70	5.30	+0.67
January	67.35	64.00	-3.35	68.50	+1.15	4.56	4.70	+0.14	4.90	+0.34	9.11	8.90	-0.21	9.30	+0.19	6.31	5.60	-0.71	6.10	-0.71
February	62.37	64.00	+1.63	60.03	-2.32	5.63	6.10	+0.47	6.70	+1.07	9.68	10.20	+0.32	10.20	+0.32	5.58	5.90	+0.32	6.10	+0.52
March	56.38	59.00	+2.62	54.00	-2.38	7.01	6.90	-0.11	7.70	+0.69	9.72	9.60	-0.12	10.00	+0.28	6.05	5.60	-0.45	5.70	-0.15
April	56.76	58.00	+1.24	50.50	-6.26	7.21	7.60	+0.39	6.30	-0.91	9.47	9.40	-0.07	9.00	-0.47	6.26	6.10	-0.06	5.30	-0.96

N = Normal (1979-88)A = ActualD = Deviation

N = Normal (1979-88)

A = Actual

D = Deviation

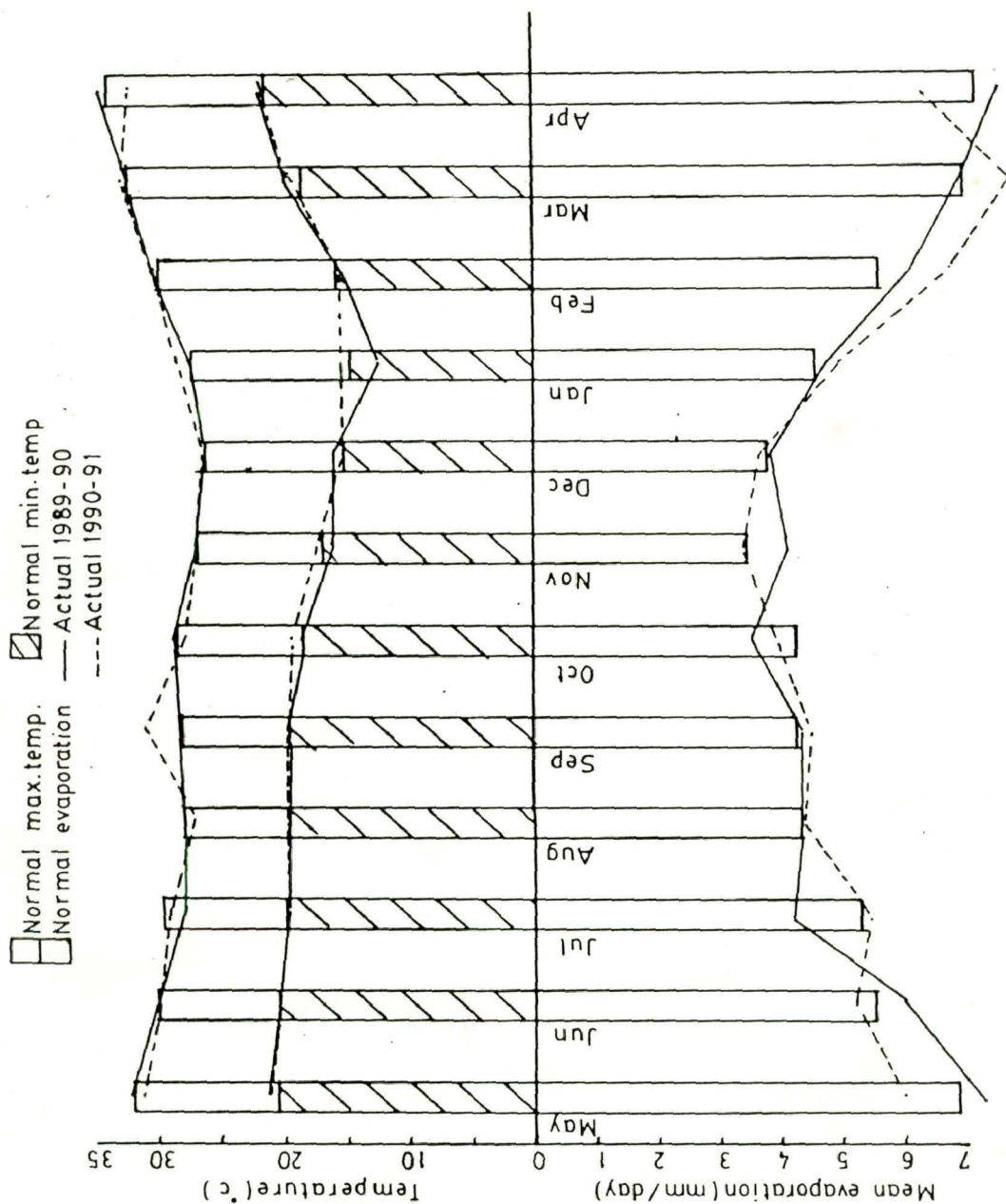


FIG. 3-1. NORMAL AND ACTUAL WEATHER DATA DURING THE CROP GROWTH PERIOD

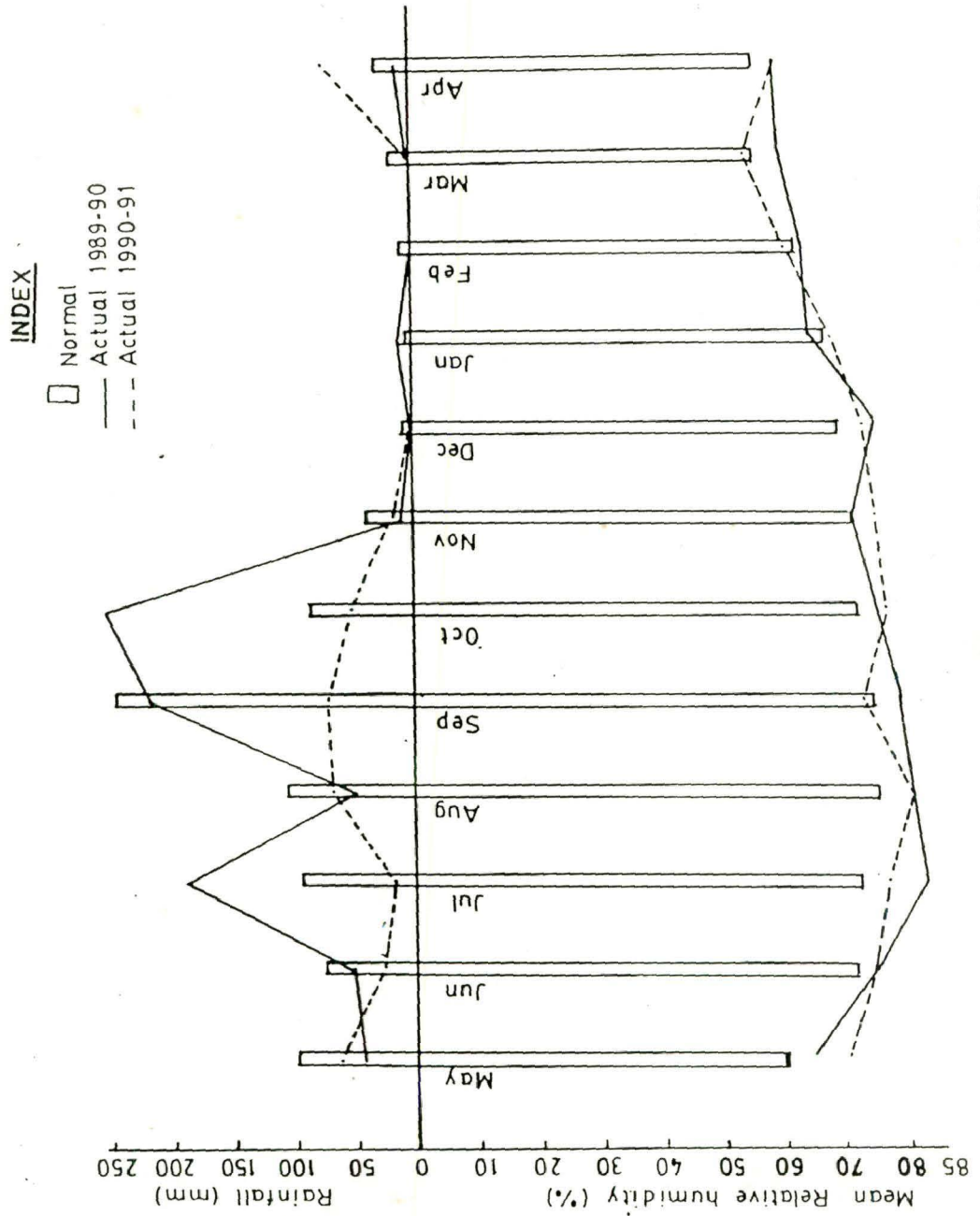


FIG. 3.2. NORMAL AND ACTUAL WEATHER DATA DURING THE CROP GROWTH PERIOD.

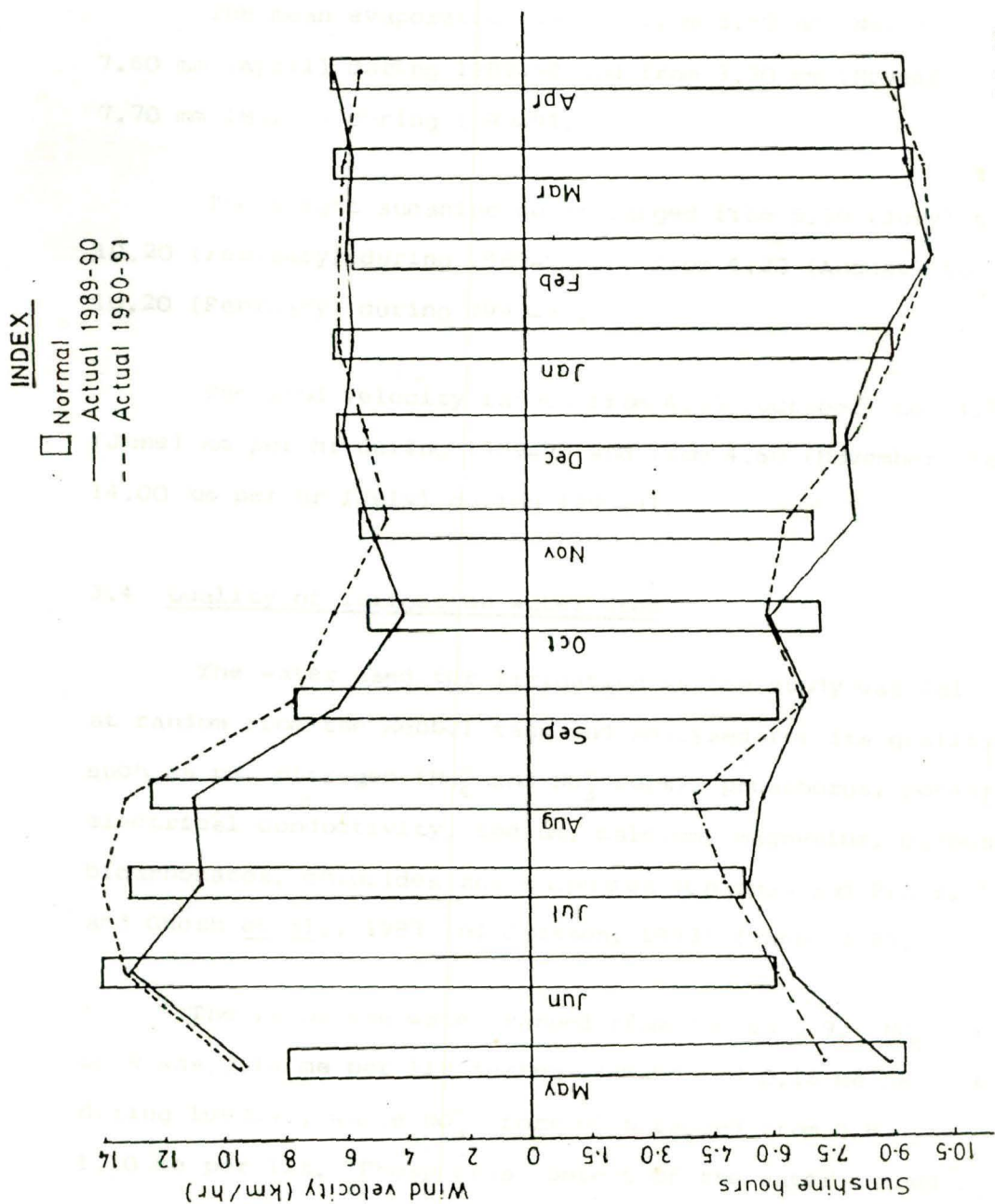


FIG. 3.3. NORMAL AND ACTUAL WEATHER DATA DURING THE CROP GROWTH PERIOD

The mean evaporation varied from 3.50 mm (November) to 7.60 mm (April) during 1989-90 and from 3.30 mm (November) to 7.70 mm (March) during 1990-91.

The bright sunshine hours ranged from 5.50 (July) to 10.20 (February) during 1989-90 and from 4.20 (August) to 10.20 (February) during 1990-91.

The wind velocity ranged from 4.00 (October) to 13.20 (June) km per hr during 1989-90 and from 4.60 (November) to 14.00 km per hr (July) during 1990-91.

3.4 Quality of irrigation water used

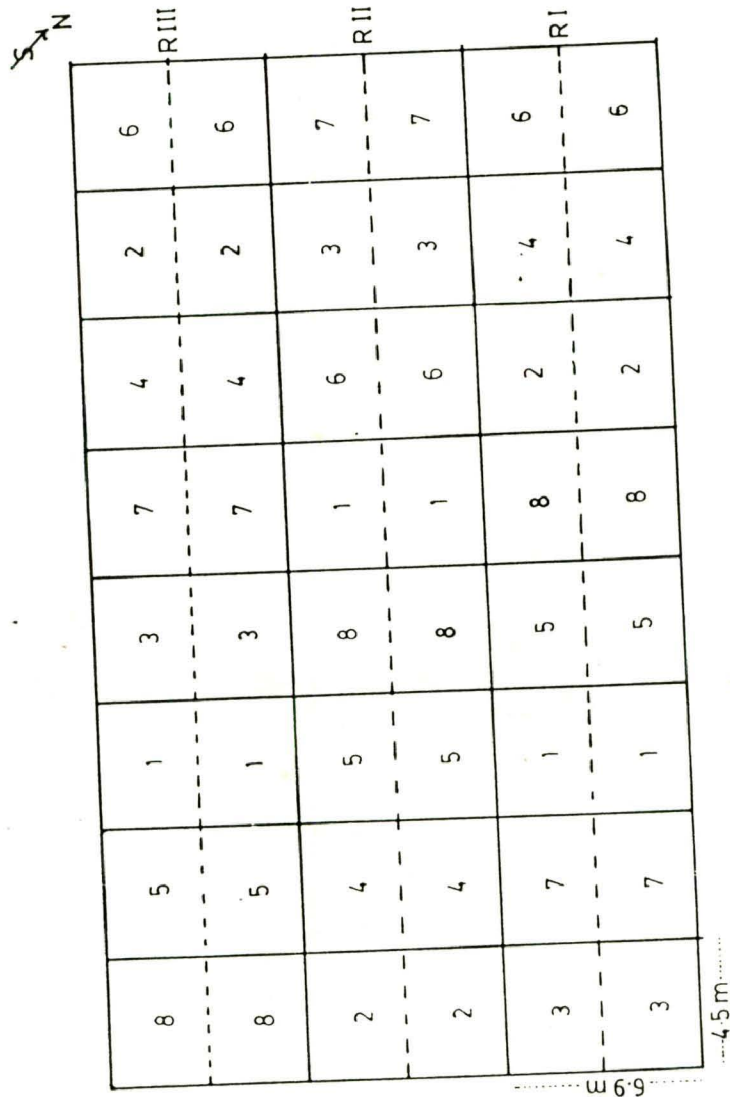
The water used for irrigation in the study was collected at random from the Hebbal tank and analysed for its quality such as pH, nitrogen (NH_4^+ and NO_3^- form), phosphorus, potassium, electrical conductivity, sodium, calcium, magnesium, carbonate, bicarbonates, chlorides and sulphates (Chapman and Pratt, 1982 and Ghosh *et al.*, 1983 and Jackson, 1973) (Table 3.3).

The pH of the water ranged from 7.6 to 7.9. NH_4^+ form of N was 0.16 me per lit during 1989-90 and 0.18 me per lit during 1990-91, while NO_3^- form of N ranged from 0.80 to 1.10 me per lit. Phosphorus content of the water ranged from

Table 3.3 Appraisal of quality of irrigation water used for the study

	1989-90	1990-91
1. pH	7.90	7.60
2. Soluble salts (μ mhos/cm)	1.30	1.25
3. Sodium (me/l)	2.88	1.81
4. Calcium (me/l)	2.20	1.60
5. Magnesium (me/l)	3.40	2.40
6. Carbonates (me/l)	Tr	Tr
7. Bicarbonates (me/l)	7.00	5.65
8. Sulphates (me/l)	Tr	Tr
9. Chlorides (me/l)	6.20	5.30
10. $\text{NH}_4\text{-N}$ (me/l)	0.16	0.18
11. $\text{NO}_3\text{-N}$ (me/l)	1.10	0.80
12. Phosphorus (me/l)	0.12	0.15
13. Potassium (me/l)	1.25	1.18
14. Residual sodium carbonate (me/l)	-1.40	-1.65
15. Sodium adsorption ratio(SAR)	1.72	1.28

(Analytical procedure followed as described by Chapman and Pratt, 1982; Ghosh et al., 1983 and Jackson, 1973)



Premonsoon treatments

1. Maize
2. Soybean
3. Sesbania rostrata
4. Sunhemp
5. Maize + Sunhemp
6. Maize + S. rostrata
7. Maize + Soybean
8. Fallow (no preceding crop)

FIG. 3.4. PLAN OF LAYOUT OF EXPERIMENT-1a

Treatments

1. Maize
2. Soybean
3. Sesbania rostrata
4. Sunhemp
5. Maize + Sunhemp in 1:1 proportion
6. Maize + S. rostrata in 1:1 proportion
7. Maize + Soybean in 1:1 proportion
8. Fallow (No preceeding crop).

Maize was harvested for fodder while the soybean, S. rostrata and sunhemp grown either in sole or intercrop with maize were used as in situ green manures for rice.

Design : Randomised Complete Block. Design

Plot size : Gross 6.90 m x 4.50 m

Replications : Three

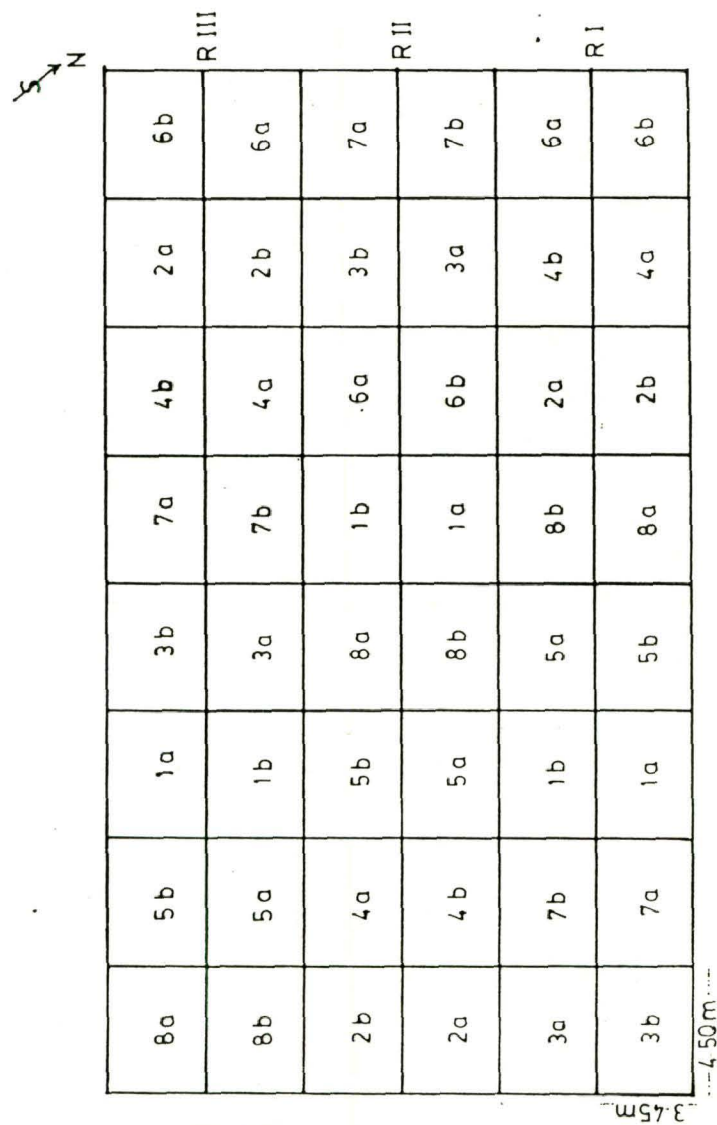
3.5.2 Experiment 1b

Effect of premonsoon fodder maize and in situ grown green manures on the succeeding rice crop under two levels of nitrogen

After harvest of premonsoon fodder maize and green manure crops, rice was taken during kharif under two levels of nitrogen. Each main plot was subdivided into two sub plots

Plate 1: Maize sole crop grown without fertilizers
for green fodder purpose as preceeding
crop of kharif rice

47



Main plot treatments for rice

- 1 Maize
- 2 Soybean
- 3 Sesbania rostrata
- 4 Sunhemp
- 5 Maize • Sunhemp
- 6 Maize • S. rostrata
- 7 Maize • Soybean
- 8 Fallow (no preceding crop)

Sub plot treatments for rice

- a) 50 Kg N / ha
- b) 100 Kg N / ha

FIG. 3.5. PLAN OF LAYOUT OF EXPERIMENT-1b

before sowing of experiment 1a. Two levels of nitrogen which were allocated to each subplot. The treatment details are given below.

Main plot : Eight treatments of experiment include

1. Maize
2. Soybean
3. Sesbania rostrata
4. Sunhemp
5. Maize + Sunhemp
6. Maize + S.rostrata
7. Maize + Soybean
8. Fallow (No preceeding crops to kharif rice)

Sub plot : Two levels of nitrogen

1. 50 kg N per ha
2. 100 kg N per ha

Design : Split plot

Plot size : Gross 4.50 m x 3.45 m
Net 4.30 m x 3.15 m

Replications : Three



Main plot treatments for sunflower

1. Maize - Rice
2. Soybean - Rice
3. Sesbania rostrata - Rice
4. Sunhemp - Rice
5. Maize • Sunhemp - Rice
6. Maize • S. rostrata - Rice
7. Maize • Soybean - Rice
8. Fallow - Rice

Sub plot treatments for sunflower

- a) 50 Kg N / ha for Rice
- b) 100 Kg N / ha for Rice

R III	8a	5b	1a	3b	7a	4b	2a	6b
	8b	5a	1b	3a	7b	4a	2b	6a
R II	2b	4a	5b	8a	1b	6a	3b	7a
	2a	4b	5a	8b	1a	6b	3a	7b
R I	3a	7b	1b	5a	8b	2a	4b	6a
	3b	7a	1a	5b	8a	2b	4a	6b

3.45m

4.50m

FIG. 3.6. PLAN OF LAYOUT OF EXPERIMENT -1C

3.5.3 Experiment 1c

Residual effects of treatments to kharif rice on
the succeeding sunflower

After harvesting of kharif rice crop sunflower was grown without disturbing the plots under residual effects of kharif rice treatments.

Main plot treatments of kharif rice

1. Maize-rice
2. Soybean-rice
3. S.rostrata-rice
4. Sunhemp-rice
5. Maize + Sunhemp-rice
6. Maize + S.rostrata-rice
7. Maize + Soybean-rice
8. Fallow-rice

Sub plot treatments of kharif rice

- a) 50 kg N per ha for rice
- b) 100 kg N per ha for rice

Design : Split plot

Replications : Three

Plot size : Gross 4.50 m x 3.45 m
Net 3.60 m x 3.00 m

These experiments were conducted at site I during the years 1989-90 and 1990-91. The plan of layout of these experiments is given in Fig.3.4, 3.5 and 3.6.

3.5.4 Experiment 2a

Effect of sources of nitrogen on the growth and yield of rice

Fertilizer nitrogen was supplied through different sources viz. urea (46.4 per cent), urea rockphos (36.4 per cent), urea gypsum (36.5 per cent) and urea super granules (46 per cent) and combination of organic and inorganic source viz. green manure and urea. The treatment details are given below.

1. Green leaf manure at 10 tons per ha + 75 kg N per ha
through urea
2. N through urea in three splits at 100 kg per ha
3. N through gypsum coated urea (GCU) at 100 kg per ha
4. N through urea supergranules (USG) at 100 kg per ha
5. N through urea rockphos (URP) at 100 kg per ha

Pongamia (Pongamia pinnata) green leaf manure was incorporated into the soil three weeks before transplanting. N through urea, gypsum coated urea and urea rockphos were applied in three splits, while urea supergranules were applied after four to five days of transplanting in a single dose. The USG were placed at the centre of four hills to a depth of 2-3 cm.



4	2	5	1	3	R I
4	2	5	1	3	
3	1	5	2	4	R II
3	1	5	2	4	
2	4	3	1	5	R III
2	4	3	1	5	
1	3	5	4	2	R IV
1	3	5	4	2	

4.40m

Treatments for rice

1. Green leaf manuring at 10t/ha + 75 Kg N/ha through urea.
2. N through urea in 3 splits at 100 Kg/ha.
3. N through Gypsum coated urea at 100 Kg/ha
4. N through urea supergranules at 100 Kg/ha
5. N through urea rockphos at 100 Kg/ha.

FIG. 37. PLAN OF LAYOUT OF EXPERIMENT-2a

Plate 8 : General view of the Experiment 1b

Plate 9 : General view of the Experiment 2a

Plate 10 : General view of the sunflower crop
grown after kharif rice

Design : Randomised Complete Block Design
Replications : Four
Plot size : Gross 7.5 m x 4.4 m
 Net 6.4 m x 4.0 m

3.5.5 Experiment 2b

Residual effect of treatments of kharif rice on the growth and yield of succeeding sunflower under two levels of nitrogen

The five sources of nitrogen of experiment 2a form five main plots. Each main plot was subdivided into two subplots before planting rice in experiment 2a. The two levels of nitrogen to sunflower form two subplots.

Main plot : Five treatments of experiment 2a
Sub plot : Two levels of N to sunflower viz.
 1. Zero kg N per ha
 2. 31 kg N per ha
Design : Split plot
Replications : Four
Plot size : Gross 4.4 m x 3.6 m
 Net 4.0 m x 2.7 m

These experiments were conducted at site II during 1989-90 and 1990-91. The plan of layout of these experiments are given in Fig.3.7 and 3.8.



4b	2a	5b	1a	3b	R I
4a	2b	5a	1b	3a	
3a	1b	5a	2b	4a	R II
3b	1a	5b	2a	4b	
2a	4b	3a	1b	5a	R III
2b	4a	3b	1a	5b	
1b	3a	5b	4a	2b	R IV
1a	3b	5a	4b	2a	

7.50m
4.40m

Main plot treatments for sunflower

1. Green leaf manuring at 10 t/ha • 75 Kg N/ha through urea for rice
2. N through urea in 3 splits at 100 Kg /ha for rice
3. N through gypsum coated urea • at 100 Kg/ha for rice.
4. N through urea supergranules at 100 Kg/ha for rice.
5. N through urea rock phos at 100 Kg /ha for rice.

Sub plot treatments for sunflower

- a) Zero N/ha for sunflower
- b) 31Kg N/ha for sunflower

FIG.3.8. PLAN OF LAYOUT OF EXPERIMENT-2b

3.6 Crops and varieties

3.6.1 Maize

African tall maize variety of fodder maize was used. It matures in 90 days, can be grown throughout the year. Its green fodder is known to enhance the milk yield in milking cows. It has yield potential about four to five tonnes of green fodder per ha.

3.6.2 Soybean

Soybean cultivar KHSb-2 developed from a cross between Mamloxi x EC 39821 released during 1979 was used. It is semi indeterminate type matures in 100-115 days and produces sufficient biomass in 60-70 days.

3.6.3 Rice

3.6.3.1 Mangala (MR-272)

It was developed from the cross between Jaya x S-317 and was released in 1976. Matures in 105 to 120 days. It grows to a height of 85-90 cm. It has medium bold grains. It is tolerant to salt and cold. Yield potential is 5.0 to 5.5 t per ha.

3.6.3.2 Pushpa (MR-301)

It was developed from the cross between Jaya x Bangarathega, and was released in 1977. It matures in 130-135 days. It has long slender grains. The plants grow to a height of 95-98 cm. It has good cooking quality. Yield potential is 6.0 to 6.5 t per ha.

3.6.4 Sunflower

Morden sunflower cultivar was used which was released in 1979. It is a dwarf (80-90 cm plant height) and short duration (75 to 80 days) variety. The yield potential is 800 kg per ha. Its oil content varies from 38 to 41 per cent. This variety is ideally suited as mixed and cash crop.

3.7 Cultural operations

Sunflower was the previous crop of the experimental site. Land was prepared thoroughly by cultivating with Kolar Mould board plough and then levelled. The individual plots of required size were prepared. In the subsequent seasons, only land within the plots was prepared to the required tilth manually.

3.7.1 Fertilizer application

Pre-monsoon maize and green manure crops were not fertilized in experiment 1a. Fifty kg P_2O_5 and 50 kg K_2O per ha was given to the rice crop of experiment 1b and 2a at the time of transplanting. Nitrogen was applied as per the treatments in three splits i.e. basal, 25 and 45 days after transplanting in experiment 1b. In experiment 2a nitrogen was applied as per treatments. Zinc sulphate at 20 kg per ha was applied after two weeks of transplanting paddy.

The succeeding sunflower after rice in experiment 1c was given 75 kg P_2O_5 and 62.5 kg K_2O as basal dose. In experiment 2b sunflower was fertilized with nitrogen as per treatments. Phosphorus and potassium were applied at 75 and 62.5 kg per ha. The basal fertilizer dose for rice was given by broadcasting after the plots were ready for transplanting. For sunflower fertilizers were band placed in rows at 2-3 inches depth before sowing. Phosphorus was applied in the form of single superphosphate (16 per cent) and potassium through muriate of potash (60 per cent). Nitrogen was supplied through urea. The seeds of soybean, S. rostrata and sunhemp were treated with Rhizobium at 375 g per ha before sowing.

3.7.2 Spacing

Maize and green manure crops in experiment 1a was sown at a row spacing of 30 cm. Mangala cultivar of rice in experiment 1b was planted at a row spacing of 15 cm and at inter-row spacing of 10 cm. Pushpa cultivar of rice in experiment 2a was planted with a spacing of 20 cm x 10 cm. Sunflower was sown at a row spacing of 45 cm and at inter row spacing of 20 cm.

3.7.3 Sowing

The dates of sowing and harvesting of maize and green-manure crops, rice and sunflower during 1989-90 and 1990-91 are given in the table 3.4.

Rice nursery was raised in raised beds of size 7.5 m length 1.2 m width and 10 cm height. Twenty five days old seedlings were transplanted in experiment 1b and 22 days old seedlings were used in experiment 2a. Two to three seedlings per hill were transplanted.

Sunflower seeds were sown at two to three seeds per hill. After 14 days of sowing one healthy and vigorous seedling per hill was allowed and the rest were removed.

Table 3.4 Dates of sowing/transplanting and harvesting of crops in Experiment-1 and Experiment-2

	<u>Sowing/Transplanting</u>		<u>Harvesting</u>	
	1989-90	1990-91	1989-90	1990-91
<u>EXPERIMENT-1</u>				
1. Maize and greenmanure crops	29-5-1989	16-5-1990	8-8-1989	19-7-1990
2. Rice	28-7-1989	9-7-1990	24-11-1989	12-11-1990
	23-8-1989	4-8-1990		
3. Sunflower	12-1-1990	9-1-1991	24-4-1990	12-4-1991
<u>EXPERIMENT-2</u>				
1. Rice	10-7-1989	22-6-1990	30-11-1989	5-11-1990
	2-8-1989	14-7-1990		
2. Sunflower	12-1-1990	9-1-1991	24-4-1990	12-4-1991

3.8.4 Hand pollination

Sunflower was hand pollinated between 8.0 AM to 11.00 AM every day for 8-10 days to improve seed setting.

3.9 Harvesting

Harvesting was done from the individual plots separately. Maize was harvested for fodder in both sole crop and intercrop treatments. S.rostrata, soybean, sunhemp were harvested by cutting close to the ground. Then the harvested plants were chuffed to pieces and incorporated into the soil in both sole and intercrop treatments.

Rice was harvested from the net plots, threshed separately and dried in Sun. After threshing the rice, the straw was also dried in Sun separately for two to three days.

The sunflower heads from net plot area were harvested dried and threshed separately. The seeds were dried in Sun separately. The stalks were cut close to the ground and dried in Sun.

3.10 Collection of experimental data

3.10.1 Growth studies

Five plants were collected each time from the destructive sampling area i.e. rows next to border rows outside the net plot.

Observations on the growth viz. plant height, number of tillers/branches, number of leaves, leaf area, drymatter production and its distribution were recorded.

Plant height

Plant height was recorded at harvest in maize, soybean, S.rostrata and sunhemp from ground level to the base of newly opened leaves. In rice plant height was recorded at 60 days after transplanting and at harvest. The plant height was recorded from ground level to the base of the newly opened leaves before panicle emergence and at harvest, the height was recorded from the ground level to the tip of the earhead. In sunflower the plant height was recorded at harvest from ground level to the top of the sunflower head. The average values of plant height was calculated from the five plants.

Number of tillers per hill

In rice the number of tillers per hill was recorded at 30 days interval from the date of planting and at the time of harvest. The mean number of tillers per hill are computed.

Leaf Area Index (LAI)

The leaf area in rice and sunflower was recorded by using LI-3100 area meter from LI-COR, Inc/LI-COR, Ltd. Nebraska, USA. In rice leaf area was recorded at 30 days

interval from the date of transplanting. In sunflower leaf area was recorded at 50 days of sowing. Average leaf area per hill/plant was calculated. The LAI was calculated as given by Watson (1952).

$$\text{LAI} = \frac{\text{Leaf area per plant}}{\text{Land area per plant}}$$

Drymatter production and distribution

Plant samples were collected at different growth stages and dried at 65 to 70°C till constant weight was reached. The mean drymatter per plant and its distribution in different parts of the plant was recorded.

3.10.2 Yield attributing characters

Rice

Five randomly selected hills per each plot were harvested from the destructive sampling area i.e. next to the border rows but outside the net plot area. From these five hills yield attributing characters viz. number of panicles per hill, panicle length, number of filled and unfilled spikelets per panicle, test weight were recorded.

Number of panicles per hill

The number of panicles per hill was counted and the mean value was recorded.

Panicle length

Five panicles were randomly selected. Panicle length was measured from base of the peduncle to the tip of the peduncle and the mean length was recorded.

Number of filled and unfilled grains per panicle

Ten panicles were selected at random. The number of filled as well as unfilled grains from each panicle was counted. The mean value was recorded.

Test weight

Grains from the panicles of five hills were separated and dried at 65 to 70°C to a constant weight. Thousand grains were counted and weighed. The weight was expressed in grams.

Sunflower

Five plants were selected at random from the rows next to border rows on either side of the plot at harvest. The heads were harvested. Yield attributes were recorded from these ear heads.

Diameter of the head

The diameter of the five randomly selected heads was measured. The mean diameter per head was expressed in cm.

Number of filled seeds

The seeds from each heads were threshed separately. The number of filled seeds per head was counted. The average value per head was recorded.

Per cent filled seeds

Per cent filled seeds per head was calculated by the values of total number of seeds and filled seeds per head as follows.

$$\text{Per cent filled seeds/head} = \frac{\text{Filled seeds/head}}{\text{Total number of seeds/head}} \times 100$$

Seed yield per plant

The filled seeds from the five plants were dried to a constant weight at 65-70°C and weighed separately. The average seed yield per plant was recorded in grams.

Test weight

Thousand filled seeds were counted from the seed yield of five plants. The weight was recorded as test weight in grams.

3.10.3 Yield studies

Biomass yield of fodder maize and green manure crops

The biomass yields of fodder maize, sunhemp, soybean and S.rostrata were recorded per plot after cutting close to the ground. The yield per ha was calculated.

Grain yield of rice

The grain yield per net plot obtained was weighed and yield per hectare was computed.

Straw yield of rice

The straw from net plots was weighed after drying. The yield per hectare was calculated from the yield of net plots.

Seed yield of sunflower

After harvest the weight of dried seeds from the net plot was recorded and yield per hectare was computed.

Stalk yield of sunflower

Dried sticks and thalamus from the net plot were weighed and yield per hectare was computed.

Oil yield of sunflower

This was calculated by multiplying the seed yield per hectare with their respective oil per cent.

Total biomass yield of individual crops and sequence

Total biomass yields in rice and sunflower were calculated by summing up the grain/seed and straw yields of respective crops.

The total biomass yield per hectare of the ~~sequence~~ in experiment-1 was computed by summing up the fresh yield of maize fodder/soybean S.rostrata/sunhemp or in combination as per the treatments and the total biomass yields of rice and sunflower per hectare. In experiment-2 the total biomass yield per hectare was calculated by summing up the total biomass yields of rice and sunflower.

Harvest index

Harvest index of rice and sunflower was calculated from the grain and total biomass yields of the respective crops using the following relationship.

$$\text{Harvest Index} = \frac{\text{Grain yield}}{\text{Total biomass yield}} \times 100$$

3.10.4 Economic analysis

The cost of cultivation, the gross and net returns per hectare were workedout based on the existing cost of inputs, labour and prices of products. The cost of cultivation per hectare for the individual crops as well as for the system as a whole for both the experiments was workedout. Similarly the gross returns per hectare was workedout. The benefit to cost ratio was calculated based on the gross returns

3.10.5 Quality studies

Oil content of sunflower seeds

The oil content of the sunflower seeds sampled at random from the net plot was determined in Nuclear Magnetic Resonance (NMR) spectrophotometer (Brokker Minispec, P-20) against a standard reference sample, whose oil content was accurately estimated by Soxhlet method using petroleum ether solvent as extractant as described in AOAC (1975). The oil content was expressed in per cent.

Chemical analysis

Plant analysis

Plant samples collected at harvest for drymatter studies in different crops were used for plant analysis. The shoot of maize fodder, sunhemp, S.rostrata and soybean, seed and shoot of rice and sunflower were powdered in Willey Mill. The powdered plant samples were used for analysing nitrogen, phosphorus and potassium.

Nitrogen was estimated by digesting one gram of the powdered sample using 10-15 ml of concentrated sulphuric acid along with digestion mixture and was carried out as described by Jackson (1973).

Phosphorus and potassium concentrations in plant samples were estimated by Wet oxidation method as described by Jackson (1973).

Phosphorus

Phosphorus was estimated on 2 ml aliquot by developing yellow colour using HNO_3 - Vanadomolybdate reagent. The intensity of the yellow colour developed in the test sample was measured at 430 nm in spectrophotometer (Model CL-24) (Jackson, 1973).

Potassium

One ml of the digested sample was diluted to known volume with distilled water and fed to a flame Photometer fitted with potassium filter as described by Jackson (1973).

3.11 Soil analysis

Fifteen days after incorporation of green manures, after harvest of rice and sunflower, soil samples were drawn plot-wise from top 0-15 cm soil layer, air dried and sieved through 2 mm sieve and used for further chemical analysis.

Organic carbon per cent of the soil was estimated by the wet digestion method (Jackson, 1973). Available nitrogen content of the soil was analysed by following the alkaline potassium permanganate method as suggested by Subbiah and Asija (1956). The available phosphorus in the soil was determined by extracting with Olsen's reagent (0.5 N NaHCO_3) (Olsen et al., 1954). The P content in the extracted solution was determined by developing typical blue colour using ammonium molybdate and stannous chloride solutions. The intensity of the blue colour developed was measured at 660 nm (Jackson, 1973). The available potassium was extracted with neutral normal ammonium acetate (NH_4OAC) and was determined flame Photometrically as described by Jackson (1973).

3.12 Statistical analysis

The experimental data were analysed statistically by "Fisher's method of analysis of variance" particular to the design as outlined by Sundarraj et al. (1972). The level of significance in 'F' test was tested at 5 per cent. The interpretation of data was done using CD values calculated at $P = 0.05$.

Pooled analysis was done by taking years as main plot and treatments of experiment 1a and experiment 2a as subplots. While in experiment 1b and 1c and experiment 2b double split plot analysis procedure was followed taking years as main factor.

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

The results of the field experiments conducted during 1989-90 and 1990-91 are presented in this chapter.

4.1 Experiment 1a

Performance of premonsoon fodder maize and green manure crops in tank irrigated areas

4.1.1 Biomass yield of fodder maize and green manure crops

The biomass yield of sole fodder maize was 12.40 and 9.47 t per ha in 1989-90 and 1990-91 respectively. The mean biomass yield of sole fodder maize was 10.94 t per ha. The biomass yield of fodder maize with maize + soybean was superior (5.51 and 7.00 t per ha in 1989-90 and 1990-91 respectively and the mean of 6.26 t per ha) over maize + sunhemp and maize + S.rostrata (mean of 5.66 and 5.00 t per ha).

The biomass production was higher with sole sunhemp (17.70 and 25.93 t per ha during 1989-90 and 1990-91 respectively) followed by S.rostrata (17.20 t per ha in 1989-90 and 20.82 t per ha in 1990-91). The mean biomass yield of sole sunhemp was also higher (21.82 t per ha) followed by S.rostrata (19.01 t per ha). The biomass yield of S.rostrata grown as intercrop was higher during both the years (6.10 and 6.77 t per ha during 1989-90 and 1990-91 respectively) followed by the biomass yield of sunhemp intercrop (mean of 5.54 t per ha (Table 4.1)).

Table 4.1 Biomass production of crops (t/ha on fresh weight basis) during premonsoon season

Treatments	1989-90			1990-91			Mean		Total Biomass		
	Maize	Green manure		Maize	Green manure		Maize	Green manure	1989-90	1990-91	Mean
Maize	12.40	-		9.47	-		10.94	-	12.40	9.47	10.94
Soybean	-	4.60		-	4.08		-	4.34	4.60	4.08	4.34
<u>Sesbania rostrata</u>	-	17.20		-	20.82		-	19.01	17.20	20.82	19.01
Sunhemp	-	17.70		-	25.93		-	21.82	17.70	25.93	21.82
Maize + Sunhemp	4.58	5.80		6.74	5.28		5.66	5.54	10.38	12.02	11.20
Maize + <u>S. rostrata</u>	5.06	6.10		4.94	6.77		5.00	6.44	11.16	11.71	11.44
Maize + Soybean	5.51	3.10		7.00	2.50		6.26	2.80	8.61	9.50	9.06
S.E.m±									7.63	0.78	0.77
CD at 5%									1.95	2.39	2.23

4.1.2 Total biomass

Total biomass of fodder maize and green manure crops differed significantly among the treatments. Sunhemp sole crop produced significantly higher total biomass in both the years (17.70 and 25.93 t per ha in 1989-90 and 1990-91 respectively with the mean total biomass of 21.82 t per ha). During 1989-90 the total biomass yield of sunhemp and S.rostrata were at par, while during 1990-91 and the mean total biomass of sunhemp was higher followed by S.rostrata. Among the intercropping treatments of maize and green manure crops, maize + S.rostrata recorded significantly higher total biomass yield (11.16 and 11.71 t per ha in 1989-90 and 1990-91 respectively) which was on par with maize + sunhemp (11.16 and 11.71 t per ha in 1989-90 and 1990-91 respectively). Sole crop of soybean recorded lowest total biomass yield 4.60 and 4.08 t per ha in 1989-90 and 1990-91 respectively and the mean of two years was also lower (4.34 t per ha) (Table 4.1).

4.1.3 Drymatter production per plant

Drymatter production per plant was higher in fodder maize during both the years (15.05 and 15.62 g per plant in 1989-90 and 1990-91 respectively). Drymatter production per plant of maize was reduced comparatively when intercropped

with sunhemp, S.rostrata and soybean. Among the intercropping treatments the drymatter production per plant was higher with maize + soybean (mean dry weight of 7.32 g per plant).

Among soybean, S.rostrata and sunhemp the drymatter production per plant was higher with S.rostrata in sole cropping (8.15 and 8.80 g per plant in 1989-90 and 1990-91 respectively) as well as in intercropping of maize + S.rostrata (6.38 and 6.37 g per plant in 1989-90 and 1990-91 respectively). The mean drymatter production per plant also followed similar trends (Table 4.2).

4.1.4 Plant height

Fodder maize was taller in sole cropping (110 cm in 1989-90 and 130 cm in 1990-91 and mean of 120 cm) followed by maize + soybean intercropping (106 cm in 1989-90 and 125 cm in 1990-91 and mean of 116 cm). Sunhemp and S.rostrata reduced the plant height of maize in maize + sunhemp and maize + S.rostrata intercropping treatments. S.rostrata grown to a height of 82 cm (mean of two years) in sole cropping while in maize + S.rostrata there was reduction in plant height (mean of 77 cm). The mean plant height of sunhemp in sole cropping and maize + sunhemp intercropping was higher than S.rostrata (91 cm in sole cropping sunhemp and 86 cm in maize + sunhemp intercropping) (Table 4.2).

4.1.5 Uptake of nitrogen by premonsoon crops

Uptake of nitrogen by fodder maize during 1989-90 was 79.9 kg per ha and was 61.08 kg per ha in 1990-91. The mean N uptake was 70.53 kg per ha. Maize in maize + S.rostrata intercropping removed more N (35.54 kg per ha in 1989-90 and 57.77 kg per ha in 1990-91 and mean of 46.66 kg per ha).

Sole S.rostrata removed more N in 1989-90 (161.00 kg per ha) while sunhemp removed more N during 1990-91 (230.29 kg per ha) and the mean N uptake was 193.74 kg per ha by sunhemp followed by S.rostrata. Among the intercropping treatments S.rostrata removed more N (60.21 kg per ha) during 1989-90 while/ 1990-91 sunhemp removed more N (60.12 kg per ha). The mean N uptake was higher by sunhemp (55.82 kg per ha) followed by S.rostrata (54.83 kg per ha) (Table 4.3).

Total N uptake was higher with sole crop of S.rostrata during 1989-90 (161.0 kg per ha) and by sunhemp in 1990-91 (230.29 kg per ha). The mean total N uptake was also higher with sunhemp in sole crop (193.74 kg per ha) followed by S.rostrata sole crop. The lowest N uptake was by soybean both in sole and intercropped treatments (Table 4.3).

4.1.6 Uptake of phosphorus by premonsoon crops

Phosphorus uptake by sole maize was higher (15.29 and 12.68 kg per ha in 1989-90 and 1990-91 respectively). Mean P uptake was 13.98 kg per ha. Phosphorus uptake by maize in maize + S.rostrata during 1990-91 and the mean P uptake was higher (11.04 kg per ha in 1990-91 and mean of 8.67 kg per ha).

Sunhemp removed more P as a sole crop (16.14 kg per ha in 1989-90 and 23.65 kg per ha in 1990-91 and mean of 19.90 kg per ha). In intercropping treatments S.rostrata removed more P in 1989-90 (5.97 kg per ha) while sunhemp in 1990-91 (6.18 kg per ha). The mean P uptake was higher (5.90 kg per ha) by sunhemp in maize + sunhemp system (Table 4.3).

Total P uptake was significantly higher with sole sunhemp (16.14 kg per ha in 1989-90 and 23.65 kg per ha in 1990-91 and mean of 19.90 kg per ha). This was on par with sole S.rostrata. Sole soybean crop removed significantly lowest phosphorus (Table 4.3).

4.1.7 Uptake of potassium by premonsoon crops

Potash uptake by maize sole crop was higher (71.72 kg per ha in 1989-90 and 54.77 kg per ha in 1990-91 with a mean value of 63.25 kg per ha) followed by maize + S.rostrata

of
Table 4.3 NPK composition/crops grown during premonsoon season (kg/ha)

Premonsoon crops	1989-90		1990-91		Mean		Total NPK		
	Maize	GM	Maize	GM	Maize	GM	1989-90	1990-91	Mean
Nitrogen									
Maize	79.98	-	61.08	-	70.53	-	79.98	61.08	70.53
Soybean	-	42.11	-	37.35	-	39.93	42.11	37.76	39.93
<u>Sesbania rostrata</u>	-	161.00	-	194.90	-	177.95	161.00	149.90	177.95
Sunhemp	-	157.18	-	230.29	-	191.74	157.18	230.29	193.74
Maize + Sunhemp	29.54	51.51	43.50	60.12	36.52	55.82	81.05	103.61	92.33
<u>Maize + S. rostrata</u>	35.54	60.21	57.77	49.45	46.66	54.83	95.75	107.22	101.49
Maize + Soybean	32.64	32.03	31.86	26.98	32.25	29.51	64.67	58.84	61.76
S.Em ²							4.38	11.46	6.13
CD at 5%							13.51	35.31	17.91
Phosphorus									
Maize	15.29	-	12.68	-	13.98	-	15.29	12.68	13.98
Soybean	-	8.10	-	7.41	-	7.76	8.10	7.41	7.76
<u>Sesbania rostrata</u>	-	15.94	-	19.80	-	17.87	15.94	19.80	17.87
Sunhemp	-	16.14	-	23.65	-	19.90	16.14	23.65	19.90
Maize + Sunhemp	5.31	5.62	8.32	6.18	6.82	5.90	10.94	14.49	12.72
<u>Maize + S. rostrata</u>	6.29	5.97	11.04	4.90	8.67	5.44	12.25	15.94	14.09
Maize + Soybean	6.40	5.04	6.09	4.24	6.25	4.64	11.44	10.33	10.88
S.Em ²							0.75	1.31	0.76
CD at 5%							2.31	4.05	2.21
Potassium									
Maize	71.72	-	54.77	-	63.25	-	71.72	54.77	63.25
Soybean	-	18.22	-	17.81	-	18.01	18.22	17.81	18.01
<u>Sesbania rostrata</u>	-	75.80	-	91.77	-	83.79	75.80	91.77	83.79
Sunhemp	-	54.27	-	79.51	-	66.89	54.27	79.51	66.89
Maize + Sunhemp	26.49	17.78	39.00	20.76	32.75	19.27	44.28	59.76	52.02
<u>Maize + S. rostrata</u>	31.87	23.35	51.80	23.28	41.84	25.82	60.22	75.09	67.65
Maize + Soybean	29.27	14.18	28.57	10.82	28.92	12.50	43.45	39.39	41.42
S.Em ²							3.08	5.66	3.22
CD at 5%							9.48	17.43	9.39

GM = Green manure crops

intercropping (31.87 kg per ha in 1989-90, 51.80 kg per ha in 1990-91 and mean of 41.84 kg per ha). Sole S.rostrata recorded maximum K uptake during both the years (75.80 kg per ha in 1989-90 and 91.77 kg per ha in 1990-91 and mean of 83.79 kg per ha). Among the intercropping treatments S.rostrata in maize + S.rostrata recorded higher K uptake (28.35 kg per ha in 1989-90 and 23.28 kg per ha in 1990-91 and mean of 25.82 kg per ha).

Total K uptake was significantly higher with S.rostrata sole crop (75.80 kg per ha in 1989-90 and 91.77 kg per ha in 1990-91 and mean 83.79 kg per ha). Potash uptake by S.rostrata during 1989-90 was on par with maize. While during 1990-91 K uptake by sole S.rostrata was on par with sunhemp sole crop (79.51 kg/ha) and maize + S.rostrata (75.09 kg/ha). Total K uptake was significantly lowest with sole soybean (mean of 18.01 kg per ha) (Table 4.3).

4.2 Experiment 1b

Effect of premonsoon fodder maize and in situ grown green manures on the succeeding rice crop under two levels of nitrogen

4.2.1 Total dry weight at 30, 60 days after transplanting and at harvest

Total dry weight at 30 DAP was significantly higher with green manuring as sole crop of S.rostrata for rice during

both the years (2.74 and 3.06 g per hill in 1989-90 and 1990-91 respectively) which was on par with green manuring sole sunhemp. The mean total dry weight was also significantly higher with green manuring sole S.rostrata (2.90 g per hill) followed by sole sunhemp (2.62 g per hill). Lowest total dry weight was recorded with maize-rice sequence (1.58 and 1.67 g per hill in 1989-90 and 1990-91 respectively with a mean value of 1.63 g per hill) which was on par with fallow-rice. Among intercropping treatments followed by rice maximum total dry weight of rice per hill was recorded with maize + S.rostrata.

Total dry weight at 30 DAP increased significantly due to addition of N at 100 kg per ha over 50 kg N per ha. The increase in dry weight was 0.44 g per hill in 1989-90, 0.61 g per hill in 1990-91 and mean increase was 0.52 g per hill (Table 4.4).

Interaction effect of premonsoon crops grown and N levels on the drymatter production per hill at 30 DAP of rice was significant (Table 4.5). Maize in the premonsoon followed by rice produced lower dry matter per hill at both the N levels during both the years (mean of 1.42 and 1.83 g per hill at 50 and 100 kg N per ha respectively) which was on par with premonsoon fallow treatment. The dry matter production of rice with S.rostrata and sunhemp at 50 kg N level per ha (mean of 2.35 and 2.25 g respectively) was on par with premonsoon

Table 4.4 Total drymatter of rice (g/hill) as influenced by crops grown and nitrogen levels

Treatments	30 days after planting			60 days after planting			At harvest		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91	Mean
Maize	1.58	1.67	1.63	5.38	5.15	5.27	16.50	12.43	14.46
Soybean	2.36	2.35	2.36	8.49	6.83	7.66	22.62	19.97	21.29
<u>Sesbania rostrata</u>	2.74	3.06	2.90	9.59	7.64	8.62	25.85	21.00	23.43
Sunhemp	2.51	2.72	2.62	8.67	7.06	7.86	23.99	20.40	22.20
Maize + Sunhemp	2.24	2.28	2.26	7.43	6.14	6.79	20.22	17.43	18.83
Maize + <u>S. rostrata</u>	2.26	2.28	2.27	7.62	6.47	7.04	21.16	17.32	19.24
Maize + Soybean	2.02	1.96	1.99	6.71	5.86	6.29	19.54	16.20	17.87
Fallow	1.79	1.80	1.80	6.33	5.26	5.80	17.38	13.82	15.60
S.Em±	0.08	0.12	0.07	0.18	0.36	0.20	0.55	0.59	0.40
CD at 5%	0.24	0.37	0.21	0.55	1.11	0.59	1.68	1.78	1.17
<u>Nitrogen levels</u>									
50 kg N/ha	1.97	1.96	1.97	6.77	5.66	6.22	18.60	15.58	17.07
100 kg N/ha	2.41	2.57	2.49	8.28	6.95	7.61	23.30	19.07	21.16
S.Em±	0.02	0.06	0.03	0.12	0.06	0.07	0.29	0.24	0.19
CD at 5%	0.06	0.18	0.09	0.37	0.19	0.20	0.88	0.73	0.55

soybean (2.62 g) intercropped sunhemp (2.43 g), S.rostrata (2.45 g) and soybean (2.23 g) at 100 kg N level.

Total dry weight at 60 DAP was significantly higher with green manuring sole S.rostrata (9.59 g per hill in 1989-90, 7.64 g per hill in 1990-91 and mean of 8.62 g per hill) During 1990-91 dry weight per hill with green manuring sole soybean (6.83 g per hill) and sunhemp (7.06 g per hill) were at par with green manuring with sole S.rostrata. Among intercropping treatments maize + S.rostrata-rice recorded higher dry weight per hill (mean of 7.04 g per hill) and was on par with maize + sunhemp-rice (mean of 6.79 g per hill). Maize-rice recorded significantly the lowest dry weight per hill (5.38 g in 1989-90, 5.15 g in 1990-91 with a mean of 5.27 g per hill) followed by fallow-rice (mean of 5.80 g per hill).

Total dry weight at 60 DAP was significantly higher with 100 kg N per ha over 50 kg N per ha. Increase in dry weight due to increase in 50 kg N per ha was 1.51 g per hill in 1989-90 and 1.29 g per hill in 1990-91 and mean of increase was 1.39 g per hill over 50 kg N per ha (Table 4.4).

Interaction effect of premonsoon crops and N levels on the mean dry weight per hill at 60 DAP was significant (Table 4.5). Maize in the premonsoon and 50 kg N per ha for rice produced lowest drymatter per hill (4.39 g). The

Table 4.5 Interaction effects of crops grown and nitrogen levels on the drymatter production of rice (g/hill)

Treatments	30 days after planting								60 days after planting			
	1989-90				1990-91				Mean			
	50 kg N/ha	100 kg N/ha	50 kg N/ha	100 kg N/ha	50 kg N/ha	100 kg N/ha	50 kg N/ha	100 kg N/ha	50 kg N/ha	100 kg N/ha	50 kg N/ha	100 kg N/ha
Maize	1.35	1.80	1.48	1.86	1.42	1.83	4.39	6.14				
Soybean	2.10	2.62	2.08	2.62	2.09	2.62	7.13	8.18				
<u>Sesbania rostrata</u>	2.37	3.11	2.33	3.75	2.35	3.45	7.58	9.65				
Sunhemp	2.29	2.74	2.21	3.23	2.25	2.99	7.10	8.62				
Maize + Sunhemp	2.08	2.39	2.10	2.46	2.09	2.43	6.29	7.28				
Maize + <u>S. rostrata</u>	2.10	2.42	2.08	2.47	2.09	2.45	6.36	7.73				
Maize + Soybean	1.78	2.26	1.72	2.19	1.75	2.23	5.44	7.13				
Fallow	1.68	1.91	1.67	1.93	1.68	1.92	5.42	6.17				
Comparison of sub plot means at the same level of main plot means												
	S.E.m $\pm$	CD at 5%	S.E.m $\pm$	CD at 5%	S.E.m $\pm$	CD at 5%	S.E.m $\pm$	CD at 5%	S.E.m $\pm$	CD at 5%	S.E.m $\pm$	CD at 5%
	0.06	0.18	0.17	0.62	0.09	0.26	0.19	0.57				
Comparison of main plot means at same or different level of sub plot means												
	0.09	0.27	0.17	0.52	0.09	0.28	0.25	0.71				

drymatter per hill of rice with premonsoon soybean, S.rostrata and sunhemp at 50 kg N level (ranged from 7.10 to 7.58 g) was on par with intercropped sunhemp, S.rostrata and soybean (ranged from 7.13 to 7.73 g) at 100 kg N level and superior to maize and fallow treatments at 100 kg N per ha (6.14 and 6.17 g respectively). S.rostrata green manure produced maximum drymatter per hill (7.58 and 9.65 g respectively) at both the N levels.

Total dry weight at harvest was significantly higher with green manuring S.rostrata for rice (25.85 g per hill in 1989-90 and 21.0 g per hill in 1990-91 and mean of 23.43 g per hill. During 1990-91 dry weight per hill with S.rostrata green manuring (21.0 g per hill) was at par with green manuring with sunhemp and soybean. Among the intercropping treatments maize + sunhemp-rice (mean of 18.83 g per hill) and maize + S.rostrata-rice (mean of 19.24 g per hill) were at par. Maize followed by rice recorded lowest total dry weight per hill (16.50 g per hill in 1989-90 and 12.43 g per hill in 1989-90 and mean of 14.46 g per hill) which was on par with fallow-rice (15.60 g per hill) (Table 4.4).

Addition of 100 kg N per ha enhanced the total dry weight significantly. The increase in total drymatter per hill due to 100 kg N per ha was 4.70 g in 1989-90, 3.49 g in 1990-91 and mean of 4.00 g over 50 kg N per ha (Table 4.4).

Table 4.6 Distribution of drymatter in leaves and stems(g/hill) of rice at 30 days after planting as influenced by crops grown and nitrogen levels

Treatments	Leaves			Stem		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean
Maize	0.77	0.65	0.71	0.81	1.03	0.92
Soybean	1.03	1.06	1.05	1.33	1.29	1.31
<u>Sesbania rostrata</u>	1.24	1.43	1.34	1.50	1.63	1.57
Sunhemp	1.16	1.29	1.23	1.35	1.43	1.39
Maize + Sunhemp	1.05	0.97	1.01	1.19	1.31	1.25
Maize + <u>S. rostrata</u>	1.04	0.96	1.00	1.22	1.31	1.27
Maize + Soybean	0.93	0.85	0.89	1.09	1.11	1.10
Fallow	0.83	0.73	0.78	0.96	1.07	1.02
S.E.m _t	0.03	0.08	0.04	0.05	0.08	0.05
CD at 5%	0.10	0.23	0.12	0.16	0.25	0.14
<u>Nitrogen levels</u>						
50 kg N/ha	0.92	0.80	0.86	1.05	1.16	1.11
100 kg N/ha	1.09	1.19	1.14	1.31	1.38	1.35
S.E.m _t	0.02	0.04	0.02	0.02	0.04	0.02
CD at 5%	0.05	0.12	0.06	0.05	0.11	0.06

Table 4.7 Interaction effects of crops grown and nitrogen levels on drymatter accumulation in leaves(g/hill) at 30 days after planting of rice

Treatments	1990-91		Mean	
	50 kg N/ha	100 kg N/ha	50 kg N/ha	100 kg N/ha
Maize	0.57	0.73	0.62	0.79
Soybean	0.86	1.27	0.90	1.20
<u>Sesbania rostrata</u>	0.97	1.89	1.03	1.64
Sunhemp	0.92	1.67	0.99	1.46
Maize + Sunhemp	0.86	1.08	0.92	1.10
Maize + <u>S. rostrata</u>	0.83	1.09	0.91	1.10
Maize + Soybean	0.70	1.00	0.77	1.01
Fallow	0.67	0.80	0.73	0.84
	<u>S.Em±</u>	<u>CD at 5%</u>	<u>S.Em±</u>	<u>CD at 5%</u>
Comparison of sub plot means at same level of main plot means	0.11	0.32	0.06	0.17
Comparison of the main plot means at same or different level of sub plot means	0.11	0.33	0.06	0.17

green manure, intercropped sunhemp, S.rostrata and soybean at 100 kg N per ha (ranged from 1.00 to 1.27 in 1990-91 and mean from 1.01 to 1.20 g).

At 60 DAP dry weight of leaves and stem was significantly higher due to green manuring with sole S.rostrata during both the years (mean of leaves and stem was 2.05 and 6.57 g per hill respectively). During 1990-91 the dry weight of leaves (1.57 g per hill) and stem (5.49 g per hill) with green manuring sunhemp sole crop was at par with sole S.rostrata. Maize followed by rice recorded the lowest leaf and stem dry weight per hill (mean of leaves and stem was 1.24 and 4.02 g per hill respectively) which was on par with fallow-rice (1.32 and 4.48 g per hill in leaves and stem respectively) (Table 4.8).

At 100 kg N per ha dry weight of leaves and stem was significantly higher (mean increase in dry weight of leaves and stem was 0.37 and 1.03 g per hill respectively) over 50 kg N per ha (Table 4.8).

Dry weight of shoot at harvest was significantly higher with green manuring sole S.rostrata for rice (10.37 g per hill in 1989-90, 7.87 g per hill in 1990-91 and mean of 9.12 g per hill). During 1990-91 dry weight of shoot with green manuring sole sunhemp (7.42 g per hill) was at par with green manuring

Table 4.8 Distribution of drymatter in leaves and stems (g/hill) of rice at 60 days after planting as influenced by crops grown and nitrogen levels

Treatments	Leaves			Stem		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean
Maize	1.43	1.06	1.24	3.95	4.09	4.02
Soybean	1.96	1.39	1.67	6.53	5.44	5.99
<u>Sesbania rostrata</u>	2.42	1.67	2.05	7.17	5.97	6.57
Sunhemp	2.09	1.57	1.83	6.58	5.49	6.04
Maize + Sunhemp	1.83	1.33	1.58	5.59	4.82	5.21
Maize + <u>S. rostrata</u>	2.02	1.42	1.72	5.60	5.05	5.32
Maize + Soybean	1.74	1.29	1.52	4.97	4.56	4.77
Fallow	1.54	1.10	1.32	4.80	4.16	4.48
S.Em±	0.08	0.07	0.05	0.17	0.32	0.18
CD at 5%	0.25	0.21	0.16	0.50	0.97	0.52
<u>Nitrogen levels</u>						
50 kg N/ha	1.67	1.20	1.43	5.11	4.46	4.78
100 kg N/ha	2.09	1.51	1.80	6.19	5.43	5.81
S.Em±	0.03	0.03	0.02	0.13	0.06	0.07
CD at 5%	0.09	0.09	0.06	0.38	0.19	0.20

sole S.rostrata (7.87 g per hill). Dry weight of shoot with maize-rice was significantly lowest (mean of 5.47 g per hill) which was on par with fallow-rice (mean of 5.86 g per hill) (Table 4.9).

Addition of N at 100 kg per ha significantly improved the drymatter accumulation in stem over 50 kg N per ha. The increase in dry weight of shoot with 100 kg N per ha was 1.55 g per hill in 1989-90, 1.04 g per hill in 1990-91 and mean of 1.29 g per hill over 50 kg N per ha (Table 4.9).

Dry weight of panicle at harvest was significantly higher with green manuring rice with sole S.rostrata (15.48 g in 1989-91, 13.13 g in 1990-91 and mean of 14.31 g per hill) which was on par with dry weight of panicles per hill with green manuring by sole sunhemp (mean of 13.80 g per hill). During 1990-91 green manuring by sole soybean also recorded dry weight of panicle (13.10 g per hill) at par with green manuring by sole S.rostrata. Dry weight of panicles was significantly lowest with maize-rice (mean of 8.99 g per hill) which was on par with fallow-rice (mean of 9.74 g per hill) (Table 4.9).

Addition of N at 100 kg per ha significantly improved the dry weight of panicles per hill during both the years (14.18 g per hill in 1989-90, 12.09 g per hill in 1990-91)

Table 4.9 Distribution of drymatter of rice at harvest as influenced by crops grown and nitrogen levels(g/hill)

Treatments	Dry weight of stem + leaves		Dry weight of panicle		
	1989-90	1990-91	Mean	1989-90	1990-91
Maize	6.36	4.58	5.47	10.13	7.85
Soybean	9.18	6.87	8.02	13.44	13.10
<u>Sesbania rostrata</u>	10.37	7.87	9.12	15.48	13.13
Sunhemp	9.38	7.42	8.40	14.61	12.98
Maize + Sunhemp	7.93	6.58	7.26	12.29	10.85
Maize + <u>S. rostrata</u>	8.88	6.70	7.79	12.28	11.45
Maize + Soybean	7.72	6.45	7.08	11.83	9.75
Fallow	6.53	5.18	5.86	10.84	8.63
S.E.m±	0.21	0.27	0.17	0.52	0.49
C.D at 5%	0.64	0.83	0.50	1.59	1.48
<u>Nitrogen levels</u>					
50 kg N/ha	7.52	5.94	6.73	11.05	9.64
100 kg N/ha	9.07	6.98	8.02	14.18	12.09
S.E.m±	0.16	0.07	0.09	0.20	0.22
C.D at 5%	0.47	0.21	0.25	0.60	0.65

and mean dry weight of panicles (13.14 g per hill) over 50 kg N per ha (Table 4.9).

4.2.3 Plant height

Plant height was significantly improved with green manuring sole S.rostrata for rice (69 cm in 1989-90 and 78 cm in 1990-91 and mean of 73 cm) which was on par with green manuring by sole sunhemp and soybean (mean plant height of 73 and 72 cm respectively). Significantly lowest plant height was noticed with maize-rice (63 cm in 1989-90 and 69 cm in 1990-91 and mean of 66 cm) which was on par with fallow-rice (mean of 67 cm). During 1989-90 plant height with all the intercropping treatments was at par with maize-rice (Table 4.10).

Nitrogen application improved the plant height significantly. Addition of 100 kg N per ha recorded significantly higher plant height during both the years (68 cm in 1989-90 and 77 cm in 1990-91) and mean plant height (73 cm) compared to 50 kg N per ha (Table 4.10).

4.2.4 Leaf area index at 30 and 60 days after planting

Leaf area index at 30 DAP was significantly higher with green manuring sole S.rostrata for rice (1.17 in 1989-90 and 1.67 in 1990-91 and mean of 1.42) which was on par with green manuring by sole sunhemp. During 1990-91 LAI ^{values} by green manuring

sole soybean (1.36) and by intercropped S.rostrata (1.41) were also at par with S.rostrata-rice (1.67). The LAI was lowest with maize-rice (0.69 and 0.78 in 1989-90 and 1990-91 respectively and mean of 0.73) which was on par with fallow-rice sequence (Table 4.10).

LAI was significantly higher due to addition of 100 kg N per ha compared to 50 kg N per ha. It was 1.02 in 1989-90 and 1.39 in 1990-91 and mean of 1.20 with 100 kg N per ha for rice (Table 4.10).

Leaf area index at 60 DAP was significantly higher by green manuring rice with sole S.rostrata during both the years (1.71 and 1.85 in 1989-90 and 1990-91 respectively) and mean LAI (1.78) which was on par with green manuring sole sunhemp (mean of 1.72). Leaf area index during 1990-91 and mean of two years by green manuring sole soybean (1.74 in 1990-91 and mean of 1.59) was on par with green manuring by sole S.rostrata. Lowest LAI was recorded with maize-rice and fallow-rice treatments (mean of 1.00 and 1.01 respectively) (Table 4.10).

Nitrogen at 100 kg per ha improved LAI significantly during both the years (1.50 and 1.61 in 1989-90 and 1990-91 respectively) over 50 kg N per ha (Table 4.10).

Table 4.10 Plant height (cm) and leaf area index of rice as influenced by crops grown and nitrogen levels

Treatments	Plant height(cm)			LAI at 30 DAP			LAI at 60 DAP		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91	Mean
Maize	63	69	66	0.69	0.78	0.73	0.92	1.08	1.00
Soybean	66	78	72	1.04	1.36	1.20	1.43	1.74	1.59
<u>Sesbania rostrata</u>	69	78	73	1.17	1.67	1.42	1.71	1.85	1.78
Sunhemp	68	78	73	1.09	1.35	1.22	1.61	1.82	1.72
Maize + Sunhemp	66	75	71	0.93	1.17	1.05	1.40	1.41	1.40
Maize + <u>S. rostrata</u>	64	76	70	0.93	1.41	1.17	1.36	1.44	1.40
Maize + Soybean	65	74	70	0.77	1.16	0.96	1.27	1.27	1.27
Fallow	65	70	67	0.77	0.88	0.82	0.94	1.09	1.01
S.Em±	1.0	0.8	0.6	0.03	0.11	0.05	0.09	0.09	0.06
CD at 5%	3.0	2.4	1.8	0.10	0.33	0.16	0.27	0.28	0.19
<u>Nitrogen levels</u>									
50 kg N/ha	64	72	68	0.82	1.05	0.94	1.16	1.32	1.24
100 kg N/ha	68	77	73	1.02	1.39	1.20	1.50	1.61	1.55
S.Em±	0.5	0.5	0.4	0.02	0.07	0.03	0.03	0.02	0.02
CD at 5%	1.6	1.5	1.1	0.05	0.19	0.09	0.09	0.07	0.60

4.2.5 Number of tillers per hill at 30, 60 days after planting and at harvest

At 30 DAP number of tillers per hill was significantly more by green manuring sole S.rostrata during both the years (8.7 in 1989-90, 11.7 in 1990-91 and mean of 10.2) which was on par with green manuring sole sunhemp (mean of 10.1). During 1989-90 green manuring by sole soybean as well as intercrops of sunhemp, S.rostrata and soybean were also at par with sole S.rostrata. Number of tillers per hill was significantly lower with maize-rice (mean of 7.3) and fallow-rice (mean of 7.4) as compared to S.rostrata-rice (mean of 10.2) and sunhemp-rice (mean of 10.1) (Table 4.11).

Addition of N at 100 kg per ha improved the tiller number per hill significantly. With 100 kg N per ha the number of tillers per hill during 1989-90 was 8.5 and during 1990-91 10.1 and the mean number was 9.3 per hill respectively as compared to 50 kg N per ha (mean of 8.2)(Table 4.11).

At 60 DAP also green manuring with sole S.rostrata recorded significantly more number of tillers per hill (9.4 in 1989-90 and 10.7 in 1990-91 and mean of 10.0) which was on par with green manuring with sole sunhemp (mean of 9.6) as compared to maize-rice and fallow-rice (mean of 7.0 and 7.5 respectively). Green manuring by soybean both in sole and intercropped treatments also recorded significantly lower number of tillers per hill (mean of 7.6 in both the treatments)(Table 4.1

Table 4.12 Interaction effects of crops grown and nitrogen levels for rice crop on the number of tillers at 60 days after planting rice

Treatments	50 kg N/ha	100 kg N/ha
Maize	6.6	7.6
Soybean	7.5	8.4
<u>Sesbania rostrata</u>	9.6	11.7
Sunhemp	9.4	10.8
Maize + Sunhemp	8.1	8.9
Maize + <u>S. rostrata</u>	7.6	8.6
Maize + Soybean	7.5	8.5
Fallow	7.5	8.2
	<u>S.E.m_t</u>	<u>CD at 5%</u>
Comparison of sub plot means at same level of main plot means	0.17	0.52
Comparison of main plot means at same or different level of sub plot means	0.36	1.08

Fallow-rice (10.0) and maize + soybean-rice (9.6) recorded significantly lower number of tillers per hill (Table 4.11).

There was significant increase in tiller number per hill with 100 kg N per ha (mean of 10.9) over 50 kg N per ha (mean of 9.5) (Table 4.11).

4.2.6 1000 grain weight

Thousand grain weight improved significantly and was highest with green manuring sole S. rostrata (22.9 g in 1989-90, 24.9 g in 1990-91 and mean of 23.9 g) followed by green manuring sole sunhemp (mean of 23.5 g). It was lowest with maize-rice (21.5 g in 1989-90, 23.5 g in 1990-91 and mean of 22.5 g) followed by fallow-rice (mean of 22.7 g). The remaining treatments were intermediate in 1000 grain weight. Nitrogen application at 100 kg per ha significantly improved the 1000 grain weight (22.4 g in 1989-90, 24.6 g in 1990-91) over 50 kg N per ha (21.7 and 23.9 g in 1989-90 and 1990-91 respectively) (Table 4.13).

4.2.7 Panicle length

Panicle length was significantly improved by green manuring with sole S. rostrata and sunhemp. The increase in panicle length by green manuring sole S. rostrata over

Table 4.13 Yield parameters of rice as influenced by crops grown and nitrogen levels

Treatments	1000 grain weight(g)			Panicle length(cm)			No. of filled grains per panicle			No. of unfilled grains per panicle		
	Mean			Mean			Mean			Mean		
	1989-90	90-91	Mean	1989-90	90-91	Mean	1989-90	90-91	Mean	1989-90	90-91	Mean
Maize	21.5	23.5	22.5	16.6	16.6	16.6	51.6	52.2	51.9	24.3	14.1	19.2
Soybean	22.2	24.4	23.3	18.7	18.0	18.4	69.8	69.4	69.6	11.7	6.8	9.3
<u>Sesbania rostrata</u>	22.9	24.9	23.9	19.3	18.8	19.0	77.8	74.3	76.0	8.9	4.6	6.7
Sunhemp	22.4	24.6	23.5	19.1	18.4	18.8	73.5	70.7	72.1	10.1	6.9	8.5
Maize + Sunhemp	22.1	24.4	23.2	18.5	18.0	18.3	68.2	65.1	66.6	12.9	7.8	10.4
Maize + <u>S. rostrata</u>	21.9	24.4	23.2	18.6	18.0	18.3	68.4	63.5	66.0	15.7	8.6	12.1
Maize + Soybean	21.7	24.2	22.9	17.7	17.5	17.6	61.9	59.9	60.9	17.9	9.4	13.7
Fallow	21.7	23.7	22.7	17.3	17.0	17.1	58.2	55.6	56.9	23.8	12.6	18.2
S.Em±	0.16	0.16	0.11	0.21	0.14	0.13	1.87	1.98	1.36	1.33	0.68	0.74
CD at 5%	0.49	0.48	0.33	0.62	0.43	0.36	5.68	6.01	3.95	4.03	2.08	2.16
<u>Nitrogen levels</u>												
0 kg N/ha	21.7	23.9	22.8	17.6	17.3	17.4	61.1	59.4	60.3	17.07	9.8	13.4
100 kg N/ha	22.4	24.6	23.5	18.8	18.3	18.6	71.2	68.3	69.7	14.23	7.9	11.1
S.Em±	0.06	0.05	0.04	0.05	0.05	0.04	0.71	0.62	0.47	0.44	0.31	0.26
CD at 5%	0.19	0.15	0.12	0.16	0.16	0.11	2.14	1.86	1.36	1.31	0.2	0.76

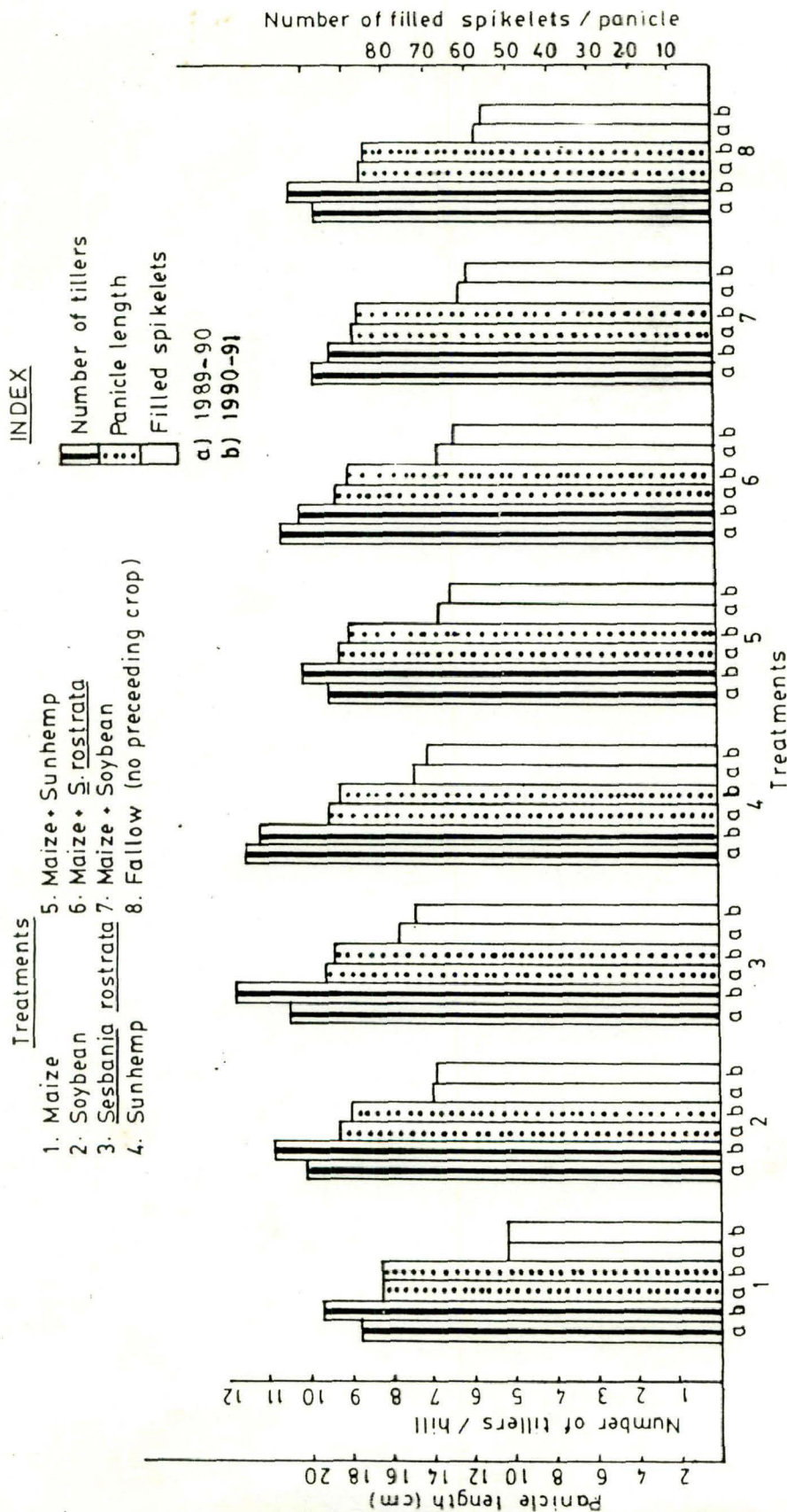


FIG. 4.1. YIELD PARAMETERS OF RICE AS INFLUENCED BY THE CROPS GROWN IN THE PREMONSOON SEASON

Table 4.14 Interaction effects of crops grown and nitrogen levels on the panicle length of rice (cm)

Treatments	1990-91		Mean	
	50 kg N/ha	100 kg N/ha	50 kg N/ha	100 kg N/ha
Maize	16.4	16.8	16.2	16.9
Soybean	17.3	18.7	17.7	19.1
<u>Sesbania rostrata</u>	17.9	19.7	18.2	19.9
Sunhemp	17.8	19.2	18.0	19.5
Maize + Sunhemp	17.6	18.4	17.9	18.7
Maize + <u>S. rostrata</u>	17.5	18.5	17.7	18.9
Maize + Soybean	17.1	17.9	17.1	18.1
Fallow	16.6	17.4	16.6	17.6
	<u>S.E.m±</u>	<u>CD at 5%</u>	<u>S.E.m±</u>	<u>CD at 5%</u>
Comparison of sub plot means at the same level of main plot means	0.15	0.46	0.11	0.31
Comparison of main plot means at the same or different level of sub plot means	0.18	0.54	0.14	0.42

Plate 11 : Rice grown after incorporation of premonsoon
Sesbania rostrata with 100 kg fertilizer
nitrogen per ha.

Plate 12 : Rice grown after incorporation of premonsoon
Sesbania rostrata with 50 kg fertilizer
nitrogen per ha.

Plate 13 : Rice grown after premonsoon fallow
treatment at 100 kg fertilizer nitrogen
per ha.

PLATE 11



PLATE 12



PLATE 13



4.2.8 Number of filled grains per panicle

The number of filled grains per panicle was maximum by green manuring rice with sole S.rostrata (77.8 in 1989-90 and 74.3 in 1990-91) which was on par with sunhemp-rice (mean of 72.1). Among the intercropping treatments followed by rice, the number of filled grains with maize + S.rostrata , maize + sunhemp were at par (mean of 66.0 and 66.6 respectively) Lowest number of filled grains was recorded with maize-rice (51.6 and 52.2 in 1989-90 and 1990-91 respectively)(Table 4.13).

The filled grains per panicles were improved significantly by N application. At 100 kg N per ha the number of filled grains was significantly superior (71.2 and 68.3 in 1989-90 and 1990-91 respectively) compared to 50 kg N per ha (61.1 and 59.4 in 1989-90 and 1990-91 respectively)(Table 4.13).

4.2.9 Number of unfilled grains per panicle

The number of unfilled grains was significantly lower by green manuring sole S.rostrata (8.9 in 1989-90 and 4.6 in 1990-91 and mean of 6.7) compared to premonsoon maize and fallow treatments (mean of 19.2 and 18.2 with premonsoon maize and fallow respectively) during both the years. During 1989-90 the number of unfilled grains with premonsoon soybean (11.7), sunhemp(10.1) and maize + sunhemp(12.9) were on par

with S.rostrata green manure(8.9). The mean number of unfilled grains with S.rostrata (6.7) and sunhemp (8.5) premonsoon green manures was also at par (Table 4.13).

There was significant reduction in number of unfilled grains per panicle due to increase in N level from 50 to 100 kg N per ha (mean of 13.4 with 50 kg N per ha and 11.1 with 100 kg N per ha) (Table 4.13).

4.2.10 Grain yield of rice

Grain yield of rice was significantly influenced by the crops grown in the premonsoon season and N levels for rice. During both the years grain yield of rice was significantly higher with premonsoon S.rostrata green manure (4382 kg per ha in 1989-90, 4549 kg per ha in 1990-91 and mean of 4465 kg per ha and was on par with premonsoon sunhemp green manure (4265 kg per ha in 1989-90 and 4462 kg per ha in 1990-91 and mean of 4363 kg per ha). During 1990-91, premonsoon soybean green manure also produced same yield of rice (4349 kg per ha) as that of S.rostrata and sunhemp green manures. The lowest grain yield of rice was recorded by premonsoon maize (mean of 3547 kg per ha), fallow (mean of 3624 kg per ha) and maize + soybean (3782 kg per ha) treatments. Among the intercropping treatments maize + S.rostrata and maize + sunhemp produced higher yields (mean of 4044 and 3957 kg per ha respectively) compared to maize + soybean followed by rice (Table 4.15).

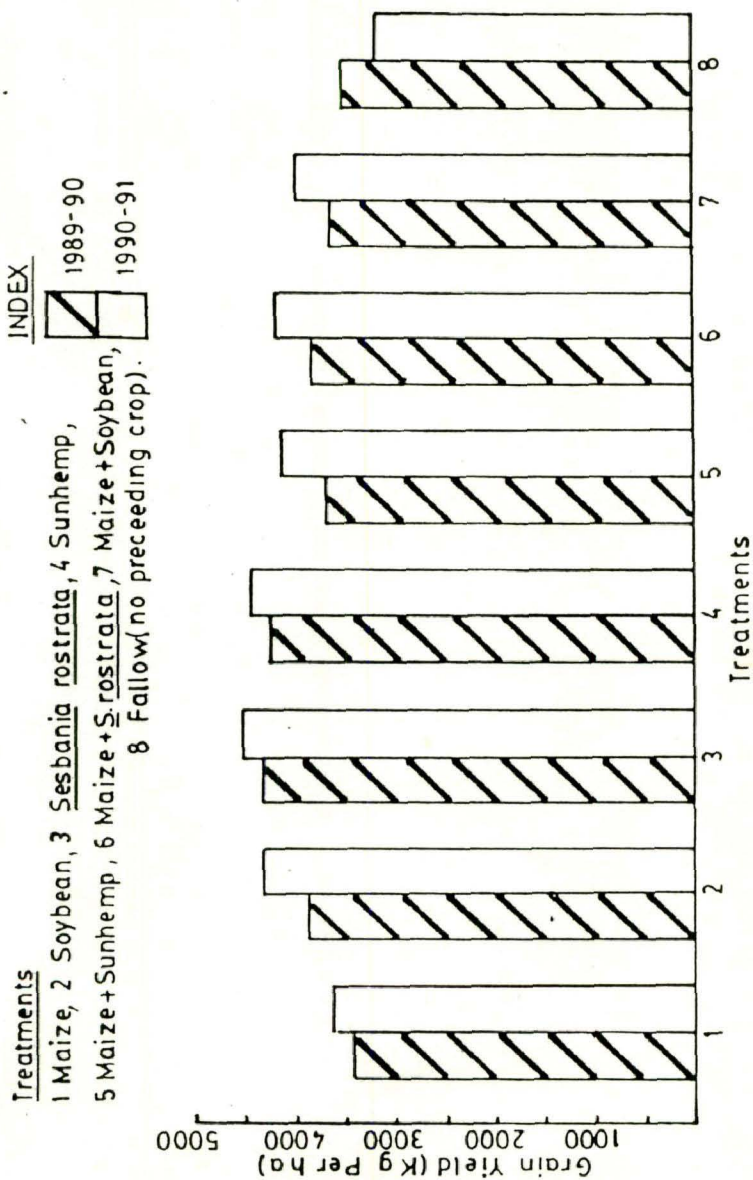


FIG.4.2.GRAIN YIELD OF RICE AS INFLUENCED BY CROPS GROWN IN
PREMONSOON SEASON.

Maximum grain yield of rice was recorded with 100 kg N per ha during both the years. The increase in grain yield with 100 kg N per ha over 50 kg N per ha was significant and was 398 kg per ha in 1989-90, 353 kg per ha in 1990-91 and the mean increase was 376 kg per ha (Table 4.15).

Interaction effect of crops grown in the premonsoon and levels of N on the grain yield of rice was significant during 1989-90 (Table 4.16). Maize in premonsoon gave same yield of rice as fallow-rice at both the N levels (3294 and 3605 kg per ha with 50 and 100 kg N per ha respectively with maize, and 3378 and 3721 kg per ha with 50 and 100 kg N per ha respectively with fallow treatment). Soybean in premonsoon followed by rice with 50 kg N per ha produced grain yield (3717 kg per ha) on par with maize-rice or fallow-rice with 100 kg N per ha (3605 and 3721 kg per ha respectively). Highest grain yield was accounted with S.rostrata and sunhemp green manures at both the N levels there being no significant differences between S.rostrata and sunhemp. Sesbania rostrata and sunhemp green manures along with 50 kg N per ha produced grain yield (4265 and 4125 kg per ha respectively) on par or better than intercropped green manures, premonsoon soybean, maize and fallow treatments with 100 kg N per ha (varied from 3605 to 4135 kg per ha).

Table 4.16 Interaction of crops grown and nitrogen levels on the grain yield of rice (kg/ha) during 1989-90

Treatments	Nitrogen levels	
	50 kg N/ha	100 kg N/ha
Maize	3294	3605
Soybean	3717	4117
<u>Sesbania rostrata</u>	4265	4498
Sunhemp	4125	4405
Maize + Sunhemp	3473	4084
Maize + <u>S. rostrata</u>	3608	4135
Maize + Soybean	3430	3912
Fallow	3378	3721
	<u>S.Em±</u>	<u>CD at 5%</u>
Comparison of sub plot means at same level of main plot means	54.8	164.5
Comparison of main plot means at same or different level of sub plot	63.1	190.6

4.2.11 Straw yield of rice

Straw yield during both the years was significantly higher with S.rostrata-rice (5333 and 7247 kg per ha in 1989-90 and 1990-91 respectively) which was on par with sunhemp-rice (5092 and 6870 kg per ha in 1989-90 and 1990-91 respectively). The mean straw yield was also significantly higher with S.rostrata-rice (6290 kg per ha) followed by sunhemp-rice (5981 kg per ha). Among intercropping treatments followed by rice, the straw yield was significantly higher with maize + S.rostrata (4509 and 5675 kg per ha in 1989-90 and 1990-91 respectively and the mean grain yield of 5092 kg per ha), which was on par with maize + sunhemp. Lowest straw yield was recorded with maize-rice during both the years (3619 and 4419 kg per ha during 1989-90 and 1990-91 respectively and mean of 4019 kg per ha) (Table 4.15).

Between the levels of 50 and 100 kg N per ha for rice, 100 kg N per ha recorded maximum straw yield during both the years (4691 and 6185 kg per ha in 1989-90 and 1990-91 respectively) as well as mean straw yield (5438 kg per ha) compared to 50 kg N per ha (Table 4.15).

4.2.12 Total biomass of rice

The total biomass of rice was significantly higher with green manuring sole S.rostrata (9.72 t per ha in 1989-90 and 11.80 t per ha in 1990-91 and mean of 10.76 t per ha) which was on par with green manuring sole sunhemp (mean of 10.34 t per ha). The biomass yield during both the years and their mean were significantly lowest with maize-rice sequence (7.07 t per ha in 1989-90, 8.06 t per ha in 1990-91 and mean of 7.57 t per ha) which was on par with fallow-rice (7.41 t per ha in 1989-90, 8.52 t per ha in 1990-91 and mean of 7.96 t per ha). During 1989-90 there was no significant difference in biomass yield among the treatments maize, fallow and maize + soybean during premonsoon season followed by rice. Among the intercropping treatments followed by rice, biomass yield of rice was highest with maize + S.rostrata-rice (8.38 t per ha in 1989-90, 9.89 t per ha in 1990-91 and mean of 9.14 t per ha), which was on par with maize + sunhemp-rice (Table 4.15).

Total biomass production was significantly higher with 100 kg N per ha for rice during both the years (8.75 t per ha in 1989-90 and 10.48 t per ha in 1990-91 and mean of 9.62 t per ha) compared to 50 kg N per ha (Table 4.15).

4.2.13 Nitrogen, phosphorus and potash uptake by rice

Nitrogen uptake by rice was maximum by green manuring with sole S.rostrata (165 kg per ha in 1989-90, 181 kg per ha in 1990-91 and mean of 173 kg per ha). During 1990-91, N uptake by rice in sunhemp-rice (180 kg per ha) was on par with S.rostrata-rice (181 kg per ha). While during 1989-90, N uptake by S.rostrata-rice was followed by soybean-rice and sunhemp-rice (147 and 143 kg per ha respectively). Lowest uptake of N was recorded with maize-rice (106 kg per ha in 1989-90, 119 kg per ha in 1990-91 and mean of 112 kg per ha). Among the intercropping treatments followed by rice maize + S.rostrata followed by rice removed more N during 1989-90 (134 kg per ha) while during 1990-91 and mean of two years, there was no significant difference in N uptake among intercropping treatments followed by rice (Table 4.17).

Nitrogen uptake was higher with the application of 100 kg N per ha (149 kg per ha in 1989-90, 169 kg per ha in 1990-91 and mean of 159 kg per ha) compared to 50 kg N per ha (Table 4.17).

Interaction effect of crops grown and levels of N on the nitrogen uptake during 1989-90 and mean of two years were significant (Table 4.18). Nitrogen uptake by rice was significantly lowest following kharif maize at both the N levels during 1989-90 and mean over two years (mean of 102 and 122 kg per ha at 50 and 100 kg N per ha respectively).

Table 4.17 NPK uptake by rice (kg/ha) as influenced by crops grown and nitrogen levels

Treatments	Nitrogen		Phosphorus		Potassium	
	1989-90	1990-91	Mean	1989-90	1990-91	Mean
Maize	106	119	112	28	43	36
Soybean	147	167	157	37	50	44
<u>Sesbania rostrata</u>	165	181	173	38	57	48
Sunhemp	143	180	162	36	51	44
Maize + Sunhemp	126	149	138	31	48	39
Maize + <u>S. rostrata</u>	134	142	138	34	49	39
Maize + Soybean	126	141	133	32	48	40
Fallow	128	137	132	33	45	41
S.E.m _t	2.2	3.1	1.9	0.4	0.9	0.5
CD at 5%	6.6	9.5	5.6	1.3	2.7	1.4
<u>Nitrogen levels</u>						
50 kg N/ha	120	135	127	30	43	36
100 kg N/ha	149	169	159	38	55	46
S.E.m _t	0.9	1.0	0.7	0.2	0.3	0.2
CD at 5%	2.9	3.1	2.0	0.6	1.0	0.6

Sesbania rostrata green manure registered maximum N uptake at both the N levels (mean of 161 kg per ha with 50 kg N per ha and 185 kg N per ha with 100 kg N per ha). Sesbania rostrata with 50 kg N per ha registered more N uptake by rice (162 kg per ha) compared to premonsoon maize (110 kg per ha), intercropped sunhemp (148 kg per ha), soybean (148 kg per ha) and fallow (136 kg per ha) treatments and was on par with premonsoon soybean (164 kg per ha), S.rostrata (168 kg per ha), sunhemp (163 kg per ha) and intercropped S.rostrata (155 kg per ha) with 100 kg N per ha during 1989-90. The mean N uptake also followed similar trend except S.rostrata green manure with 50 kg N per ha and was inferior (161 kg per ha) to S.rostrata and sunhemp green manures with 100 kg N per ha (185 and 181 kg per ha respectively) and was on par with intercropped sunhemp and S.rostrata with 100 kg N per ha (157 and 155 kg per ha respectively).

Phosphorus uptake by rice was significantly higher in S.rostrata-rice (38 kg per ha in 1989-90 and 57 kg per ha in 1990-91 and mean of 48 kg per ha). During 1989-90 phosphorus uptake by rice in soybean-rice was on par with S.rostrata-rice. During 1990-91 and mean phosphorus uptake by rice in sunhemp-rice (mean of 44 kg per ha) and soybean-rice (mean of 44 kg per ha) ranked next to S.rostrata-rice. Rice in maize-rice

removed lowest P (28 kg per ha in 1989-90 and 43 kg per ha in 1990-91 and mean of 36 kg per ha). Among the inter-cropping treatments followed by rice P uptake by rice was on par among maize + sunhemp, maize + S.rostrata and maize + soybean during 1990-91 and mean of two years. During 1989-90 maize + S.rostrata followed by rice registered maximum P uptake (Table 4.17).

Application of 100 kg N per ha increased the P uptake significantly over 50 kg N per ha. The magnitude of increase in P uptake due to addition of 100 kg N per ha was 8 kg per ha in 1989-90, 12 kg per ha in 1990-91 and mean of 10 kg per ha over 50 kg N per ha (Table 4.17).

The interaction effect of crops grown and nitrogen levels on the uptake of P by rice was significant during both the years (Table 4.18). Phosphorus uptake was maximum with S.rostrata green manure (mean of 43 and 52 kg per ha at 50 and 100 kg per ha respectively) while it was lowest with premonsoon maize at both the N levels during 1989-90 as well as during 1990-91. S.rostrata green manure and 50 kg N per ha recorded significantly highest P uptake by rice (mean of 43 kg per ha) compared to maize in premonsoon with 100 kg N per ha during both the years (mean of 32 kg per ha in 1989-90 and 48 kg per ha in 1990-91) and it was on par with inter-cropped sunhemp, S.rostrata and fallow treatments with

100 kg N per ha. The rest of the treatments with 100 kg N per ha were superior in P uptake compared to S.rostrata green manure and 50 kg N per ha.

Potash uptake of rice was significantly higher by green manuring sole sunhemp (87 kg per ha) in 1989-90 followed by sole S.rostrata (80 kg per ha). During 1990-91 green manuring sole S.rostrata recorded significantly higher (147 kg per ha) K uptake followed by sole soybean (126 kg per ha) and sole sunhemp (118 kg per ha). The mean K uptake was also higher with S.rostrata-rice (114 kg per ha) followed by sunhemp-rice (102 kg per ha) and soybean-rice (100 kg per ha). Lowest potash uptake was noticed with maize-rice sequence (51 kg per ha in 1989-90, 97 kg per ha in 1990-91 and mean of 74 kg per ha). Potash uptake with maize-rice was on par with fallow-rice during 1990-91 (95 kg per ha). The K uptake by rice among the intercropping treatments followed by rice was at par (varied from 83 to 87 kg per ha) (Table 4.17

Nitrogen application increased potassium uptake significantly. With 100 kg N per ha mean K uptake was 104 kg per ha, while with 50 kg per ha it was 77 kg per ha (Table 4.17

Interaction effect of crops grown and levels of N on the K uptake of rice was significant during both the years (Table 4.19). Potassium uptake by rice was higher by

Table 4.19 Interaction effects of crops grown and nitrogen levels on potassium uptake by rice crop (kg/ha)

Treatments	1989-90		1990-91		Mean	
	50 kg	100 kg	50 kg	100 kg	50 kg	100 kg
	N/ha					
Maize	44	58	79	114	62	86
Soybean	60	88	106	146	83	117
<u>Sesbania rostrata</u>	65	95	129	165	97	130
Sunhemp	69	105	90	144	80	125
Maize + Sunhemp	56	68	98	124	77	97
Maize + <u>S. rostrata</u>	51	73	93	116	72	95
Maize + soybean	49	64	98	120	74	92
Fallow	64	80	82	107	73	93
	<u>S.E.m±</u>	<u>CD at 5%</u>	<u>S.E.m±</u>	<u>CD at 5%</u>	<u>S.E.m±</u>	<u>CD at 5%</u>
Comparison of sub plot means at the same level of main plot means	2.2	6.5	3.2	9.6	1.9	5.6
Comparison of main plot means at the same or different level of sub plot means	2.4	7.2	3.6	10.8	2.1	6.2

sunhemp green manure during 1989-90 and by S.rostrata green manure during 1990-91 while it was least with maize as premonsoon crop at both the N levels. Sunhemp premonsoon crop followed by rice with 50 kg N per ha registered more K uptake (69 kg per ha) which was equal or superior to intercropped sunhemp, S.rostrata, soybean and sole maize treatments at 100 kg N level for rice during 1989-90. During 1990-91 and mean of two years, the K uptake was more with S.rostrata green manure and 50 kg N per ha for rice (129 kg per ha in 1990-90 and mean of 97 kg per ha) which was equal or higher than K uptake by rice with maize + sunhemp, maize + S.rostrata, maize + soybean and sole maize and fallow premonsoon treatments. Thus S.rostrata and 50 kg N per ha and sunhemp and 50 kg N per ha were superior next only to S.rostrata and 100 kg N per ha and, sunhemp and 100 kg N per ha for rice in respect of K uptake.

4.3 Experiment 1c

Residual effects of treatments to kharif rice on the succeeding sunflower

4.3.1 Total dry weight of rice at 50 days after sowing and at harvest

Total dry weight of sunflower at 50 DAS with S.rostrata-rice-sunflower was significantly higher (13.02 g in 1989-90 and 8.17 in 1990-91 and mean of 10.60 g per plant) which was on par with sunhemp-rice-sunflower. Mean total dry weight

Table 4.20 Influence of premonsoon cropping and residual fertility status of kharif rice crop on the total drymatter production and its distribution in sunflower crop at 50 days after sowing (g/plant)

Treatments	Dry weight of leaves			Dry weight of stem			Total dry weight		
	-----			-----			-----		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91	Mean
Maize	2.20	2.29	2.25	2.85	2.09	2.47	5.05	4.39	4.72
Soybean	4.35	3.33	3.84	6.49	3.75	5.12	10.84	7.08	8.96
<u>Sesbania rostrata</u>	4.92	3.89	4.41	8.09	4.28	6.19	13.02	8.17	10.60
Sunhemp	4.50	3.40	3.95	7.35	4.23	5.79	11.85	7.63	9.74
Maize + Sunhemp	3.82	3.19	3.51	4.95	3.48	4.21	8.77	6.66	7.72
Maize + <u>S. rostrata</u>	4.09	3.04	3.56	5.41	3.51	4.46	9.51	6.55	8.03
Maize + Soybean	3.59	2.81	3.20	5.10	3.34	4.22	8.69	6.15	7.42
Fallow	2.62	2.21	2.42	3.67	2.54	3.10	6.29	4.75	5.52
S.E.m _t	0.18	0.12	0.11	0.37	0.14	0.20	0.42	0.22	0.23
CD at 5%	0.54	0.36	0.31	1.13	0.41	0.57	1.26	0.66	0.68
<u>Nitrogen levels</u>									
50 kg N/ha	3.29	2.87	3.08	5.03	3.13	4.08	8.32	6.00	7.16
100 kg N/ha	4.23	3.17	3.70	5.95	3.68	4.82	10.19	6.85	8.52
S.E.m _t	0.08	0.03	0.04	0.10	0.07	0.06	0.15	0.08	0.08
CD at 5%	0.24	0.09	0.12	0.31	0.21	0.18	0.45	0.23	0.24

Table 4.21 Influence of premonsoon cropping and residual fertility status of Kharif rice crop on the total drymatter production and its distribution in sunflower crop at harvest (g/plant)

Treatments	Dry weight of stem + leaves			Dry weight of Disc			Total dry weight		
	-----			-----			-----		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91	Mean
Maize	8.85	5.47	7.16	17.45	10.13	13.79	26.30	15.60	20.95
Soybean	14.42	8.68	11.55	29.20	16.07	22.63	43.62	24.75	34.18
<u>Sespania rostrata</u>	17.48	9.99	13.74	34.82	20.08	27.45	52.30	30.07	41.19
Sunhemp	16.55	9.45	13.00	31.04	18.07	24.55	47.59	27.52	37.56
Maize + Sunhemp	13.61	7.92	10.76	27.80	17.67	22.73	41.41	25.58	33.50
Maize + <u>S. rostrata</u>	13.54	7.92	10.73	27.72	17.30	22.51	41.26	25.27	33.26
Maize + Soybean	12.83	7.43	10.13	25.40	15.63	20.52	38.23	23.06	30.65
Fallow	10.70	5.97	8.33	18.27	11.02	14.64	28.97	16.98	22.98
S.Em±	0.92	0.42	0.51	0.83	0.77	0.57	1.13	1.04	0.77
CD at 5%	2.80	1.26	1.47	2.51	2.34	1.64	3.43	3.15	2.22
<u>Nitrogen levels</u>									
50 kg N/ha	12.82	7.38	10.10	24.72	14.95	19.83	37.53	22.35	29.94
100 kg N/ha	14.18	8.32	11.25	28.21	16.54	22.37	42.38	24.86	33.63
S.Em±	0.14	0.06	0.08	0.27	0.13	0.15	0.28	0.17	0.17
CD at 5%	0.43	0.19	0.23	0.80	0.40	0.43	0.85	0.52	0.48

50 kg N level were inferior to residual effects of S.rostrata or sunhemp green manures at 50 kg N level.

Total dry weight at harvest differed significantly among the green manure treatments and N levels for rice. Total dry weight was significantly highest with S.rostrata-rice-sunflower sequence during both the years (52.30 and 30.07 g per plant in 1989-90 and 1990-91 respectively and mean of 41.19 g per plant). The next best treatment was sunhemp-rice-sunflower which recorded a mean dry weight of 37.56 g per plant. Lowest dry weight per plant was recorded in maize-rice-sunflower (26.3 and 15.6 g per plant and mean of 20.95 g per plant) which was on par with fallow-rice-sunflower (28.97 and 16.98 g per plant during 1989-90 and 1990-91 respectively and mean of 22.98 g per plant). There was no significant difference in dry weight per plant among intercropping treatments followed by rice-sunflower (Table 4.21

With 100 kg N per ha, there was significant increase in total dry weight over 50 kg N per ha. The increase in total dry weight was 4.85 g per plant in 1989-90, 2.51 g per plant in 1990-91 and mean of 3.69 g per plant (Table 4.21).

Interaction of the residual effects of premonsoon crops and N levels on the drymatter per plant at harvest of the succeeding sunflower crop was significant during 1989-90

Table 4.22 Interaction of the residual effects of premonsoon cropping and N levels for Khari rice on the total drymatter production at different growth stages of sunflower (g/plant)

Treatments	Mean of two years at 50 DAS			At harvest during 1989-90			Mean of two years at harvest		
	50 kg	100 kg	100 kg	50 kg	100 kg	100 kg	50 kg	100 kg	100 kg
	----- N/ha -----								
Maize	4.4	5.0		25.2	27.5		20.0	21.9	
Soybean	8.1	9.9		41.4	45.9		32.4	35.9	
<u>Sesbania rostrata</u>	9.6	11.6		48.2	56.4		38.5	43.8	
Sunhemp	8.8	10.7		45.2	49.9		35.7	39.4	
Maize + Sunhemp	7.2	8.2		39.2	43.6		31.7	35.3	
Maize + <u>S. rostrata</u>	7.3	8.7		37.7	44.9		30.7	35.8	
Maize + Soybean	6.7	8.2		35.9	40.5		28.6	32.7	
Fallow	5.2	5.8		27.5	30.5		21.7	24.2	

	CD at 5%		CD at 5%		CD at 5%	
	S.E.m $\pm$		S.E.m $\pm$		S.E.m $\pm$	
Comparison of sub plot means at the same level of main plot means	0.24	0.69	0.80	2.40	0.47	1.35
Comparison of main plot means at the same or different level of sub plot means	0.29	0.83	1.26	3.83	0.84	2.41

and mean over two years (Table 4.22) premonsoon S.rostrata green manure produced highest dry weight per plant at both the N levels for rice (mean of 38.5 and 43.8 g per plant at 50 and 100 kg N per ha). The next best treatment was premonsoon sunhemp-rice-sunflower. Drymatter production of sunflower with the residual effects of S.rostrata green manure and 50 kg N per ha (48.2 g per plant) was higher compared to maize, fallow and intercropped sunhemp, S.rostrata and soybean treatments and was equal to soybean and sunhemp followed by rice at 100 kg N per ha for rice. Residual effect of sunhemp green manure and 50 kg N per ha for rice stood second in drymatter production per plant (mean of 35.7 g per plant) and was superior or equal to all the intercropped treatments followed by rice-sunflower, sole soybean, maize and fallow kharif rice treatments. Maize and fallow premonsoon treatments have least effect on improving the drymatter of sunflower crop.

4.3.2 Drymatter distribution at 50 days after sowing

Drymatter distribution of sunflower at 50 DAS on leaves and stems was significantly higher in S.rostrata-rice-sunflower (The mean drymatter of leaves and stem was 4.41 and 6.19 g per plant respectively). There was no significant differences in drymatter of leaves and stem with intercropping treatments

followed by rice-sunflower. Lowest drymatter of leaves and stem was noticed in maize-rice-sunflower (mean of 2.25 and 2.47 g per plant respectively) followed by fallow-rice-sunflower (mean of 2.42 and 3.10 g per plant) (Table 4.20).

Addition of 100 kg N per ha to rice significantly improved the drymatter of leaves and stem of sunflower over 50 kg N per ha. The mean increase of dry weight of leaves was 0.62 g per plant and of stem was 0.74 g per plant over 50 kg N per ha (Table 4.20).

Interaction of the residual effects of the crops grown and levels of N on the mean drymatter accumulation in leaves of the succeeding sunflower crop at 50 DAS was significant (Table 4.23). Residual effect S.rostrata green manure at both the N levels for rice produced higher drymatter in leaves. There was significantly higher drymatter accumulation in leaves (3.92 g) with residual effect of S.rostrata and 50 kg N level compared to maize (2.40 g) intercropped soybean (3.46 g) and fallow (2.57 g) treatments at 100 kg N level and there being no significant difference with soybean, intercropped sunhemp and S.rostrata. Residual effects of maize and fallow treatments at both the N levels accumulated lower drymatter in leaves compared to the rest of the treatments.

Table 4.23 Interaction of the residual effects of premonsoon cropping and N levels for kharif rice on the drymatter distribution in the succeeding sunflower crop (g/plant)

Treatments	Mean dry weight of leaves at 50 DAS		Dry weight of leaves + stem at harvest			
			1990-91		Mean of two years	
	50 kg	100 kg	50 kg	100 kg	50 kg	100 kg
	----- N/ha -----					
Maize	2.09	2.40	5.27	5.67	6.94	7.37
Soybean	3.37	4.32	8.03	9.33	10.80	12.30
<u>Sesbania rostrata</u>	3.92	4.89	9.68	10.29	12.81	14.66
Sunhemp	3.55	4.35	8.97	9.94	12.35	13.65
Maize + Sunhemp	3.31	3.70	7.53	8.30	10.38	11.15
Maize + <u>S. rostrata</u>	3.21	3.92	7.17	8.67	10.03	11.43
Maize + Soybean	2.94	3.46	6.69	8.17	9.49	10.77
Fallow	2.27	2.57	5.73	6.20	8.00	8.66

Comparison of sub plot means at the same level of main plot means

Comparison main plot means at the same or different level of sub plot means

S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%
0.12	0.35	0.18	0.54	0.22	0.64
0.14	0.40	0.44	1.32	0.53	1.53

4.3.3 Drymatter distribution at harvest

Dry weight of stem + leaves as well as dry weight of head was significantly higher with S.rostrata-rice-sunflower sequence (The mean dry weight of stem + leaves and disc per plant was 13.74 and 27.45 g per plant respectively). The dry weight of stem + leaves with sunhemp-rice-sunflower sequence was at par with S.rostrata-rice-sunflower sequence during both the years (mean of 13.00 g per plant). But the dry weight of disc with sunhemp-rice-sunflower was significantly lower during 1989-90 (31.04 g) while it was on par during 1990-91 (18.07 g) with S.rostrata-rice-sunflower sequence (34.82 g in 1989-90 and 20.08 g in 1990-91). The dry weight of stem + leaves and disc was lowest with maize-rice-sunflower (mean of 7.16 and 13.79 g per plant respectively) which was on par with fallow-rice-sunflower sequence (mean of 8.33 and 14.64 g per plant respectively). There was no significant difference in the dry weight stem + leaves and disc among the premonsoon intercropping treatments followed by rice-sunflower (Table 4.21).

Drymatter distribution in stem + leaves and heads increased significantly with the addition of 100 kg N per ha. The mean increase in drymatter of stem + leaves was 1.15 g per plant and in heads was 2.54 g per plant over 50 kg N per ha (Table 4.21).

Interaction of the residual effects of crops grown and levels of N on the drymatter accumulation in leaves + stem at harvest of sunflower was significant during 1990-91 and mean over two years (Table 4.23). Residual effect of S.rostrata and sunhemp green manures at both the N levels produced more drymatter in leaves + stem during 1990-91 and mean of two years. Sesbania rostrata in premonsoon at 50 kg N level for rice produced more drymatter in leaves + stem (9.68 g) compared to maize (5.67 g), intercropped sunhemp (8.30 g), soybean (8.17 g) and fallow (6.20 g) treatments and was on par with soybean (9.33 g), sunhemp (9.44 g) and intercropped S.rostrata (8.67 g) at 100 kg N per ha. Pre-monsoon maize and fallow followed by rice-sunflower produced lower drymatter of leaves + stem at both the N levels compared to the rest of the treatments. Similar trend was observed in the mean drymatter accumulation of leaves + stem.

4.3.4 Plant height

Plant height at harvest of sunflower was significantly higher with sole S.rostrata-rice-sunflower sequence (91.5 cm in 1989-90 and 55.0 cm in 1990-91 and mean of 73.3 cm) which was on par with sunhemp-rice-sunflower sequence (85.3 and 53.8 cm in 1989-90 and 1990-91 respectively and mean of 69.6 cm). Maize-rice-sunflower sequence recorded significantl

lowest plant height (mean of 52.80 cm) which was on par with fallow-rice-sunflower sequence (mean of 56.6 cm). Among the intercropping treatments followed by rice-sunflower the plant height did not differ significantly (Table 4.24).

Plant height was significantly higher with 100 kg N per ha for rice. At 100 kg N per ha mean plant height was 66.5 cm whereas with 50 kg N per ha it was 62.4 cm (Table 4.24).

4.3.5 Leaf area index

Leaf area index of sunflower was significantly higher with S. rostrata-rice-sunflower sequence (1.08 in 1989-90, 0.80 in 1990-91 and mean of 0.94) which was on par with sunhemp-rice-sunflower sequence. Maize-rice-sunflower recorded lowest LAI during both the years (0.54 in 1989-90 and 0.47 in 1990-91 and mean of 0.50) which was on par with fallow-rice-sunflower. Among intercropping treatments followed by rice-sunflower, LAI of maize + S. rostrata-rice-sunflower and maize + sunhemp-rice-sunflower was at par (0.81 and 0.82 respectively) (Table 4.24).

Leaf area index was maximum with the addition of 100 kg N per ha for rice (0.96 in 1989-90 and 0.67 in 1990-91 and mean of 0.81) over 50 kg N per ha (Table 4.24).

Table 4.24 Influence of premonsoon cropping and residual fertility status of Kharif rice crop on the plant height and leaf area index of sunflower

Treatments	Plant height at harvest (cm)			LAI at 50 DAP		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean
Maize	61.8	43.8	52.8	0.54	0.47	0.50
Soybean	78.3	50.7	64.5	0.94	0.61	0.77
<u>Sesbania rostrata</u>	91.5	55.0	73.3	1.08	0.80	0.94
Sunhemp	85.3	53.8	69.6	1.03	0.76	0.90
Maize + Sunhemp	81.7	52.7	67.2	0.94	0.68	0.81
Maize + <u>S. rostrata</u>	82.0	51.0	66.5	0.97	0.68	0.82
Maize + Soybean	79.7	48.5	64.1	0.89	0.61	0.75
Fallow	66.0	47.3	56.6	0.65	0.51	0.58
S.Em±	2.46	1.15	1.36	0.04	0.02	0.02
CD at 5%	7.45	3.48	3.93	0.11	0.06	0.06
<u>Nitrogen levels</u>						
50 kg N/ha	75.9	48.9	62.4	0.79	0.61	0.70
100 kg N/ha	81.1	51.8	66.5	0.96	0.67	0.81
S.Em±	0.61	0.33	0.35	0.02	0.01	0.01
CD at 5%	1.84	0.98	1.01	0.05	0.02	0.03

4.3.6 Diameter of the head

Diameter of the head was significant and was highest with S.rostrata-rice-sunflower (10.8 cm in 1989-90, 10.7 cm in 1990-91) which was on par with sunhemp-rice-sunflower sequence (mean of 10.3 cm). Maize-rice-sunflower recorded the lowest diameter of the head (6.7 and 5.7 cm in 1989-90 and 1990-91 respectively) followed by fallow-rice-sunflower (mean of 6.7 cm). The diameter of the head in treatments of soybean-rice-sunflower (mean of 8.6 cm), maize + sunhemp-rice-sunflower (mean of 8.6 cm), maize + S.rostrata-rice-sunflower (mean of 8.6 cm) and maize + soybean-rice-sunflower (mean of 8.2 cm) was at par (Table 4.25).

Addition of 100 kg N per ha for rice significantly increased the diameter of the head over 50 kg N for rice. With 100 kg N per ha the head diameter was 9.0 cm in 1989-90 and 8.5 cm in 1990-91 and mean of 8.8 cm (Table 4.25).

Interaction effect of the residual effect of premonsoon crops and N levels on the diameter of the head of succeeding sunflower was significant during 1989-90 (Table 4.26). Residual effect of S.rostrata and sunhemp green manures produced large sized heads at both the N levels compared to the rest of the treatments (10.5 and 10.2 cm at 50 kg N level and 11.1 and 10.3 cm at 100 kg N level, with S.rostrata and sunhemp respectively). Residual effect of S.rostrata and

Table 4.25 Yield parameters of sunflower as influenced by residual fertility status of rice

Treatments	Diameter of the head (cm)		No. of filled seeds		% filled seeds		Seed weight per head (g)		1000 seed weight (g)						
	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91	Mean			
Maize	6.7	5.7	6.2	203	157	180	54.6	52.9	53.7	5.62	4.15	4.89	30.2	29.7	29.9
Soybean	8.7	8.5	8.6	240	178	209	74.7	62.1	68.4	7.59	5.43	6.51	34.8	35.2	34.9
<u>Sesbania rostrata</u>	10.8	10.7	10.8	285	206	245	81.2	72.5	76.8	9.36	6.73	8.05	36.7	37.5	37.1
Sunhemp	10.3	10.3	10.3	275	188	232	78.7	69.2	73.9	8.80	6.08	7.44	35.1	36.7	35.9
Maize + Sunhemp	8.6	8.5	8.6	269	179	224	70.9	60.6	65.8	8.43	5.24	6.83	32.7	34.5	33.6
Maize + <u>S. rostrata</u>	8.9	8.2	8.6	278	181	229	69.9	61.0	65.4	8.05	5.27	6.66	34.5	34.6	34.5
Maize + Soybean	8.4	8.1	8.2	255	169	212	63.8	56.9	60.4	7.66	4.81	6.23	32.7	33.5	33.1
Fallow	7.2	5.1	6.7	215	162	188	56.4	49.1	52.7	6.15	4.37	5.26	32.2	31.7	32.0
S.E.m _t	0.27	0.32	0.21	6.58	5.70	4.36	1.5	1.4	1.0	0.24	0.22	0.16	0.59	0.61	0.43
CD at 5%	0.83	0.96	0.60	19.96	17.40	12.60	4.6	4.4	3.0	0.73	0.66	0.47	1.79	1.86	1.23
<u>Nitrogen levels</u>															
50 kg N/ha	8.4	8.1	8.2	239	172	205	64.2	56.4	60.3	7.38	5.07	6.23	30.6	31.9	31.3
100 kg N/ha	9.0	8.5	8.8	266	183	225	73.3	64.7	69.0	8.03	5.44	6.74	36.7	36.3	36.3
S.E.m _t	0.06	0.09	0.05	1.75	0.81	0.96	0.4	0.4	0.3	0.08	0.04	0.05	0.21	0.24	0.16
CD at 5%	0.18	0.26	0.15	5.24	2.43	2.67	1.1	1.3	0.8	0.29	0.12	0.15	0.61	0.73	0.46

Treatments for Kharif rice

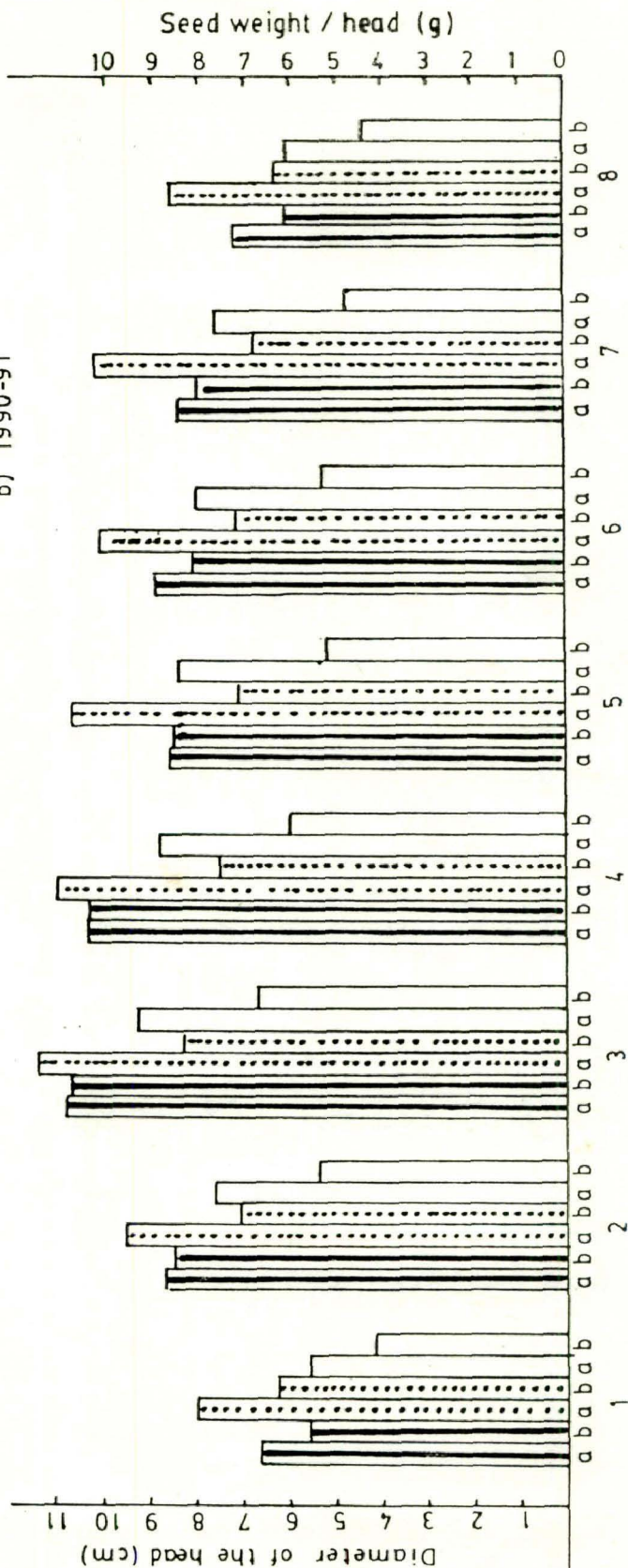
- 1 Maize
- 2 Soybean
- 3 Sesbania rostrata
- 4 Sunhemp

- 5 Maize+Sunhemp
- 6 Maize+S. rostrata
- 7 Maize+ Soybean
- 8 Fallow (no preceeding crop)

INDEX

-  Diameter of head
-  Number of seeds/head
-  Seed weight / head

- a) 1989-90
- b) 1990-91



43. YIELD PARAMETERS OF SUNFLOWER AS INFLUENCED BY THE RESIDUAL EFFECT OF KHARIF RICE TREATMENTS.

50 kg N per ha for rice produced significantly larger sized heads (10.5 cm) compared to maize, soybean, intercropped sunhemp, soybean and fallow treatments at 100 kg N level (varied from 7.1 to 9.0 cm) and was on par with intercropped S. rostrata at 100 kg N level. Residual effects of maize and fallow treatments produced significantly smaller sized heads at both N levels.

4.3.7 Number of filled seeds per head

Number of filled seeds per head was significant and highest with S. rostrata-rice-sunflower during both the years (285 in 1989-90, 206 in 1990-91 and mean of 245). During 1989-90 the filled seeds with S. rostrata-rice-sunflower(285) was at par with sunhemp-rice-sunflower (275) maize + sunhemp-rice-sunflower (269) and maize-S. rostrata-rice-sunflower(278). Lowest number of filled seeds per head was recorded with maize-rice-sunflower (mean of 180 per head) which was on par with fallow-rice-sunflower sequence (mean of 188 grains per head). Among the intercropping treatments followed by rice-sunflower, maize + sunhemp and maize + S. rostrata produced more number filled seeds per head(mean of 65.8 and 65.4 with maize + sunhemp and maize + S. rostrata respectively) (Table 4.25).

Addition of N at 100 kg per ha increased the number of filled seeds per head over 50 kg N per ha for rice. Mean increase in number of filled seeds per head was 27 in 1989-90 and 11 in 1990-91 and mean of 20 seeds per head (Table 4.25).

4.3.8 Percent filled seeds per head

Per cent filled seeds were significantly higher with S.rostrata-rice-sunflower during both the years (81.2 and 72.5 per cent in 1989-90 and 1990-91 respectively with the mean of 76.8 per cent) which was on par with sunhemp-rice-sunflower sequence. Per cent filled seeds with maize + sunhemp-rice-sunflower and with maize + S.rostrata-rice-sunflower were at par and superior to maize + soybean-rice-sunflower. During 1990-91 the per cent filled seeds with soybean-rice-sunflower and maize + soybean-rice-sunflower were on par with maize + S.rostrata-rice-sunflower. Lowest per cent filled seeds were recorded in maize-rice-sunflower (mean of 53.7 per cent) and fallow-rice-sunflower (mean of 52.71 per cent)(Table 4.25).

Addition of 100 kg N per ha to rice significantly increased the per cent filled seeds per head over 50 kg N per ha. The increase in per cent filled seeds during 1989-90 was 9.1, during 1990-91 it was 8.3 and mean increase of 8.7 (Table 4.25).

Table 4.26 Interaction of the residual effects of premonsoon cropping and N levels for kharif rice on the diameter of the disc, and per cent filled seeds per head of the succeeding sunflower crop

Treatments	Diameter of the disc (g)		% filled seeds/head	
	50 kg	100 kg	50 kg	100 kg
	N/ha			
Maize	6.4	7.1	52.4	56.8
Soybean	8.5	8.8	69.9	79.5
<u>Sesbania rostrata</u>	10.5	11.1	76.4	86.0
Sunhemp	10.2	10.3	73.0	84.4
Maize + Sunhemp	8.1	9.0	66.2	75.6
Maize + <u>S. rostrata</u>	8.0	9.8	63.5	76.3
Maize + Soybean	8.1	8.7	59.3	68.3
Fallow	7.1	7.4	53.0	59.7
	<u>S.E.m_±</u>	<u>CD at 5%</u>	<u>S.E.m_±</u>	<u>CD at 5%</u>
Comparison of sub plot means at the same level of main plot means	0.2	0.5	1.1	3.1
Comparison of main plot means at same or different level of sub plot means	0.3	0.9	1.7	5.1

Per cent filled seeds per head differed significantly due to interaction of the residual effect of the crops grown and levels of N during 1989-90 (Table 4.26). Residual effect of S.rostrata and sunhemp registered higher number of per cent filled seeds per head at both the N levels (76.4 and 86.0 per cent at 50 and 100 kg N per ha respectively). Sesbania rostrata green manure and 50 kg N per ha registered more per cent filled seeds (76.4) compared to maize (56.8) intercropped soybean (68.3) and fallow (59.7) treatments and was on par with soybean (79.5) intercropped sunhemp (75.6) and S.rostrata (76.3) at 100 kg N level. The rest of the treatments at 50 kg N level produced lower per cent of filled seeds per head.

4.3.9 Seed weight per head

Seed weight per head increased significantly with S.rostrata-rice-sunflower (9.36 g in 1989-90 and 6.73 g in 1990-91 and mean of 8.05 g per head). Which was on par with sunhemp-rice-sunflower (8.80 g in 1989-90 and 6.08 g in 1990-91 and mean of 7.44 g per head). While the seed weight per head was significantly lowest with maize-rice-sunflower (5.62 g in 1989-90 and 4.15 g in 1990-91 and mean of 4.89 g per head) and fallow-rice-sunflower (mean of 5.26 g per head) sequence.

Per cent filled seeds per head differed significantly due to interaction of the residual effect of the crops grown and levels of N during 1989-90 (Table 4.26). Residual effect of S.rostrata and sunhemp registered higher number of per cent filled seeds per head at both the N levels (76.4 and 86.0 per cent at 50 and 100 kg N per ha respectively). Sesbania rostrata green manure and 50 kg N per ha registered more per cent filled seeds (76.4) compared to maize (56.8) intercropped soybean (68.3) and fallow (59.7) treatments and was on par with soybean (79.5) intercropped sunhemp (75.6) and S.rostrata (76.3) at 100 kg N level. The rest of the treatments at 50 kg N level produced lower per cent of filled seeds per head.

4.3.9 Seed weight per head

Seed weight per head increased significantly with S.rostrata-rice-sunflower (9.36 g in 1989-90 and 6.73 g in 1990-91 and mean of 8.05 g per head). Which was on par with sunhemp-rice-sunflower (8.80 g in 1989-90 and 6.08 g in 1990-91 and mean of 7.44 g per head). While the seed weight per head was significantly lowest with maize-rice-sunflower (5.62 g in 1989-90 and 4.15 g in 1990-91 and mean of 4.89 g per head) and fallow-rice-sunflower (mean of 5.26 g per head) sequence.

Among the intercropping treatments followed by rice-sunflower sequence maize + sunhemp and maize + S.rostrata were superior to maize + soybean (Table 4.25).

Application of 100 kg N per ha increased the seed weight per head significantly. The increase in seed weight with 100 kg N per ha for rice was 0.65 g in 1989-90, 0.37 g in 1990-91 and mean of 0.51 g per head over 50 kg N per ha (Table 4.25).

4.3.10 1000 seed weight

Green manuring rice with sole S.rostrata and sole sunhemp has significantly influenced the 1000-seed weight of succeeding sunflower. Thousand seed weight with S.rostrata-rice-sunflower during 1989-90 was 36.7 g and during 1990-91 it was 37.5 g with mean of 37.1 g which was on par with sunhemp-rice-sunflower sequence. Lowest 1000-seed weight was recorded with maize-rice-sunflower sequence (30.2 g in 1989-90, 29.7 g in 1990-91 and mean of 29.9 g). Among the intercropping treatments followed by rice-sunflower, maize + S.rostrata-rice-sunflower recorded higher 1000-seed weight (mean of 34.5 g which was on par with soybean-rice-sunflower sequence (mean of 34.9 g) (Table 4.25).

Plate 14 : Sunflower grown under residual fertility
status of kharif rice treatments viz.
Sesbanja rostrata green manure along with
50 kg fertilizer N per ha.

Plate 15 : Sunflower grown under residual fertility
status of kharif rice treatment viz.
premonsoon fallow and 50 kg fertilizer
N per ha.

PLATE 14



PLATE 15



Addition of 100 kg N per ha improved the 1000 seed weight significantly over 50 kg N per ha. The increase in 1000 seed weight due to addition of 100 kg N per ha over 50 kg N per ha was 6.1 g in 1989-90 and 4.4 g in 1990-91 (Table 4.25).

4.3.11 Seed yield of sunflower

Seed yield of sunflower was significantly enhanced with S.rostrata-rice-sunflower during both the years (929 kg per ha in 1989-90 and 637 kg per ha in 1990-91 and mean of 783 kg per ha). Seed yield with S.rostrata-rice-sunflower during 1989-90 was at par with sunhemp-rice-sunflower sequence (867 kg per ha). Lowest seed yield was recorded with maize-rice-sunflower (511 kg per ha in 1989-90, 351 kg per ha in 1990-91 and mean of 431 kg per ha) which was on par with fallow-rice-sunflower (572 kg per ha in 1989-90, 375 kg per ha in 1990-91 with the mean of 473 kg per ha). The seed yield among intercropping treatments followed by rice-sunflower was significantly higher with maize + sunhemp-rice-sunflower (mean of 648 kg per ha) which was on par with maize + S.rostrata-rice-sunflower (mean of 639 kg per ha) (Table 4.27).

Addition of 100 kg N per ha to kharif rice crop increased the seed yield of sunflower significantly over 50 kg N per ha. The increase in seed yield was 73 kg per ha in 1989-90, 45 kg per ha in 1990-91 and mean increase of 59 kg per ha (Table 4.27).

Table 4.27 Seed and stalk yields and total biomass production of sunflower as influenced by premonsoon cropping and residual fertility status of kharif rice crop

Treatments	Seed yield (kg/ha)			Stalk yield (kg/ha)			Total biomass (t/ha)		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91	Mean
Maize	511	351	431	1299	694	996	1.81	1.04	1.43
Soybean	732	492	612	1784	1016	1400	2.52	1.51	2.01
<u>Sesbania rostrata</u>	929	637	783	1977	1204	1591	2.91	1.84	2.37
Sunhemp	867	560	713	1862	1140	1501	2.73	1.70	2.21
Maize + Sunhemp	826	471	648	1593	954	1274	2.42	1.43	1.92
Maize + <u>S. rostrata</u>	784	494	639	1657	979	1318	2.44	1.47	1.96
Maize + Soybean	738	424	581	1533	893	1213	2.27	1.32	1.79
Fallow	572	375	473	1470	763	1116	2.04	1.14	1.59
S.E.m±	26.7	22.6	17.5	27.3	37.9	23.4	0.04	0.04	0.03
CD at 5%	81.1	68.5	50.7	82.8	114.9	67.6	0.13	0.11	0.08
<u>Nitrogen levels</u>									
50 kg N/ha	708	453	581	1594	909	1252	2.30	1.36	1.83
100 kg N/ha	781	498	640	1700	1001	1350	2.48	1.50	1.99
S.E.m±	10.8	3.2	5.6	7.5	7.3	5.2	0.01	0.01	0.01
CD at 5%	32.2	9.6	16.2	22.4	21.9	15.1	0.04	0.02	0.02

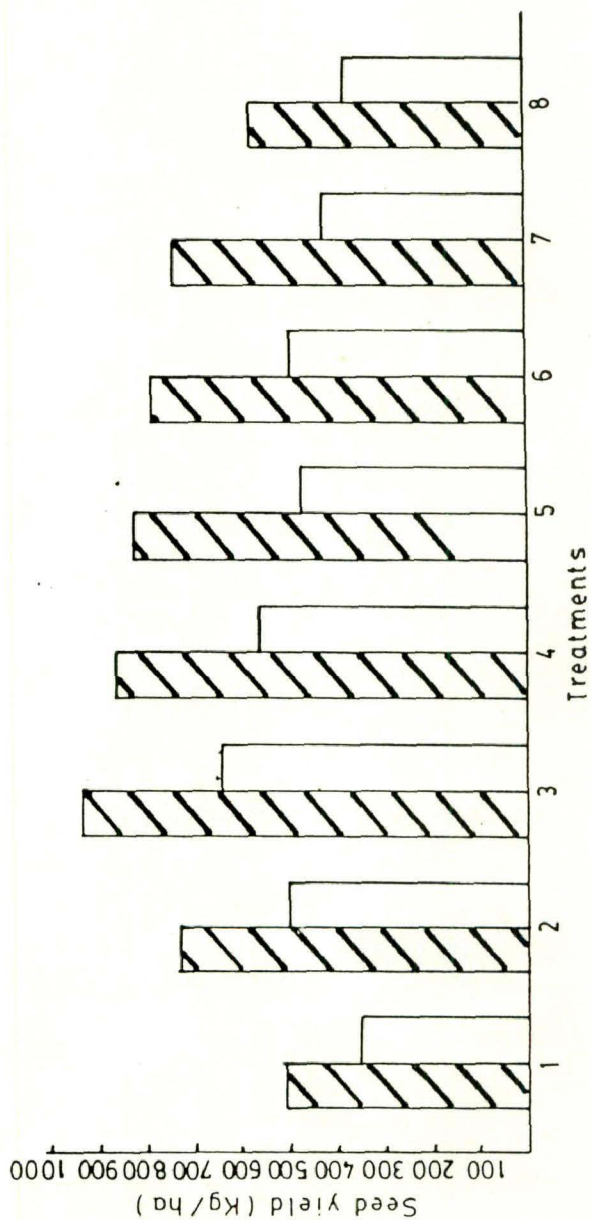
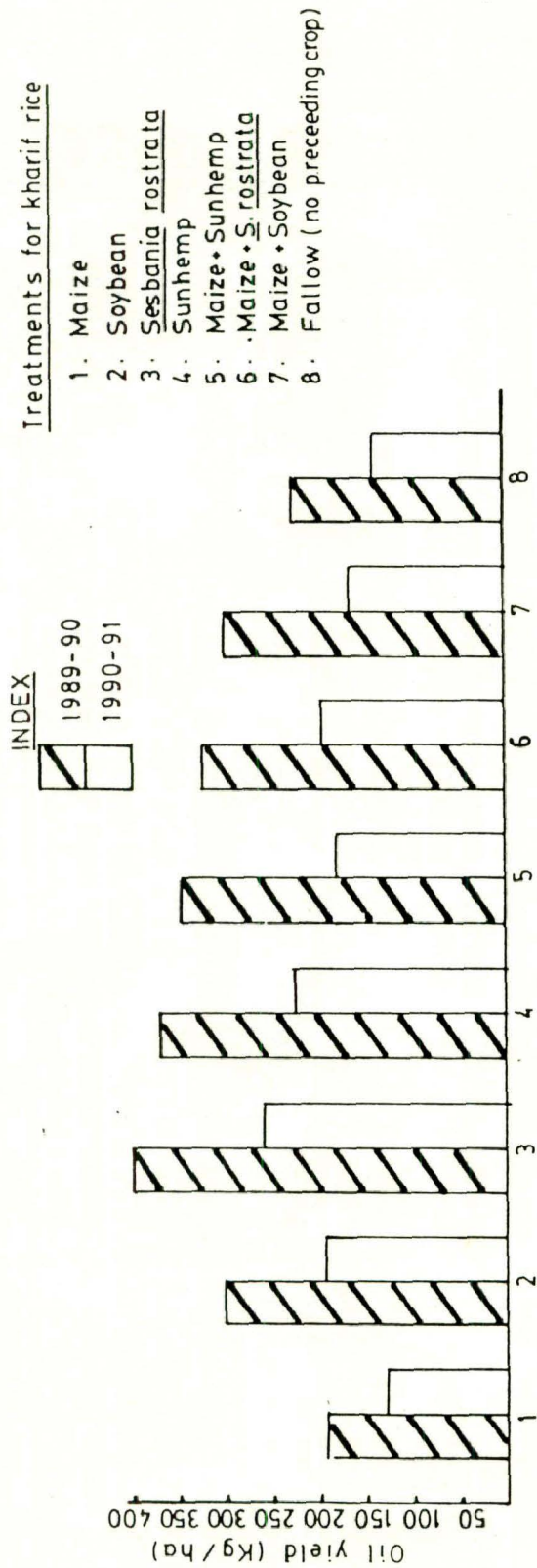


FIG. 4.4. SEED AND OIL YIELD OF SUNFLOWER AS INFLUENCED BY THE RESIDUAL EFFECT OF KHARIF RICE TREATMENTS

4.3.12 Stalk yield of sunflower

Stalk yield was significantly higher during both the years with S.rostrata-rice-sunflower (1977 and 1204 kg per ha in 1989-90 and 1990-91 respectively and mean of 1591 kg per ha). During 1990-91 the stalk yield with sunhemp-rice-sunflower sequence (1140 kg per ha) was at par with S.rostrata-rice-sunflower sequence (1204 kg per ha). Lowest stalk yield was recorded with maize-rice-sunflower sequence (mean of 996 kg per ha). Among the intercropping treatments followed by rice-sunflower, maize + S.rostrata-rice-sunflower sequence recorded maximum stalk yield during both the years (1657 kg per ha in 1989-90 and 979 kg per ha in 1990-91 and mean of 1318 kg per ha) and was on par with maize + sunhemp-rice-sunflower during both the years (Table 4.27).

Addition of N at 100 kg per ha to rice improved the stalk yield significantly over 50 kg N per ha. The increase in stalk yield with 100 kg N per ha was 106 kg per ha in 1989-90, 92 kg per ha in 1990-91 and mean of 98 kg per ha over 50 kg N per ha (Table 4.27).

Interaction of the residual effects of crops grown and N levels on the stalk yield of succeeding sunflower crop was significant during 1990-91 (Table 4.28). Sesbania rostrata and sunhemp premonsoon crops followed by rice-sunflower

Table 4.28 Interaction of the residual effects of premonsoon cropping and N levels for kharif rice on the stalk yield and total biomass production of succeeding sunflower crop

Treatments	Stalk yield(kg/ha)		Biomass (t/ha)	
	50 kg	100 kg	50 kg	100 kg
	----- N/ha -----		-----	
Maize	651	736	0.99	1.10
Soybean	992	1040	1.47	1.55
<u>Sesbania rostrata</u>	1148	1259	1.76	1.92
Sunhemp	1040	1239	1.57	1.83
Maize + Sunhemp	916	992	1.36	1.49
Maize + <u>S. rostrata</u>	929	1030	1.40	1.54
Maize + Soybean	856	930	1.25	1.38
Fallow	742	781	1.10	1.18
	<u>S.E.m±</u>	<u>CD at 5%</u>	<u>S.E.m±</u>	<u>CD at 5%</u>
Comparison of sub plot means at the same level of main plot means	20.7	62.1	0.02	0.05
Comparison of main plot means at the same or different level of sub plot means	40.6	123.1	0.04	0.11

produced higher stalk yield at both the N levels compared to the rest of the treatments. Stalk yield of sunflower due to S.rostrata (1148 kg per ha) or sunhemp (1040 kg per ha) premonsoon green manures with 50 kg N per ha was equal or superior to premonsoon maize, soybean, fallow and intercropped sunhemp, S.rostrata and soybean treatments followed by rice-sunflower (varied from 736 to 1040 kg per ha). Stalk yield with premonsoon soybean and intercropped sunhemp, S.rostrata and soybean at 50 kg N per ha (varied from 856 to 992 kg per ha) was equal or superior to premonsoon maize and fallow treatments at 100 kg N per ha (736 and 781 kg per ha).

4.3.13 Total biomass of sunflower

Total biomass of sunflower was significantly higher with S.rostrata-rice-sunflower sequence (2.91 t per ha in 1989-90, 1.84 t per ha in 1990-91 and mean at 2.37 t per ha). The next best was sunhemp-rice-sunflower sequence (2.73 t per ha in 1989-90, 1.70 t per ha in 1990-91 and mean of 2.21 t per ha). Among the intercropping treatments followed by rice-sunflower, maize + S.rostrata recorded higher total biomass (mean of 1.96 t per ha) compared to maize + soybean-rice-sunflower and was on par with maize + sunhemp-rice-sunflower (mean of 1.79 t per ha). Lowest total biomass recorded with maize-rice-sunflower sequence (1.81 t per ha in 1989-90, 1.04 t per ha in 1990-91 and mean of 1.43 t per ha) (Table 4.27).

Total biomass with 100 kg N per ha for rice was significantly higher over 50 kg N per ha. The increase in total biomass with 100 kg N per ha was 0.18 t per ha in 1989-90, 0.14 t per ha in 1990-91 and mean increase of 0.16 t per ha over 50 kg N per ha (Table 4.27).

Interaction of the residual effect of crops grown and levels of N on the total biomass yield of the succeeding sunflower crop was significant during 1990-91 (Table 4.28). The biomass yield of sunflower due to the residual effect of S.rostrata green manure was superior compared to the rest of the treatments at both the N levels (1.76 and 1.92 t per ha at 50 and 100 kg N per ha respectively). Residual effect of S.rostrata green manure at 50 kg N per ha registered more biomass yield (1.76 t per ha) compared to maize soybean and fallow treatments and was on par with sunhemp green manure at 100 kg N per ha. The next best treatment at 50 kg N level was sunhemp-rice-sunflower (1.57 t per ha). Maize and fallow premonsoon treatments produced lowest biomass yield at both the N levels compared to rest of the treatments.

4.3.14 Harvest index

Harvest index differed significantly during 1989-90, while, there was no significant difference in harvest index

during 1990-91 as well as of mean harvest index due to green manuring treatments. Harvest index during 1989-90 in maize + sunhemp-rice-sunflower was maximum (34.11) which was on par with S.rostrata-rice-sunflower (32.00) sunhemp-rice-sunflower (31.85) maize + S.rostrata-rice-sunflower (32.15) and maize + soybean-rice-sunflower (32.46). During 1990-91 harvest index was maximum with S.rostrata-rice-sunflower (34.74) compared to maize + soybean-rice-sunflower (32.31). Fallow-rice-sunflower and maize-rice-sunflower recorded significantly lowest harvest index (27.88 and 28.23 respectively) (Table 4.29).

With 100 kg N per ha harvest index did not differ significantly over 50 kg N per ha. However with 100 kg N per ha harvest index was higher compared to 50 kg N per ha (Table 4.29).

4.3.15 Oil content of sunflower

Oil content of sunflower improved significantly and was higher with S.rostrata-rice-sunflower (43.1 and 40.8 per cent during 1989-90 and 1990-91 respectively and mean oil per cent was 41.9) which was on par with sunhemp-rice-sunflower sequence. Lowest oil per cent was recorded in maize-rice-sunflower and fallow-rice-sunflower sequence (mean of 37.9 and 38.2 respectively). The oil content of the sunflower seeds did not vary much due to the residual effects

of premonsoon intercropping treatments viz., maize + sunhemp, maize + S.rostrata and maize + soybean followed by rice-sunflower (mean oil content varied from 39.8 to 40.3 per cent) (Table 4.29).

Addition of N improved the oil per cent significantly. The increase in oil per cent with 100 kg N per ha over 50 kg N per ha was 1.40 per cent each during both the years (Table 4.29).

4.3.16 Oil yield of sunflower

Oil yield was significantly higher with S.rostrata-rice-sunhemp (403 kg per ha in 1989-90 and 260 kg per ha in 1990-91 and mean of 332 kg per ha) which was on par with sunhemp-rice-sunflower during 1989-90. The oil yield during 1990-91 as well as the mean of two years with sunhemp-rice-sunflower ranked the second highest (226 and 299 kg per ha respectively). Lowest oil yield was recorded with maize-rice-sunflower and fallow-rice-sunflower sequences (mean of 164 and 182 kg per ha respectively). Among the intercropping treatments maize + sunhemp and maize + S.rostrata produced higher oil yield compared to maize + soybean followed by rice-sunflower (Table 4.29).

Table 4.29 Harvest index, oil content and oil yield of sunflower as influenced by premonsoon cropping and residual fertility status of kharif rice

Treatments	Harvest index(%)			Oil content(%)			Oil yield (kg/ha)		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91	Mean
Maize	28.23	33.77	31.00	38.7	37.3	37.9	198	131	164
Soybean	29.13	32.92	31.02	41.9	38.9	40.4	307	192	250
<u>Sesbania rostrata</u>	32.00	34.74	33.37	43.1	40.8	41.9	403	260	332
Sunhemp	31.85	33.09	32.47	42.8	40.4	41.6	371	226	299
Maize + Sunhemp	34.11	33.10	33.60	41.7	38.9	40.3	345	183	264
Maize + <u>S. rostrata</u>	32.15	33.59	32.87	41.6	39.0	40.3	326	193	260
Maize + Soybean	32.46	32.31	32.38	40.5	39.0	39.8	300	166	233
Fallow	27.88	32.91	30.40	39.4	36.9	38.2	226	139	182
S.E.m±	0.77	1.55	0.87	0.32	0.42	0.27	11.0	9.7	7.4
CD at 5%	2.32	-	-	0.96	1.28	0.78	33.5	24.5	21.3
<u>Nitrogen levels</u>									
50 kg N/ha	30.59	33.27	31.93	40.5	38.2	39.4	289	174	232
100 kg N/ha	31.37	33.33	32.35	41.9	39.6	40.8	330	198	264
S.E.m±	0.29	0.25	0.19	0.22	0.14	0.13	4.48	1.60	2.38
CD at 5%	-	-	-	0.66	0.40	0.37	13.44	4.80	6.86

Addition of N at 100 kg per ha to rice improved the oil yield significantly. Increase in oil yield with 100 kg N per ha was 41 kg per ha in 1989-90 and 24 kg per ha in 1990-91 and mean of 32 kg per ha over 50 kg N per ha (Table 4.29).

4.3.17 Total biomass of the sequence

Total biomass of the sequence of crops differed significantly due to green manuring as well as with N levels for rice. During 1989-90 S.rostrata-rice-sunflower recorded significantly highest total biomass (29.82 t per ha) which was on par with sunhemp-rice-sunflower sequence (29.79 t per ha). The total biomass during 1990-91 and mean total biomass was significantly highest with sunhemp-rice-sunflower (38.96 and 34.4 respectively) followed by S.rostrata-rice-sunflower sequence. Significantly lowest total biomass yield of the sequence was registered with fallow-rice-sunflower sequence (9.45 t per ha in 1989-90, 9.65 t per ha in 1990-91 and mean of 9.55 t per ha). Among the intercropping treatments maize + S.rostrata-rice-sunflower and maize + sunhemp-rice-sunflower produced higher biomass yield (mean of 24.0 and 22.7 t per ha respectively) compared to maize + soybean-rice-sunflower (mean of 18.7 t per ha) (Table 4.30).

Table 4.30 Cumulative yield of biomass production by sequence of crops as influenced by different crops grown, with nitrogen levels and on residual fertility status of rice (t/ha)

Treatments	1989-90	1990-91	Mean
Maize	21.28	18.58	19.9
Soybean	15.37	15.98	15.7
<u>Sesbania rostrata</u>	29.82	34.46	32.1
Sunhemp	29.79	38.96	34.4
Maize + Sunhemp	20.85	24.58	22.7
Maize + <u>S.rostrata</u>	22.43	25.61	24.0
Maize + Soybean	18.59	18.72	18.7
Fallow	9.45	9.65	9.6
<u>S.E.m_t</u>	0.67	1.31	0.74
CD at 5%	2.04	3.98	2.13
<u>Nitrogen levels</u>			
50 kg N/ha	20.32	22.63	21.47
100 kg N/ha	21.58	24.00	22.79
<u>S.E.m_t</u>	0.06	0.07	0.05
CD at 5%	0.20	0.22	0.14

Addition of N at 100 kg per ha recorded significantly highest total biomass of the sequence. The increase in total biomass with 100 kg N per ha was 1.26 t per ha in 1989-90 and 1.37 t per ha in 1990-91 and mean increase of 1.32 t per ha over 50 kg N per ha (Table 4.30).

4.3.18 Uptake of NPK by sunflower

Total N uptake was significantly higher with S. rostrata-rice-sunflower sequence (59.9 kg per ha in 1989-90 and 42.6 kg per ha in 1990-91 with the mean of 51.3 kg per ha) followed by sunhemp-rice-sunflower sequence (mean of 44.6 kg per ha). Maize-rice-sunflower recorded the lowest N uptake (31.4 kg per ha in 1989-90, 22.2 kg per ha in 1990-91 and mean of 26.8 kg per ha) which was on par with fallow-rice-sunflower (24.3 kg per ha) during 1990-91. Among the intercropping treatments followed by rice-sunflower the N uptake was significantly higher with maize + sunhemp-rice-sunflower (mean of 38.2 kg/ha) and maize + S. rostrata-rice-sunflower (37.9 kg per ha) compared to maize + soybean-rice-sunflower (mean of 34.0 kg per ha) (Table 4.31).

Nitrogen uptake of sunflower was significantly higher with 100 kg N per ha for rice (47.9 kg per ha in 1989-90 and 33.5 kg per ha in 1990-91 and mean of 40.7 kg per ha) compared to 50 kg N per ha (Table 4.31).

Table 4.31 NPK uptake by sunflower as influenced by premonsoon cropping and residual fertility status of kharif rice crop (kg/ha)

Treatments	Nitrogen			Phosphorus			Potassium		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91	Mean
Maize	31.4	22.2	26.8	9.9	4.9	7.5	45.4	25.5	35.4
Soybean	46.3	31.6	38.9	14.4	7.0	10.7	70.3	36.2	53.2
<u>Sesbania rostrata</u>	59.9	42.6	51.3	17.2	8.9	13.1	83.5	45.2	64.3
Sunhemp	51.9	37.3	44.6	16.3	8.3	12.3	79.6	41.2	60.4
Maize + Sunhemp	44.9	31.4	38.2	13.8	6.7	10.3	62.0	34.4	48.2
Maize + <u>S. rostrata</u>	45.2	30.6	37.9	13.9	7.1	10.5	62.6	33.1	47.8
Maize + Soybean	39.3	28.7	34.0	13.0	6.2	9.6	63.1	31.9	47.5
Fallow	35.0	24.3	29.6	11.1	5.3	8.2	62.8	27.5	45.2
S.E.m _t	1.01	0.74	0.62	0.32	0.17	0.18	1.17	1.09	0.80
CD at 5%	3.05	2.20	1.81	0.98	0.51	0.53	3.56	3.30	2.32
<u>Nitrogen levels</u>									
50 kg N/ha	40.6	28.7	34.6	12.5	6.2	9.4	62.6	31.8	47.2
100 kg N/ha	47.9	33.5	40.7	15.0	7.4	11.2	69.7	36.9	53.4
S.E.m _t	0.39	0.12	0.20	0.11	0.03	0.06	0.29	0.22	0.18
CD at 5%	1.15	0.34	0.57	0.34	0.08	0.17	0.86	0.66	0.52

Interaction of the residual effect of crops grown and levels of N on the N uptake of succeeding sunflower was significant during 1990-91 (Table 4.32). Nitrogen uptake by sunflower was highest with the residual effect of S.rostrata green manure at both the N levels (40.5 and 44.7 kg per ha at 50 and 100 kg N per ha respectively). Premonsoon S.rostrata green manure and 50 kg N per ha registered higher N uptake (40.5 kg per ha) compared to maize, soybean, intercropped sunhemp, S.rostrata soybean and fallow treatments (varied from 23.6 to 34.3 kg per ha) and was on par with sunhemp green manure (41.1 kg per ha) at 100 kg N per ha. Residual effect of premonsoon maize and fallow treatments registered significantly lower N uptake at both N levels for rice.

Phosphorus uptake was significantly higher with S.rostrata-rice-sunflower (17.2 and 8.9 kg per ha in 1989-90 and 1990-91 respectively) which was on par with sunhemp-rice-sunflower sequence (16.3 kg per ha) during 1989-90. The mean P uptake was also significantly higher with S.rostrata-rice-sunflower (13.1 kg per ha) followed by sunhemp-rice-sunflower sequence (12.3 kg per ha). Significantly lowest P uptake was recorded with maize-rice-sunflower (9.9 kg per ha in 1989-90 and 4.9 kg per ha in 1990-91). Among the intercropping treatments maize + S.rostrata-rice-sunflower,

registered more P uptake (mean of 10.5 kg per ha) which was on p. with maize+sunhemp-rice-sunflower (mean of 10.3 kg per ha) (Table 4.31).

Addition of 100 kg N per ha improved the P uptake significantly over 50 kg N per ha. The increase in P uptake with 100 kg N per ha over 50 kg N per ha was 2.5 and 1.2 kg per ha in 1989-90 and 1990-91 respectively and mean of 1.8 kg per ha (Table 4.31).

Interaction of the residual effect of crops grown and N levels on the P uptake by the succeeding sunflower was significant during 1989-90, 1990-91 and their mean (Table 4.32). Phosphorus uptake by sunflower was consistently higher with the residual effect of S.rostrata green manure at both the N levels (mean of 11.6 and 14.5 kg per ha at 50 and 100 kg N per ha respectively). Residual effect of maize registered lower P uptake at both the N levels (mean of 6.8 and 8.1 at 50 and 100 kg N per ha respectively). Residual effect of S.rostrata at 50 kg N level registered higher P uptake (14.9 and 8.3 kg per ha in 1989-90 and 1990-91 respectively) compared to maize and fallow treatments and was on par with soybean intercropped sunhemp, S.rostrata and soybean at 100 kg N level during 1989-90. During 1990-91 P uptake by sunflower was significantly higher with S.rostrata green manure at

Table 4.32 Interaction of the residual effects of premonsoon cropping and N levels for kharif rice on the nitrogen and phosphorus uptake by the succeeding sunflower crop (kg/ha)

Treatments	Nitrogen		Phosphorus					
	1990-91		1989-90					
	50 kg	100 kg	50 kg	100 kg	50 kg	100 kg	50 kg	100 kg
			N/ha					
			Mean					
Maize	20.9	23.6	9.3	10.6	4.3	5.5	6.8	8.1
Soybean	28.9	34.3	12.8	16.1	6.7	7.4	9.7	11.8
<u>Sesbania rostrata</u>	40.5	44.7	14.9	19.3	8.3	9.6	11.6	14.5
Sunhemp	33.4	41.1	15.3	17.4	7.4	9.1	11.4	13.2
Maize + Sunhemp	28.8	34.1	12.3	15.4	6.2	7.4	9.2	11.4
Maize + <u>S. rostrata</u>	28.5	32.1	12.7	15.3	6.6	7.5	9.7	11.4
Maize + Soybean	26.3	31.1	12.2	13.8	5.8	6.6	8.9	10.2
Fallow	22.5	26.0	10.2	12.1	4.8	5.9	7.5	8.9
Comparison of sub plot means at the same level of main plot means	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%
	0.32	0.97	0.32	0.95	0.07	0.22	0.16	0.47
Comparison of main plot means at the same or different level of sub plot means	0.77	2.34	0.39	1.19	0.18	0.53	0.22	0.62

50 kg N level compared to all the treatments except S.rostrata and sunhemp at 100 kg N per ha. The mean P uptake also registered same trend.

Potassium uptake was significantly higher with S.rostrata-rice-sunflower during both the years (83.5 kg per ha in 1989-90 and 45.2 kg per ha in 1990-91 and mean of 64.3 kg per ha). The next highest K removal was in sunhemp-rice-sunflower sequence (79.6 kg per ha in 1989-90, 41.2 kg per ha in 1990-91 and mean of 60.4 kg per ha). Lowest potash uptake was observed with maize-rice-sunflower sequence (45.4 kg per ha in 1989-90 and 25.5 kg per ha in 1990-91 and mean of 35.4 kg per ha). Among intercropping treatments followed by rice-sunflower K uptake did not differ significantly during both the years (Table 4.31).

Addition of N at 100 kg per ha improved the K uptake significantly over 50 kg N per ha. The increase in K uptake with 100 kg N per ha was 7.1 kg per ha in 1989-90, 5.1 kg per ha in 1990-91 and mean of 6.2 kg per ha over 50 kg N per ha (Table 4.31).

Interaction of the residual effect of crops grown and levels of N on the uptake of potassium by the succeeding sunflower was significant during both the years (Table 4.33). Residual effect of S.rostrata green manure recorded significantly more K uptake compared to the rest of the treatments during

Table 4.33 Interaction of the residual effects of premonsoon cropping and N levels for Kharif rice on the potassium uptake by the succeeding sunflower crop (kg/ha)

Treatments	1989-90			1990-91			Mean	
	50 kg	100 kg		50 kg	100 kg		50 kg	100 kg
	N/ha							
Maize	42.0	48.8		23.8	27.1		32.9	37.9
Soybean	68.9	71.7		34.4	37.9		51.6	54.8
<u>Sesbania rostrata</u>	78.6	88.3		41.5	48.9		60.1	68.6
Sunhemp	76.9	82.4		37.1	45.2		56.9	63.8
Maize + Sunhemp	58.8	65.2		31.6	37.3		45.2	51.3
Maize + <u>S. rostrata</u>	54.3	70.8		30.9	35.3		42.6	53.1
Maize + Soybean	61.2	65.1		28.5	35.2		44.9	50.1
Fallow	60.0	65.6		26.4	26.7		43.2	47.1
Comparison of sub plot means at the same level of main plot means	S.Em±	CD at 5%		S.Em±	CD at 5%		S.Em±	CD at 5%
	0.81	2.43		0.62	1.87		0.51	1.48
Comparison of main plot means at the same or different level of sub plot means	1.31	3.95		1.17	3.56		0.88	2.53

both the years (mean of 60.1 and 68.6 kg per ha at 50 and 100 kg N per ha respectively). Potassium uptake due to residual effect S.rostrata at 50 kg N level was consistently higher (78.6 and 41.5 kg per ha during 1989-90 and 1990-91 respectively) compared to maize, soybean, intercropped sunhemp, S.rostrata, soybean and fallow treatments at 100 kg N per ha. The next best treatment at 50 kg N level was the residual effect of sunhemp green manure. Residual effect of maize in premonsoon registered lowest K uptake at both the N levels (mean of 32.9 and 37.9 kg per ha at 50 and 100 kg N level per ha).

4.3.19 Changes in fertility status of the soil after harvest of premonsoon crops, kharif rice and sunflower

Organic carbon (%) did not differ significantly among the treatments after harvest of premonsoon crops, while available P_2O_5 and K_2O differed significantly during 1990-91 and 1989-90 respectively. The mean of available P_2O_5 and K_2O also differed significantly. After harvest of rice, organic carbon and available P_2O_5 and K_2O did not differ significantly. But after harvest of sunflower, organic carbon and available P_2O_5 and K_2O recorded significant differences among the treatments (Table 4.34).

The accumulation of organic carbon and available N was maximum after harvest of S.rostrata (mean of 1.21% and 285 kg per ha respectively). The available P_2O_5 was maximum (56 kg per ha) in fallow treatment. Available K_2O of soil after harvest of soybean was maximum (mean of 214 kg per ha). Organic carbon per cent diminished after harvest of maize (mean of 0.95) and available N, P_2O_5 and K_2O after harvest of maize + sunhemp (mean of 183 kg per ha), maize (mean of 22 kg per ha) and S.rostrata (mean of 156 kg per ha) respectively (Table 4.34).

The organic carbon and available P_2O_5 content of the soil after harvest S.rostrata-rice were higher (mean of 0.96 per cent and 62 kg per ha respectively) compared to maize-rice sequence (mean of 0.85 per cent and 49 kg per ha respectively). The available N status of the soil was higher after harvest of S.rostrata-rice, maize + S.rostrata-rice and fallow-rice treatments (mean of 242 kg per ha) as compared to S.rostrata-rice and sunhemp-rice sequences (mean of 209 kg per ha in both the treatments). The available K_2O content of the soil after harvest of maize-rice was maximum (mean of 356 kg per ha) and it was minimum after harvest of S.rostrata-rice sequence (mean of 209 kg per ha) (Table 4.34).

The status of organic carbon and available N, P_2O_5 and K_2O was highest after harvest of sunflower in S. rostrata-rice-sunflower sequence (mean of 1.07 per cent, 258, 98 and 482 kg per ha). The next best treatment in improving the fertility status of soil was sunhemp-rice-sunflower (mean of organic carbon, N, P_2O_5 and K_2O were 0.99 per cent, 258, 84 and 456 kg per ha respectively). The maize-rice-sunflower sequence has lower fertility status of the soil compared to the rest of the treatments (0.62 per cent, 204, 50 and 333 kg per ha). Maize + soybean-rice-sunflower sequence also registered lower available N after harvest of sunflower crop (mean of 204 kg per ha). Among intercropping treatments followed by rice-sunflower. Maize + S. rostrata-rice-sunflower and maize + sunhemp-rice-sunflower sequences has higher soil fertility status compared to maize + soybean-rice-sunflower sequence (Table 4.34).

Over the seasons there was a perceptible increase in organic carbon from the initial value of 0.44 per cent to 0.91 per cent after harvest of sunflower in S. rostrata-rice-sunflower sequence during 1989-90. During 1990-91 it further increased from 0.91 to 1.24 per cent. There was a marginal increase in organic carbon content of the soil from 0.44 to 0.55 per cent in 1989-90 and from 0.55 to 0.70 during 1990-91

after harvest sunflower in maize-rice-sunflower sequence. Among the intercropping treatments followed by rice-sunflower, maize + S.rostrata-rice-sunflower and maize + sunhemp-rice-sunflower sequences registered higher build up of organic carbon in the soil compared to maize + soybean-rice-sunflower (Table 4.34).

Available N content of the soil decreased marginally from the initial value of 256 kg per ha to 242 kg after harvest of sunflower in sunhemp-rice-sunflower sequence during 1989-90 and increased from 242 to 274 kg per ha during 1990-91. But during the second year the increase in available N was from 231 to 285 kg per ha after harvest of sunflower in S.rostrata-rice-sunflower sequence. There was perceptible decrease in available N content of the soil after harvest of sunflower in maize-rice-sunflower sequence (decreased from 256 to 198 kg per ha in 1989-90) and there was marginal increase from 198 to 209 kg per ha during 1990-91 after harvest of sunflower crop (Table 4.34).

Available P_2O_5 status of soil increased over the seasons from the initial level of 56 to 87 kg P_2O_5 per ha in 1989-90 and from 87 kg per ha to 99 kg P_2O_5 per ha in 1990-91 after harvest of sunflower in S.rostrata-rice-sunflower sequence.

While with maize-rice-sunflower there was decrease in available P_2O_5 from the initial level of 56 kg per ha to 49 kg per ha in 1989-90 and there was no change in available P_2O_5 during 1990-91. There were marginal differences in the available P_2O_5 status of the soil at the end of first and second year among the premonsoon intercropping treatments followed by rice and sunflower (Table 4.34).

There was perceptible increase in available K_2O status of the soil from the initial values of 218 and 374 kg per ha in 1989-90 and 1990-91 to 374 and 591 kg K_2O per ha respectively after harvest of sunflower in S.rostrata-rice-sunflower sequence. While there was marginal increase in available K_2O from the initial values of 218 to 232 kg per ha during 1989-90 and there was perceptible increase from 232 to 434 kg per ha during 1990-91 in maize-rice-sunflower sequence. There were marginal differences in the increase in available K_2O status of the soil at the end of first and second year in premonsoon intercropping treatments followed by rice-sunflower (Table 4.34).

4.4 Experiment 2a

Effect of sources of nitrogen on the growth and yield of rice

4.4.1 Total drymatter production

Total drymatter per hill at 30 DAP differed significantly during 1989-90. It was highest with 100 kg N per ha through urea super granule (USG) (1.30 g per hill) and was on par with 100 kg N per ha through GCU (1.09 g per hill) and urea in three splits (1.16 g per hill). The mean drymatter per hill was also highest with 100 kg N per ha through USG (1.27 g per hill).

The mean dry weight at 60 DAP was significantly different among the treatments. Urea super granule to supply 100 kg N per ha recorded maximum total dry weight (7.43 g per hill) which was on par with 100 kg N per ha through GCU (7.21 g per hill) and green leaf manuring at 10 t per ha + 75 kg N per ha through urea (7.13 g per hill).

At 90 DAP and at harvest total dry weight per hill differed significantly during 1990-91 only. Maximum total dry weight at 90 DAP was recorded with 100 kg N per ha through USG (19.12 g per hill) which was on par with rest of the treatments except 100 kg N per ha through URP (17.21 g per hill). At harvest 100 kg N per ha through GCU recorded

Table 4.35 Total dry matter and its distribution at different stages of growth of rice as influenced by sources of nitrogen (g/hill)

Treatments	30 DAP		60 DAP		90 DAP		At harvest	
	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91
	Total dry weight							
GLM at 10 t per ha + 75 kg N through urea	1.02	0.97	0.99	7.05	7.22	7.13	21.35	19.12
100 kg N through urea	1.16	1.04	1.09	5.60	7.02	6.31	18.12	17.16
100 kg N through GCU	1.09	0.99	1.04	6.65	7.78	7.21	19.42	16.64
100 kg N through USG	1.30	1.24	1.27	6.99	7.67	7.43	19.42	19.27
100 kg N through URP	0.98	0.99	0.99	5.46	7.05	6.26	19.02	15.40
S.E.m. CD at 5%	0.08 0.25	0.09 -	0.06 0.18	0.59 -	0.46 1.08	0.37 1.08	1.6 -	1.15 3.54
	Drymatter distribution in stem							
GLM at 10 t per ha + 75 kg N through urea	0.52	0.49	0.51	3.80	4.21	4.00	8.03	7.80
100 kg N through urea	0.61	0.57	0.59	3.13	4.39	3.80	6.58	6.20
100 kg N through GCU	0.55	0.56	0.55	3.93	5.10	4.50	7.20	7.40
100 kg N through USG	0.66	0.67	0.67	3.99	4.77	4.40	6.70	7.20
100 kg N through URP	0.52	0.58	0.55	3.27	4.46	3.90	6.69	6.20
S.E.m. CD at 5%	0.05 -	0.06 -	0.04 0.11	0.35 -	0.32 -	0.24 -	0.68 -	0.35 1.07
	Drymatter distribution in leaves							
GLM at 10 t per ha + 75 kg N through urea	0.50	0.48	0.49	3.25	3.01	3.13	4.21	3.01
100 kg N through urea	0.55	0.47	0.51	2.48	2.63	2.55	3.01	2.63
100 kg N through GCU	0.54	0.43	0.48	2.73	2.66	2.70	3.27	2.68
100 kg N through USG	0.63	0.57	0.60	3.00	3.10	3.05	3.24	3.09
100 kg N through URP	0.47	0.41	0.44	2.20	2.59	2.40	3.38	2.59
S.E.m. CD at 5%	0.04 0.12	0.04 0.12	0.03 0.08	0.25 0.78	0.18 0.45	0.16 0.45	0.32 0.99	0.18 0.54
	Drymatter distribution in panicles							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	9.10	6.08
100 kg N through urea	-	-	-	-	-	-	8.96	7.76
100 kg N through GCU	-	-	-	-	-	-	8.61	7.40
100 kg N through USG	-	-	-	-	-	-	9.72	8.31
100 kg N through URP	-	-	-	-	-	-	8.76	6.60
S.E.m. CD at 5%	-	-	-	-	-	-	0.84	0.79
	Stem + Leaves							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	20.20	12.43
100 kg N through urea	-	-	-	-	-	-	15.70	13.28
100 kg N through GCU	-	-	-	-	-	-	16.90	14.93
100 kg N through USG	-	-	-	-	-	-	17.90	13.41
100 kg N through URP	-	-	-	-	-	-	18.90	10.23
S.E.m. CD at 5%	-	-	-	-	-	-	1.45	1.13
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27
100 kg N through URP	-	-	-	-	-	-	19.02	15.40
S.E.m. CD at 5%	-	-	-	-	-	-	1.6	1.15
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27
100 kg N through URP	-	-	-	-	-	-	19.02	15.40
S.E.m. CD at 5%	-	-	-	-	-	-	1.6	1.15
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27
100 kg N through URP	-	-	-	-	-	-	19.02	15.40
S.E.m. CD at 5%	-	-	-	-	-	-	1.6	1.15
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27
100 kg N through URP	-	-	-	-	-	-	19.02	15.40
S.E.m. CD at 5%	-	-	-	-	-	-	1.6	1.15
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27
100 kg N through URP	-	-	-	-	-	-	19.02	15.40
S.E.m. CD at 5%	-	-	-	-	-	-	1.6	1.15
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27
100 kg N through URP	-	-	-	-	-	-	19.02	15.40
S.E.m. CD at 5%	-	-	-	-	-	-	1.6	1.15
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27
100 kg N through URP	-	-	-	-	-	-	19.02	15.40
S.E.m. CD at 5%	-	-	-	-	-	-	1.6	1.15
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27
100 kg N through URP	-	-	-	-	-	-	19.02	15.40
S.E.m. CD at 5%	-	-	-	-	-	-	1.6	1.15
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27
100 kg N through URP	-	-	-	-	-	-	19.02	15.40
S.E.m. CD at 5%	-	-	-	-	-	-	1.6	1.15
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27
100 kg N through URP	-	-	-	-	-	-	19.02	15.40
S.E.m. CD at 5%	-	-	-	-	-	-	1.6	1.15
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27
100 kg N through URP	-	-	-	-	-	-	19.02	15.40
S.E.m. CD at 5%	-	-	-	-	-	-	1.6	1.15
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27
100 kg N through URP	-	-	-	-	-	-	19.02	15.40
S.E.m. CD at 5%	-	-	-	-	-	-	1.6	1.15
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27
100 kg N through URP	-	-	-	-	-	-	19.02	15.40
S.E.m. CD at 5%	-	-	-	-	-	-	1.6	1.15
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27
100 kg N through URP	-	-	-	-	-	-	19.02	15.40
S.E.m. CD at 5%	-	-	-	-	-	-	1.6	1.15
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27
100 kg N through URP	-	-	-	-	-	-	19.02	15.40
S.E.m. CD at 5%	-	-	-	-	-	-	1.6	1.15
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27
100 kg N through URP	-	-	-	-	-	-	19.02	15.40
S.E.m. CD at 5%	-	-	-	-	-	-	1.6	1.15
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27
100 kg N through URP	-	-	-	-	-	-	19.02	15.40
S.E.m. CD at 5%	-	-	-	-	-	-	1.6	1.15
	Mean							
GLM at 10 t per ha + 75 kg N through urea	-	-	-	-	-	-	21.35	19.12
100 kg N through urea	-	-	-	-	-	-	18.12	17.16
100 kg N through GCU	-	-	-	-	-	-	19.42	16.64
100 kg N through USG	-	-	-	-	-	-	19.42	19.27

significantly higher total dry weight per hill (41.13 g per hill) which was on par with rest of the treatments except 100 kg N per ha through URP (38.01 g per hill) (Table 4.35).

4.4.2 Drymatter distribution

Drymatter distribution in stem did not differ significantly at 30 DAP during both the years. Mean drymatter of stem was highest with 100 kg N per ha through USG (0.67 g per plant) which was on par with 100 kg N per ha through urea (0.59 g per plant). At 60 DAP drymatter of stem did not differ significantly. At 90 DAP maximum drymatter of stem was recorded with green leaf manuring at 10 t per ha + 75 kg N per ha through urea during 1990-91 and mean dry weight (7.80 and 7.92 g per hill respectively) which was on par with 100 kg N per ha through USG and GCU. At harvest drymatter of shoot differed significantly during 1990-91. Maximum drymatter of shoot was recorded with 100 kg N per ha through GCU (15.90 g per hill) which was on par with rest of the treatments except 100 kg N per ha through URP (Table 4.35).

At 30 DAP drymatter distribution in leaves differed significantly during both the years. Maximum drymatter of leaves was recorded with 100 kg N per ha through USG (mean of 0.60 g per hill). At 60 DAP drymatter of leaves differed significantly during 1989-90 and mean of two years. Green leaf manuring at 10 t per ha + 75 kg N through urea accumulated

significantly higher drymatter in leaves (3.25 g per hill in 1989-90 and mean of 3.13 g per hill) which was on par with 100 kg N per ha through USG and GCU. At 90 DAP also drymatter of leaves differed significantly during 1989-90 and mean dry weight. Maximum dry weight of 4.21 g per hill was recorded with green leaf manuring at 10 t per ha + 75 kg N through urea which was on par with rest of the treatments except 100 kg N per ha through urea (3.01 g per hill). Mean dry weight of leaves was also significantly more with green leaf manuring at 10 t per ha + 75 kg N through urea (3.61 g per hill) which was on par with 100 kg N per ha through USG (3.17 g per hill (Table 4.35).

The drymatter distribution in the panicle was not significantly different among the treatments at 90 DAP and at harvest. However maximum panicle dry weight was observed with 100 kg N through USG (mean of 8.91 and 27.39 g per hill) (Table 4.35).

4.4.3 Leaf area per hill

At 30 DAP during 1990-91 leaf area per hill was significantly higher with 100 kg N per ha through USG (151 cm² per hill) which was on par with green leaf manuring at 10 t per ha + 75 kg N per ha through urea and 100 kg N per ha through urea

(125 and 121 cm^2 per hill). The mean leaf area was also higher with 100 kg N per ha through USG (122 cm^2 per hill).

At 60 DAP and 90 DAP leaf area differed significantly during 1989-90 and mean leaf area in two years. Maximum leaf area was recorded with 100 kg N per ha through USG at both the stages (mean of 575 and 615 cm^2 per hill at 60 and 90 DAP respectively) which was on par with green leaf manuring at 10 t per ha + 75 kg N through urea (551 and 573 cm^2 at 30 and 60 DAP respectively) and 100 kg N per ha through GCU (Table 4.36).

4.4.4 Leaf area index (LAI)

At 30 DAP mean LAI was significantly higher with 100 kg N through USG (0.61) which was on par with green leaf manuring at 10 t per ha + 75 kg N per ha through urea. At 60 DAP during 1989-90, 100 kg N per ha through USG recorded significantly more LAI (2.97) which was on par with green leaf manuring at 10 t per ha + 75 kg N through urea and 100 kg N per ha through urea in three splits (2.92 and 2.33 respectively). Mean LAI was 2.87 with 100 kg N per ha through USG which was on par with green leaf manuring at 10 t per ha + 75 kg N through urea (2.75) and 100 kg N through GCU (2.29). During 1990-91 LAI did not differ significantly among the treatments at 60 DAP. At 90 DAP LAI did not differ significantly

Table 4.36 Number of leaves, leaf area and leaf area index of rice as influenced by sources of nitrogen

Treatments	30 DAP			60 DAP			90 DAP		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91	Mean
<u>Number of leaves per hill</u>									
GLM at 10 t per ha + 75 kg N through urea	24.8	24.3	24.5	44.8	39.8	42.3	31.8	28.3	30.0
100 kg N through urea	23.0	20.3	21.6	37.3	35.8	36.5	25.5	24.8	25.1
100 kg N through OCU	27.3	20.0	23.6	31.8	32.8	32.3	27.0	27.3	27.1
100 kg N through USG	25.0	23.8	24.4	38.8	41.0	39.9	28.0	30.5	29.3
100 kg N through URP	23.3	19.5	21.4	33.8	34.8	34.3	26.8	25.0	25.9
S.E.m _d	1.8	1.23	1.09	2.2	2.2	1.5	2.7	3.3	2.10
CD at 5%	-	3.79	-	6.8	6.1	4.5	-	-	-
<u>Leaf area per hill (cm²)</u>									
GLM at 10 t per ha + 75 kg N through urea	72	125	98	585	517	551	543	603	573
100 kg N through urea	73	121	97	306	459	382	465	493	479
100 kg N through OCU	71	108	90	467	451	459	465	587	526
100 kg N through USG	93	151	122	594	556	575	592	637	615
100 kg N through URP	70	104	87	303	307	305	460	514	487
S.E.m _d	8.9	11.8	7.4	74.1	89.1	58	43	81	46
CD at 5%	-	36.3	21.6	228.4	-	169	132	-	133
<u>Leaf area index</u>									
GLM at 10 t per ha + 75 kg N through urea	0.36	0.63	0.50	2.92	2.58	2.75	2.72	3.01	2.87
100 kg N through urea	0.37	0.61	0.49	1.53	2.29	1.91	2.32	2.46	2.39
100 kg N through OCU	0.35	0.54	0.45	2.33	2.26	2.29	2.33	2.94	2.63
100 kg N through USG	0.47	0.76	0.61	2.97	2.78	2.87	2.96	3.19	3.07
100 kg N through URP	0.35	0.52	0.44	1.52	1.54	1.53	2.30	2.57	2.44
S.E.m _d	0.05	0.06	0.04	0.37	0.45	0.29	0.21	0.40	0.23
CD at 5%	-	-	0.11	1.14	-	0.87	-	-	-

DAP - Days after planting

GLM - Green leaf manure

USG - Urea super granules

OCU - Oypalun coated urea.

URP - Urea rock phosphate

Table 4.37 Plant height(cm) of rice at 60 DAP and at harvest as influenced by sources of nitrogen

Treatments	60 DAP			At harvest		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean
GLM at 10 t per ha+ 75 kg N through urea	29	28	29	80	88	84
100 kg N through urea	27	26	27	76	87	82
100 kg N through GCU	26	29	27	78	85	82
100 kg N through USG	29	28	28	79	87	83
100 kg N through URP	28	28	28	77	87	82
S.E.m±	0.7	0.9	0.6	1.6	0.9	0.9
CD at 5%	2.1	-	1.7	-	2.9	-

DAP - Days after planting

GCU - Gypsum coated urea

URP - Urea rock phosphate

GLM - Green leaf manure

USG - Urea super granules

green leaf manuring at 10 t per ha + 75 kg N per ha through urea recorded significantly more (88 cm) plant height which was on par with rest of the treatments except 100 kg N per ha through GCU. Plant height during 1989-90 and mean of the two years at harvest did not differ significantly among the treatments (Table 4.37).

4.4.7 Number of tillers per hill

Number of tillers per hill was significantly more at 30 DAP with green leaf manuring at 10 t per ha + 75 kg N per ha through urea (7.8 during 1990-91 and mean of 7.6) followed by 100 kg N through USG (7.3 during 1990-91). At 60 DAP also the tiller number per hill was maximum with green leaf manuring at 10 t per ha + 75 kg N per ha through urea (9.2 in 1989-90 and 10.1 in 1990-91) followed by 100 kg N per ha through USG (7.9 and 9.8 during 1989-90 and 1990-91 respectively). There was no significant difference among the treatments at 90 DAP. However, green leaf manuring at 10 t per ha + 75 kg N per ha through urea recorded more number of tillers per hill followed by 100 kg N per ha through USG (Table 4.38).

Yield parameters

4.4.8 Number of panicles per hill

The panicle number per hill during both the years and the mean of two years was significantly higher with

Table 4.38 Number of tillers per hill at different growth stages of rice crop as influenced by sources of nitrogen

Treatments	30 DAP			60 DAP			90 DAP		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91	Mean
GLM at 10 t per ha + 75 kg N through urea	7.4	7.8	7.6	9.2	10.1	9.6	8.7	6.9	7.8
100 kg N through urea	7.2	6.5	6.9	9.1	8.4	8.7	7.9	7.4	7.6
100 kg N through GCU	7.9	6.7	7.3	7.3	8.9	8.1	6.8	6.4	6.6
100 kg N through USG	7.2	7.3	7.3	7.9	9.8	8.9	7.7	7.6	7.7
100 kg N through URP	6.9	6.7	6.8	6.6	8.2	7.4	7.3	6.1	6.7
S.E.m _t	0.3	0.3	0.2	0.6	0.5	0.4	0.7	0.7	0.5
CD at 5%	-	0.9	0.7	2.0	1.5	1.2	-	-	-
DAP - Days after planting	GLM - Green leaf manure			GCU - Gypsum coated urea					
USG - Urea super granules	URP - Urea rock phosphate								

100 kg N per ha through USG (13.5 in 1989-90, 14.0 in 1990-91 and mean of 13.8). This was followed by green leaf manuring at 10 t per ha + 75 kg N per ha through urea (12.5 in 1989-90 and 12.3 in 1990-91) (Table 4.39).

4.4.9 1000 grain weight

Thousand grain weight during 1989-90 and 1990-91 and mean of two years were significantly higher with 100 kg N per ha through USG (19.05 and 22.58 during 1989-90 and 1990-91 respectively) followed by green leaf manuring at 10 t per ha + 75 kg N per ha through urea (Table 4.39).

4.4.10 Number of filled grains per panicle

The number of filled grains per panicle during both the years and their mean were significantly higher with 100 kg N per ha through USG (161 in 1989-90 and 129 in 1990-91 and mean of 145). This was followed by green leaf manuring at 10 t per ha + 75 kg N per ha through urea (137 in 1989-90 and 123 in 1990-91) (Table 4.39).

4.4.11 Number of unfilled grains per panicle

The number of unfilled grains differed significantly among the treatments. Lowest number of unfilled grains during

Table 4.39 Yield parameters of rice as influenced by the sources of nitrogen

Treatments	Number of panicles/ hill		1000 grain weight (g)		Number of filled grains per panicle		Number of unfilled grains per panicle		Panicle length (cm)						
	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91	Mean			
GLM at 10 t per ha + 75 kg N through urea	12.5	12.3	12.4	18.75	22.15	20.43	137	123	130	38	23	31	23.6	23.0	23.3
100 kg N through urea	11.3	10.5	10.9	18.45	21.53	19.99	108	105	106	42	29	36	24.2	22.4	23.3
100 kg N through GCU	12.0	10.8	11.4	18.65	21.18	20.25	136	113	124	42	27	34	24.7	21.6	23.2
100 kg N through USG	13.5	14.0	13.8	19.05	22.58	20.81	161	129	145	35	20	28	23.7	24.2	23.9
100 kg N through URP	10.3	9.5	9.9	17.83	20.80	19.31	106	97	102	61	36	49	23.5	22.6	23.0
S.E.M.	0.4	0.5	0.3	0.11	0.15	0.09	4.9	4.5	3.3	1.6	2.9	1.6	0.56	0.44	0.36
CD at 5%	1.3	1.4	0.9	0.35	0.46	0.27	14.9	13.9	9.7	4.8	8.9	4.8	-	1.36	-
GLM - Green leaf manure	GCU - Gypsum coated urea		USG - Urea super granules		URP - Urea rock phosphate										

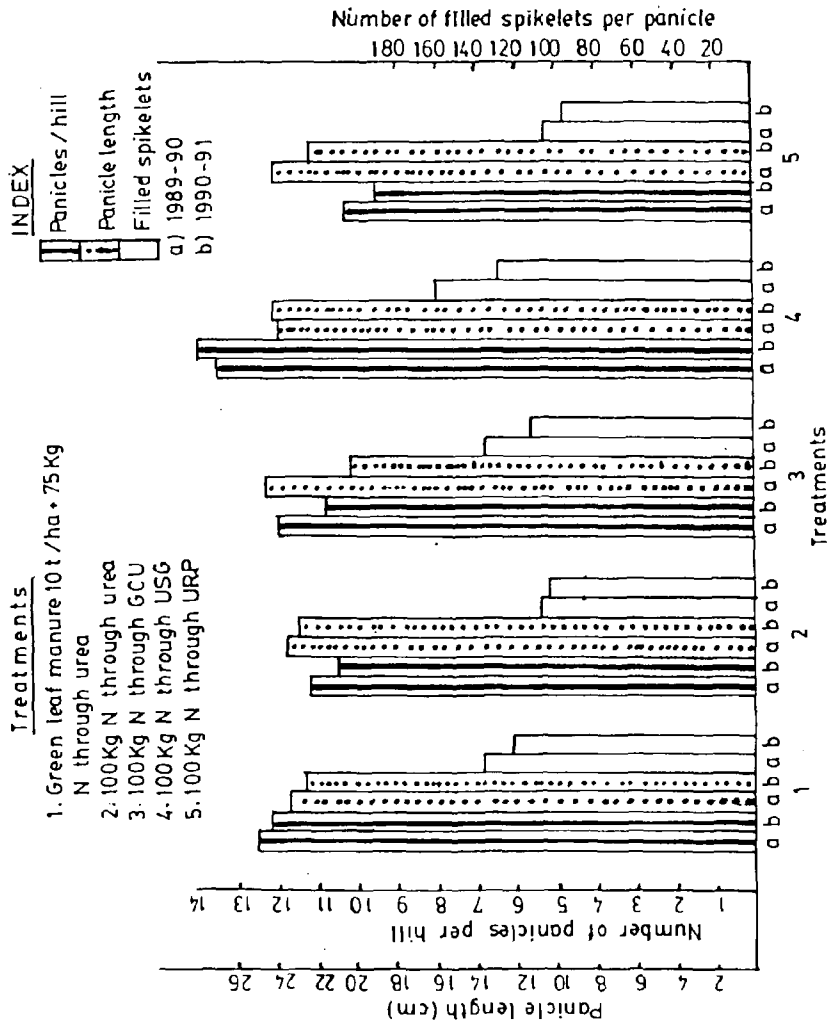


FIG.4.5. YIELD PARAMETERS OF RICE AS INFLUENCED BY SOURCES OF NITROGEN.

Plate 16 : Kharif rice grown with green leaf manure
at 10 t per ha and 75 kg N per ha through
urea.

Plate 17 : Kharif rice grown with 100 kg N per ha
through urea super granules.

Plate 18 : Kharif rice grown with 100 kg N per ha
through urea alone in three splits.

green leaf manuring at 10 t per ha + 75 kg N per ha through urea recorded significantly more (88 cm) plant height which was on par with rest of the treatments except 100 kg N per ha through GCU. Plant height during 1989-90 and mean of the two years at harvest did not differ significantly among the treatments (Table 4.37).

4.4.7 Number of tillers per hill

Number of tillers per hill was significantly more at 30 DAP with green leaf manuring at 10 t per ha + 75 kg N per ha through urea (7.8 during 1990-91 and mean of 7.6) followed by 100 kg N through USG (7.3 during 1990-91). At 60 DAP also the tiller number per hill was maximum with green leaf manuring at 10 t per ha + 75 kg N per ha through urea (9.2 in 1989-90 and 10.1 in 1990-91) followed by 100 kg N per ha through USG (7.9 and 9.8 during 1989-90 and 1990-91 respectively). There was no significant difference among the treatments at 90 DAP. However, green leaf manuring at 10 t per ha + 75 kg N per ha through urea recorded more number of tillers per hill followed by 100 kg N per ha through USG (Table 4.38).

Yield parameters

4.4.8 Number of panicles per hill

The panicle number per hill during both the years and the mean of two years was significantly higher with

both the years was recorded with 100 kg N per ha through USG (35 in 1989-90 and 20 in 1990-91) followed by green leaf manuring at 10 t per ha + 75 kg N through urea (38 in 1989-90 and 23 in 1990-91) (Table 4.39).

4.4.12 Panicle length

Panicle length differed significantly during 1990-91 while it was not so during 1989-90 as well the mean over two years. During 1990-91, 100 kg N per ha through USG recorded maximum panicle length (24.2 cm) which was on par with green leaf manuring at 10 t per ha + 75 kg N per ha through urea (23.0 cm) (Table 4.39).

4.4.13 Grain yield of rice

Grain yield differed significantly among the treatments during 1989-90 and 1990-91 as well as the mean of two years. Maximum grain yield was recorded with 100 kg N per ha through USG (6309 and 5608 kg per ha in 1989-90 and 1990-91 respectively and mean of 5958 kg per ha). During 1990-91 grain yield with green leaf manuring at 10 t per ha + 75 kg N per ha through urea (5359 kg per ha) was on par with 100 kg N per ha through USG. Green leaf manuring at 10 t per ha + 75 kg N per ha through urea produced second highest grain yield of rice

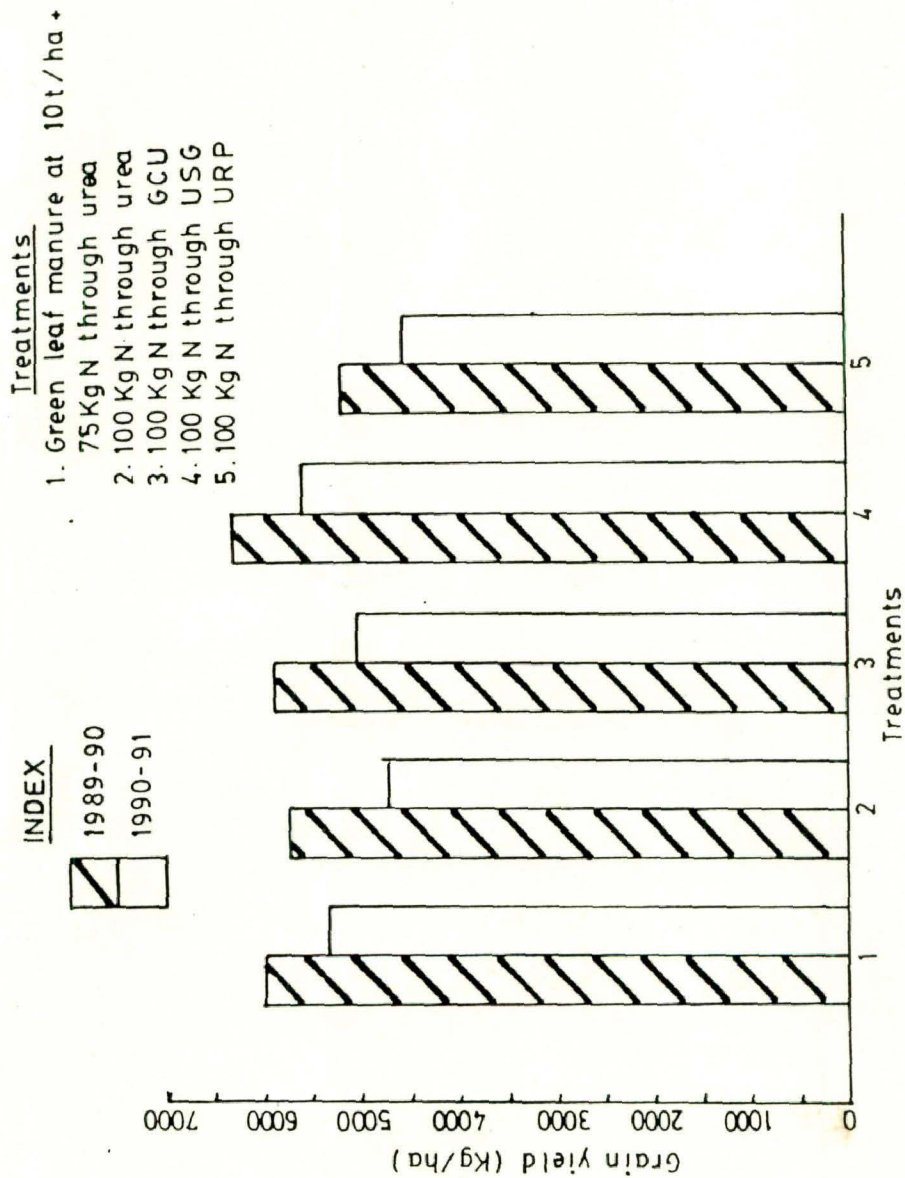


FIG. 4.6 GRAIN YIELD OF RICE AS INFLUENCED BY SOURCES OF NITROGEN.

during both the years (5999 kg per ha in 1989-90 and 5359 kg per ha in 1990-91). While grain yield with 100 kg N each through GCU or urea was intermediate (mean of 5471 and 5225 kg per ha). The lowest yield was recorded with 100 kg N per ha through URP (mean of 4882 kg per ha (Table 4.40)).

4.4.14 Straw yield of rice

Straw yield differed significantly during 1989-90 only. The pooled straw yield data also differed significantly among the treatments. Maximum straw yield was recorded with 100 kg N per ha through USG (8136 kg per ha in 1989-90 and mean of 8171 kg per ha) which was on par with green leaf manuring at 10 t per ha + 75 kg N per ha through urea and 100 kg N per ha GCU. It was lower with 100 kg N per ha each through URP and urea (mean of 7456 and 7594 kg per ha respectively) (Table 4.40).

4.4.15 Total biomass

Total biomass differed significantly during both the years. Hundred kg N per ha through USG recorded maximum biomass yield (14.45 t per ha in 1989-90 and 13.82 t per ha in 1990-91 and mean of 14.13 t per ha) which was on par with green leaf manuring at 10 t per ha + 75 kg N per ha through urea (14.11 t per ha and 13.36 t per ha during 1989-90 and

Table 4.40 Grain and straw yield, total biomass and harvest index of rice as influenced by sources of nitrogen

Treatments	Grain yield(kg/ha)			Straw yield(kg/ha)			Total biomass(t/ha)			Harvest index(%)		
	89-90	90-91	Mean	89-90	90-91	Mean	89-90	90-91	Mean	89-90	90-91	Mean
GLM at 10 t per ha + 75 kg N through urea	5999	5359	5679	8106	7996	8051	14.11	13.36	13.73	44.01	38.85	41.43
100 kg N through urea	5733	4716	5225	7195	7993	7594	12.93	12.71	12.82	44.32	37.01	40.67
100 kg N through GCU	5899	5044	5471	7539	8005	7772	13.44	13.02	13.23	43.81	40.73	42.27
100 kg N through USG	6309	5608	5956	8136	8207	8171	14.45	13.82	14.13	42.51	40.10	41.31
100 kg N through URP	5229	4534	4882	7340	7571	7456	12.57	12.11	12.34	41.62	37.37	39.50
S.E.m _t	76	131	76	238	288	187	0.25	0.30	0.19	0.84	1.15	0.71
CD at 5%	235	403	221	734	-	546	0.76	0.92	0.57	-	-	-

GLM - Green leaf manure GCU - Gypsum coated urea USG - Urea super granules

URP - Urea rock phosphate

1990-91 respectively). Lowest total biomass was recorded with 100kg N per ha through URP (12.57 t per ha in 1989-90 and 12.11 t per ha in 1990-91 and mean of 12.34 t per ha) (Table 4.40).

4.4.16 Harvest index

Harvest index did not differ significantly during both the years. It varied from 41.62 to 44.32 in 1989-90 and 37.01 to 40.23 in 1990-91 while the mean varied from 39.50 to 42.27 (Table 4.40).

4.4.17 Uptake of NPK by rice

Uptake of NPK by rice differed significantly during both the years among the treatments and also in pooled data of two years. Nitrogen and phosphorus uptake by rice was significantly higher during both the years with 100 kg N per ha through USG compared to the rest of the treatments. The mean N uptake by rice was 233 kg per ha and P was 66 kg per ha with 100 kg N per ha through USG. Potassium uptake by rice was significantly highest with green leaf manuring at 10 t per ha + 75 kg N per ha through urea during 1989-90 (127 kg per ha) while during 1990-91, 100 kg N per ha through USG removed maximum K (182 kg per ha). The NPK uptake by rice was lower with 100 kg N per ha through URP (mean of 185, 51 and 129 kg per ha N, P and K respectively). Green leaf manuring at 10 t per ha + 75 kg N per ha through urea ranked second in N and P uptake --

Table 4.41 NPK uptake by rice as influenced by sources of nitrogen (kg/ha)

Treatments	Nitrogen			Phosphorus			Potassium		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91	Mean
GLM at 10 t per ha + 75 kg N through urea	240	182	211	47	73	60	127	156	142
100 kg N through urea	210	180	195	51	58	55	115	143	129
100 kg N through GCU	241	181	211	51	70	61	114	135	124
100 kg N through USG	244	201	223	54	78	66	106	182	144
100 kg N through URP	188	181	185	46	56	51	104	154	129
S.E.m±	4.0	4.1	2.9	0.7	1.6	0.9	2.5	5.0	2.8
CD at 5%	12.9	12.6	8.5	2.0	4.9	2.6	7.6	15.5	8.2
GLM - Green leaf manure	GCU - Gypsum coated urea			USG - Urea super granules					
URP - Urea rock phosphate									

equal to N and P removal by 100 kg N through GCU. The K uptake did not follow same trend during first and second year (Table 4.41).

4.5 Experiment 2B

Residual effect of treatments of kharif rice on the growth and yield of succeeding sunflower under two levels of nitrogen

4.5.1 Total dry weight per plant at 50 DAS and at harvest

Total dry weight at 50 DAS during 1989-90 was significantly higher (9.88 g per plant) with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea which was on par with 100 kg N per ha through USG (9.49 g per plant). During 1990-91 and in the pooled data of two years total dry weight was significantly higher with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea for rice (7.04 g per plant in 1990-91 and mean of 8.46 g per plant) followed by the residual effect of 100 kg N per ha through USG (Table 4.42).

Total dry weight during both the years and their mean was significantly higher with N application for sunflower. With 31 kg N per ha the increase in dry weight was 2.24 g per plant in 1989-90 and 1.62 g per plant in 1990-91 over no fertilizer N (Table 4.42).

Table 4.42 Total drymatter (g/plant) at 50 DAS and at harvest of sunflower as influenced by residual fertility status of rice and nitrogen levels

Treatments	At 50 DAS			At harvest		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean
GLM at 10 t per ha +						
75 kg N through urea	9.88	7.04	8.46	40.45	24.14	32.29
100 kg N through urea	8.24	5.35	6.79	34.04	19.91	26.97
100 kg N through GCU	8.63	5.59	7.11	34.56	18.99	26.78
100 kg N through USG	9.49	6.31	7.89	37.79	22.74	30.26
100 kg N through URP	8.34	5.63	6.98	34.80	20.37	27.58
S.E.m±	0.18	0.09	0.10	0.52	0.47	0.35
CD at 5%	0.55	0.29	0.30	1.60	1.45	1.02
<u>Nitrogen levels</u>						
0 kg N/ha	7.79	5.17	6.48	33.41	19.66	26.54
31 kg N/ha	10.03	6.79	8.41	39.25	22.81	31.03
S.E.m±	0.12	0.07	0.07	0.33	0.16	0.18
CD at 5%	0.35	0.21	0.19	0.98	0.47	0.52
DAS - Days after sowing	GLM - Green leaf manure			GCU - Gypsum coated urea		
USG - Urea super granules	URP - Urea rock phosphate					

Total dry weight at harvest was also significantly higher with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea for rice during both the years (40.45 g per plant in 1989-90 and 24.14 g per plant in 1990-91 and the mean of 32.29 g per plant) followed by N through USG at 100 kg per ha (37.79 g per plant in 1989-90 and 22.74 g per plant in 1990-91) (Table 4.42).

Nitrogen application improved the total dry weight significantly during both the years. With 31 kg N per ha the total dry weight per plant was 39.25 g per plant in 1989-90, 22.81 g per plant in 1990-91, while with no fertilizer N it was 33.41 and 19.66 g per plant in 1989-90 and 1990-91 respectively (Table 4.42).

Interaction of the residual effects of kharif rice treatments and N levels on the total drymatter production of sunflower was significant during 1990-91 (Table 4.43). Green leaf manure at 10 t per ha + 75 kg N per ha through urea and 31 kg N per ha for sunflower produced significantly more total drymatter of sunflower (26.4 g). Interaction of the residual effect of green leaf manure at 10 t per ha + 75 kg N per ha through urea at zero N level for sunflower registered drymatter (21.9 g) on par with the residual effect of 100 kg N through urea, GCU and URP at 31 kg N per ha and 100 kg N through USG at zero N level for sunflower. Drymatter of sunflower due to the residual effect of URP at 100 kg N per ha and zero N for sunflower

Table 4.43 Interaction effect of residual fertility status of kharif rice and nitrogen levels on the total drymatter of sunflower (g/plant) at harvest during 1990-91

Treatments	Nitrogen levels	
	0 kg/ha	31 kg/ha
GLM at 10 t per ha + 75 kg N through urea	21.85	26.44
100 kg N through urea	18.78	21.04
100 kg N through GCU	17.68	20.32
100 kg N through USG	21.10	24.37
100 kg N through URP	18.88	21.87
	<u>S. Em±</u>	<u>CD at 5%</u>
Comparison of sub plot means at the same level of main plot means	0.35	1.05
Comparison of main plot means at same or different level of sub plot means	0.53	1.63
GLM - Green leaf manure	GCU - Gypsum coated urea	
USG - Urea super granules	URP - Urea rock phosphate	

4.5.2 Drymatter distribution at 50 DAS

Drymatter distribution in leaves was significantly higher with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea during both the years (3.64 g per plant in 1989-90 and 3.12 g per plant in 1990-91 and the mean of 3.38 g per plant). During 1989-90 the residual effects of 100 kg N per ha through USG and URP was also on par with the residual effect of green leaf manuring (3.51 g per plant each with 100 kg N through USG or URP respectively). Lowest dry weight of leaves was recorded with the residual effect of 100 kg N per ha through urea (mean of 2.58 g per plant) (Table 4.44).

Drymatter distribution in stem was maximum during both the years with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea (6.24 g in 1989-90 and 3.92 g in 1990-91). During 1989-90 drymatter of stem with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea was on par with 100 kg N per ha through USG (5.97 g per plant). The drymatter distribution in stem with the residual effect of 100 kg N through USG ranked second place, while the remaining treatments accumulated significantly lowest drymatter in stem (mean varied from 4.13 to 4.19 g per plant) (Table 4.44).

Nitrogen at 31 kg per ha for sunflower significantly influenced the dry weight of leaves and stem over zero N per ha.

Table 4.44 Drymatter distribution (g/plant) in sunflower as influenced by the residual fertility status of kharif rice and nitrogen levels at 50 days after sowing

Treatments	Dry weight of leaves			Dry weight of stem		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean
GLM at 10 t per ha + 75 kg N through urea	3.64	3.12	3.38	6.24	3.92	5.08
100 kg N through urea	2.86	2.29	2.58	5.25	3.05	4.15
100 kg N through GCU	3.26	2.57	2.92	5.36	3.02	4.19
100 kg N through USG	3.51	2.78	3.15	5.97	3.53	4.75
100 kg N through URP	3.51	2.50	2.85	5.13	3.13	4.13
S.E.m±	0.09	0.04	0.05	0.13	0.08	0.08
CD at 5%	0.27	0.13	0.14	0.41	0.26	0.23
<u>Nitrogen levels</u>						
0 kg N/ha	2.84	2.25	2.54	4.96	2.92	3.94
31 kg N/ha	3.26	3.05	3.41	6.22	3.74	4.98
S.E.m±	0.07	0.06	0.04	0.08	0.05	0.05
CD at 5%	0.20	0.17	0.13	0.23	0.15	0.13
GLM - Green leaf manure	URP - Urea rock phosphate					
USG - Urea super granules	GCU - Gypsum coated urea					

The increase in dry weight of leaves with 31 kg N per ha was 0.42 g per plant in 1989-90 and 0.80 g per plant in 1990-91. While the increase in dry weight of stem was 1.26 g per plant in 1989-90 and 0.82 g per plant in 1990-91 over 50 kg N per ha (Table 4.44).

Interaction of the residual effect of kharif rice treatments and N levels on the drymatter accumulation in stem of the succeeding sunflower crop was significant during 1989-90 (Table 4.45). Residual effect of green leaf manure at 10 t per ha + 75 kg N per ha and 100 kg N through USG accumulated more drymatter in stem at both the N levels during 1989-90 and in the pooled data of two years. During 1989-90 the drymatter accumulation in stem of sunflower grown under the residual fertility of green leaf manure at 10 t per ha + 75 kg N per ha through urea (5.34 g per plant) was on par with the drymatter accumulation with the residual fertility of 100 kg N per ha through urea or URP in conjunction with 31 kg N per ha for sunflower (5.65 and 5.53 g per plant respectively). The rest of the treatments at 31 kg N level were superior in drymatter accumulation in stem compared to the residual effect of green leaf manure at 10 t per ha + 75 kg N per ha through urea at zero N level. Similar trend was observed in the pooled data of two years.

4.5.3 Drymatter distribution at harvest

Drymatter distribution in shoot was significantly highest with 10 t per ha or green leaf manuring + 75 kg N per ha through urea (13.40 and 5.60 g per plant during 1989-90

Table 4.45 Interaction effects of residual fertility status of rice and nitrogen levels on the drymatter accumulation in stem (g/plant) of sunflower at 50 days after sowing

Treatments	1989-90		Mean	
	0 kg	31 kg	0 kg	31 kg
	----- N/ha -----			
GLM at 10 t per ha + 75 kg N through urea	5.35	7.13	4.40	5.70
100 kg N through urea	4.85	5.65	3.70	4.60
100 kg N through GCU	4.68	6.05	3.60	4.70
100 kg N through USG	5.20	6.75	4.10	5.40
100 kg N through URP	4.73	5.53	3.80	4.50
	<u>S.E.m±</u>	<u>CD at 5%</u>	<u>S.E.m±</u>	<u>CD at 5%</u>
Comparison of sub plot means at the same level of main plot means	0.17	0.52	0.10	0.29
Comparison of main plot means at same or different level of sub plot means	0.18	0.55	0.11	0.30
GLM - Green leaf manure	GCU - Gypsum coated urea			
USG - Urea super granules	URP - Urea rock phosphate			

and 1990-91 respectively and mean of 9.54 g per plant). The next best treatment was 100 kg N per ha through USG (13.00 and 4.90 g per plant during 1989-90 and 1990-91 respectively and mean of 9.01 g per plant). The remaining treatments recorded significantly lower drymatter in shoot of sunflower during both the years (Table 4.46).

Addition of 31 kg N per ha for sunflower significantly improved the dry weight of shoot. With 31 kg N per ha the dry weight of shoot was 13.30 and 5.30 g per plant in 1989-90 and 1990-91 respectively and mean of 9.29 g per plant compared to 11.20 and 4.60 g per plant and mean of 7.89 g per plant with no fertilizer N for sunflower crop (Table 4.46).

Dry weight of head differed significantly during both the years. Maximum dry weight per head was recorded with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea for rice (27.02 and 18.50 g per plant in 1989-90 and 1990-91 respectively and mean was 22.80 g per plant). The next best treatment in respect of dry weight of head was 100 kg N per ha through USG (24.78 and 17.70 g per plant in 1989-90 and mean of 21.30 g per plant). Hundred kg N per ha each through urea or GCU recorded lower dry weight of head (mean of 18.90 and 18.60 g per plant) (Table 4.46).

Table 4.46 Drymatter distribution of sunflower at harvest as influenced by residual fertility status of rice and nitrogen levels (g)

Treatments	Dry weight of stem + leaves		Dry weight of head	
	1989-90	1990-91	1989-90	1990-91
		Mean		Mean
GLM at 10 t per ha + 75 kg N through urea	13.40	5.60	27.02	18.50
100 kg N through urea	11.30	4.70	22.71	15.20
100 kg N through GCU	11.70	4.60	22.94	14.30
100 kg N through USG	13.00	4.90	24.78	17.70
100 kg N through URP	11.70	4.70	23.06	15.70
S.E.m _t	0.32	0.18	0.38	0.39
CD at 5%	0.99	0.54	1.19	1.21
<u>Nitrogen levels</u>				
0 kg N/ha	11.20	4.60	22.20	15.10
31 kg N/ha	13.30	5.30	25.96	17.40
S.E.m _t	0.17	0.05	0.25	0.15
CD at 5%	0.51	0.15	0.75	0.45
GLM - Green leaf manure	GCU - Gypsum coated urea			
USG - Urea super granules	URP - Urea rock phosphate			

Table 4.47 Plant height and leaf area index of sunflower as influenced by residual fertility status of rice and nitrogen levels

Treatments	Plant height at harvest (cm)			Leaf area index		
	-----			-----		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean
GLM at 10 t per ha + 75 kg N through urea	86.6	50.9	68.8	0.72	0.61	0.66
100 kg N through urea	76.8	44.6	60.8	0.56	0.45	0.51
100 kg N through GCU	83.0	45.4	64.2	0.64	0.50	0.57
100 kg N through USG	77.3	46.9	62.2	0.69	0.55	0.62
100 kg N through URP	83.9	48.8	66.3	0.63	0.49	0.56
S.E.m _t	3.1	1.4	1.7	0.02	0.01	0.01
CD at 5%	-	-	5.0	0.05	0.03	0.03
<u>Nitrogen levels</u>						
0 kg N/ha	79.9	46.6	63.3	0.56	0.44	0.50
31 kg N/ha	83.1	47.9	65.5	0.74	0.60	0.67
S.E.m _t	1.5	0.6	0.8	0.01	0.01	0.01
CD at 5%	-	-	-	0.04	0.03	0.03
GLM - Green leaf manure	GCU - Gypsum coated urea					
USG - Urea super granules	URP - Urea rock phosphate					

respectively and mean of 0.62). Lowest LAI was recorded with 100 kg N per ha through urea in three splits (Table 4.47).

Leaf area index was also significantly influenced by addition of N for sunflower. At 31 kg N per ha LAI was higher (0.74 and 0.60 in 1989-90 and 1990-91 respectively and mean of 0.67) over no fertilizer N application (Table 4.47).

4.5.6 Diameter of the sunflower heads

Diameter of the head was significantly highest with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea (17.7 cm in 1989-90 and 16.9 cm in 1990-91 and mean of 17.3 cm). During 1990-91 the diameter of the head with 100 kg N per ha through USG and URP was on par with the green leaf manuring at 10 t per ha + 75 kg N per ha through urea. The mean diameter with the residual effect of 100 kg N per ha through USG (16.7 cm) was also on par with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea (Table 4.48).

During both the years nitrogen at 31 kg per ha for sunflower recorded significantly larger sized heads than zero N per ha for sunflower. The increase in head diameter with 31 kg N per ha was 1.7 cm in 1989-90 and 1.5 cm in 1990-91 and mean of 1.6 cm over no fertilizer N for sunflower (Table 4.48).

Table 4.48 Yield parameters of sunflower as influenced by residual fertility status of rice and by nitrogen levels

Treatments	Diameter of the head (cm)		1000 seed weight (g)		Number of filled seeds/head		% filled seeds/head		Seed weight/head (g)						
	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91	Mean			
GLN at 10 t per ha + 75 kg N through urea	17.7	16.9	17.3	40.9	39.8	40.4	254	183	218	74.5	59.5	66.9	10.03	6.77	8.40
100 kg N through urea	15.6	15.5	15.6	36.0	36.8	36.4	231	138	184	75.7	58.8	67.3	8.41	5.08	6.74
100 kg N through CCU	15.3	15.5	15.4	38.1	36.7	37.4	224	148	186	73.4	51.7	62.6	8.59	5.29	6.94
100 kg N through USG	16.2	17.1	16.7	41.3	39.8	40.5	242	163	202	74.5	54.2	69.3	9.09	5.92	7.51
100 kg N through URP	15.3	16.4	15.8	38.6	36.3	37.5	221	152	187	71.1	58.9	65.0	8.50	5.25	6.87
S.E.m	0.31	0.41	0.25	1.0	0.8	0.6	3.1	5.5	3.2	2.7	1.9	1.7	0.14	0.16	0.10
CD at 5%	0.95	1.26	0.75	3.1	2.5	1.9	9.5	16.9	9.2	-	2.7	-	0.44	0.49	0.31
Nitrogen levels															
0 kg N/ha	15.2	15.5	15.4	36.7	36.4	36.6	227	151	189	68.3	54.1	61.2	8.59	5.42	7.00
51 kg N/ha	16.9	17.0	17.0	41.3	39.3	40.3	242	162	202	79.4	63.1	71.3	9.26	5.91	7.58
S.E.m	0.12	0.16	0.10	0.7	0.3	0.4	2.3	0.7	1.2	0.6	0.6	0.4	0.69	0.05	0.04
CD at 5%	0.36	0.48	0.30	2.1	0.8	1.1	6.8	1.9	3.4	1.9	1.8	1.3	-	0.14	0.12
GLM - Green leaf manure	CCU - Gypsum coated urea		USG - Urea super granules		URP - Urea rock phosphate										

- Treatments
1. Green leaf manure at 10t/ha + 75Kg N through urea
 2. 100 Kg N through urea
 3. 100 Kg N through GCU
 4. 100 Kg N through USG
 5. 100 Kg N through URP

INDEX

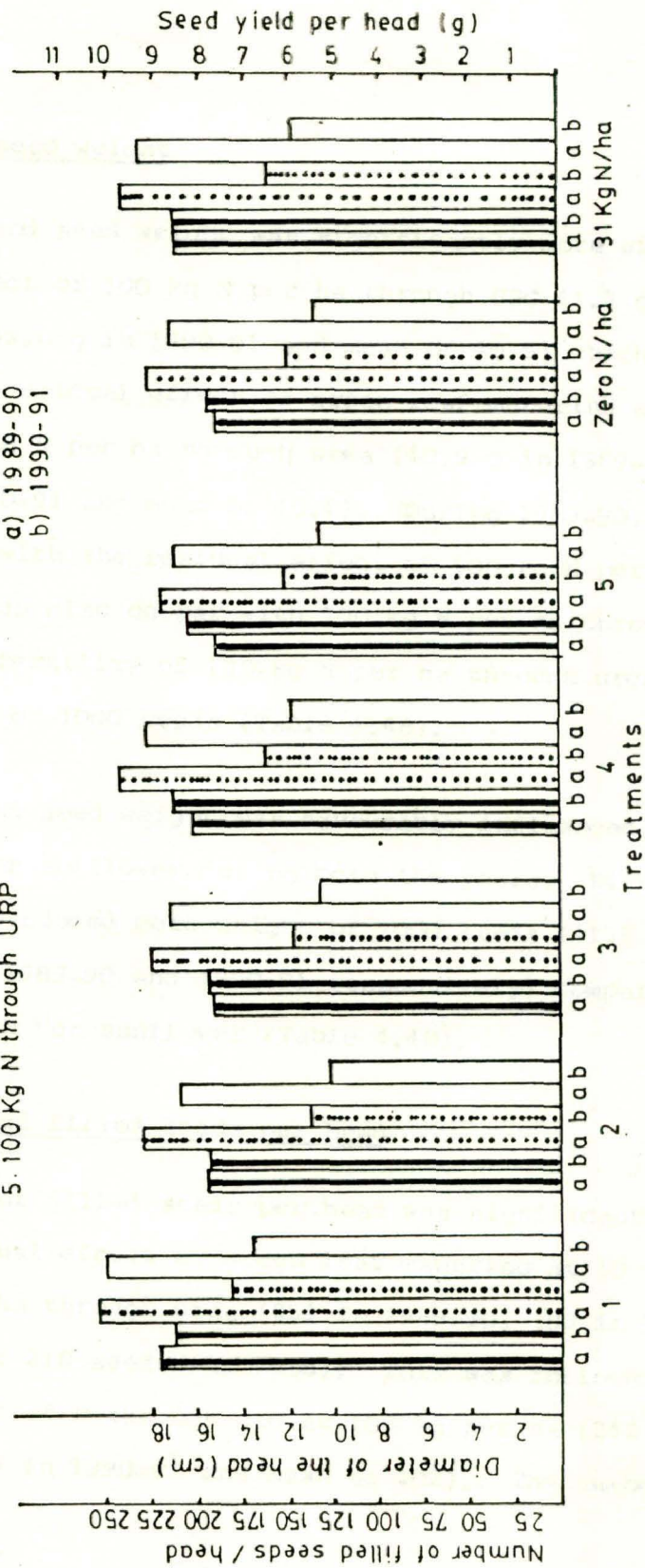
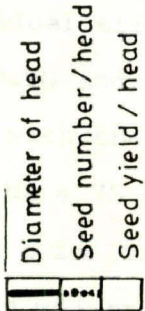


FIG.4.7. YIELD PARAMETERS OF SUNFLOWER AS INFLUENCED BY THE RESIDUAL EFFECT OF KHARIF RICE TREATMENTS AND NITROGEN LEVELS FOR SUNFLOWER.

4.5.7 1000 seed weight

Thousand seed weight was significantly more with the residual effect of 100 kg N per ha through USG 41.3 g in 1989-90 and 39.8 g in 1990-91 and mean of 40.5) which was on par with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea (40.9 g in 1989-90 and 39.8 g in 1990-91 and mean of 40.4). During 1989-90, 1000 grain weight with the residual effect of 100 kg N per ha through URP was also on par with 100 kg N per ha through USG. The residual fertility of 100 kg N per ha through urea recorded lowest weight of 1000 seeds (Table 4.48).

Thousand seed weight was favourably influenced by N application for sunflower during both the years. Nitrogen at 31 kg per ha produced more weight of 1000 seeds (41.3 and 39.3 g during 1989-90 and 1990-91 respectively) compared to no fertilizer N for sunflower (Table 4.48).

4.5.8 Number of filled seeds per head

Number of filled seeds per head was significantly higher with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea (254 in 1989-90, 183 in 1990-91 and the mean of 218 seeds per head). This was followed by the residual effect of N through USG at 100 kg per ha (242 in 1989-90 and 163 in 1990-91 and mean of 202). The number of

filled seeds was lower with the residual effect 100 kg N per ha through urea or URP (Table 4.48).

Nitrogen at 31 kg per ha for sunflower significantly influenced the number of seeds per head during both the years. The increase in seed number per head with the addition of 31 kg N per ha was 15 in 1989-90 and 11 in 1990-91 and mean of 13 over no fertilizer N (Table 4.48).

Interaction of the residual effect of treatments for rice and levels of N for sunflower was significant during 1990-91 (Table 4.49). Residual effect of green leaf manure at 10 t per ha + 75 kg N per ha through urea and 100 kg N per ha through USG recorded significantly more number of filled seeds at both the N levels. Interaction of green leaf manures at 10 t per ha + 75 kg N per ha through urea and no fertilizer N for sunflower produced more number of filled seeds(247) compared to the residual effect of 100 kg N per ha each through GCU (232) and URP (231) and was on par with 100 kg N per ha each through urea (238) and USG (249) at 31 kg N per ha for sunflower.

4.5.9 Per cent filled seeds

Per cent filled seeds differed significantly during 1990-91 only. Hundred kg N per ha through USG recorded significantly higher per cent of filled seeds (64.2 per cent)

followed by green leaf manuring at 10 t per ha + 75 kg N per ha through urea (59.5 per cent). The lowest per cent of filled seeds were registered with the residual effect of 100 kg N per ha through GCU. Similar trend was observed during 1989-90 and in the pooled data of two years (Table 4.48).

Addition of N significantly increased the percentage of filled seeds. With 31 kg N per ha, the increase in per cent filled seeds was 11.1 per cent in 1989-90, 9.0 per cent in 1990-91 and mean of 10.1 per cent over zero fertilizer N (Table 4.48).

Interaction of the residual effect of sources of N for kharif rice and N levels for sunflower was significant during 1990-91 (Table 4.49). Residual effect of green leaf manure at 10 t per ha + 75 kg N per ha through urea, 100 kg N per ha through USG registered significantly higher per cent of filled seeds at both the N levels. The per cent of filled seeds due to the interaction of the residual effect of 100 kg N per ha through USG and zero fertilizer N for sunflower (58.4) was on par with all the treatments (varied from 58.5 to 64.0) except with the residual effect of 100 kg N per ha through USG (69.9) at 31 kg N per ha for sunflower.

Plate 19 : Sunflower crop grown under the residual fertility status of kharif rice treatment viz. green leaf manure at 10 t per ha + 75 kg N per ha through urea.

Plate 20 : Sunflower crop grown under the residual fertility status of kharif rice treatment viz. 100 kg fertilizer N per ha through urea.

PLATE 19



PLATE 20



4.5.10 Seed weight per head

Residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea significantly increased the seed weight per head. It was 10.03 g in 1989-90, 6.77 g in 1990-91 and mean of 8.40 g. It was lowest with the residual effect of 100 kg N per ha through urea (8.41 g in 1989-90 and 5.08 g in 1990-91 and mean of 6.74 g). Residual effect of 100 kg N per ha through USG ranked second highest in seed weight per head (mean of 7.51 g per head)(Table 4.48).

Addition of N for sunflower significantly increased the seed weight per head. The increase in seed weight was 0.67 g in 1989-90, 0.49 g in 1990-91 and mean of 0.58 g with 31 kg N per ha over no fertilizer N for sunflower (Table 4.48).

4.5.11 Seed yield of sunflower

Seed yield improved significantly during both the years among the treatments. Maximum seed yield was recorded with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea during both the years (1003 and 641 kg per ha during 1989-90 and 1990-91 respectively and mean of 822 kg per ha) followed by the residual effect of N through USG at 100 kg N per ha (900 kg per ha in 1989-90 and 547 kg per ha in 1990-91 and mean of 723 kg per ha). Lowest seed yield was recorded with 100 kg N per ha through urea

ble 4.50 Seed and stalk yields, total biomass and harvest index of sunflower as influenced by residual fertility status of kharif rice with nitrogen levels

Treatments	Seed yield (kg/ha)		Stalk yield (kg/ha)		Total Biomass (t/ha)		Harvest index (%)					
	89-90	90-91	Mean	89-90	90-91	Mean	89-90	90-91	Mean			
N at 10 t per ha + kg N through urea	1003	641	822	2456	1531	1993	3.46	2.17	2.82	29.39	29.66	29.53
0 kg N through urea	823	453	638	1911	1384	1648	2.73	1.84	2.29	30.41	25.00	27.71
0 kg N through CCU	840	476	658	2039	1335	1687	2.88	1.81	2.35	29.63	26.70	28.16
0 kg N through USG	900	547	723	2309	1448	1879	3.21	2.00	2.60	28.28	27.54	27.91
0 kg N through URP	833	471	652	2068	1383	1726	2.90	1.85	2.38	29.07	25.77	27.42
Em+	16	18	12	47	26	27	0.06	0.03	0.03	0.31	0.77	0.41
at 5%	49	55	35	146	82	79	0.18	0.09	0.09	0.94	2.37	1.21
<u>Nitrogen levels</u>												
kg N/ha	843	490	667	2089	1339	1714	2.93	1.83	2.38	29.27	26.96	28.11
kg N/ha	916	545	731	2225	1494	1859	3.14	2.04	2.59	29.45	26.91	28.18
Em+	8	5	4	14	12	9	0.02	0.01	0.01	0.23	0.21	0.15
at 5%	23	15	13	42	36	26	0.05	0.04	0.03	-	-	-
1 - Green leaf manure CCU - Gypsum coated urea USG - Urea super granules												
2 - Urea rock phosphate												

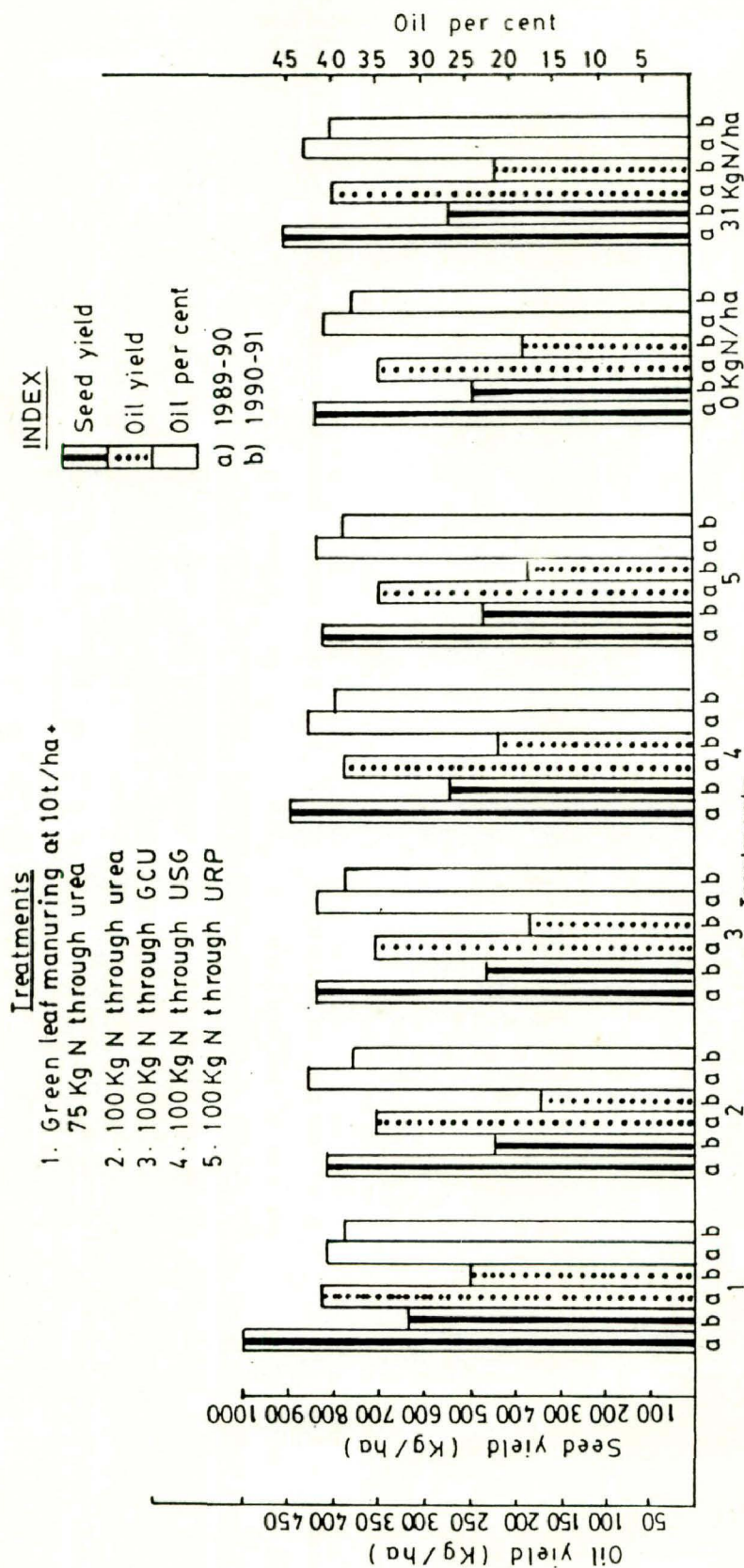


FIG.4-8. SEED AND OIL YIELD AND OIL PER CENT OF SUNFLOWER AS INFLUENCED BY THE RESIDUAL EFFECT OF KHARIF RICE TREATMENTS AND NITROGEN LEVELS FOR SUNFLOWER

(823 kg per ha in 1989-90 and 453 kg per ha in 1990-91 and mean of 638 kg per ha) (Table 4.50).

Addition of N for sunflower significantly improved the seed yield of sunflower. Nitrogen at 31 kg per ha for sunflower recorded higher seed yield during both the years (916 and 545 kg per ha in 1989-90 and 1990-91 respectively and mean of 731 kg per ha) compared to zero fertilizer N (Table 4.50).

Interaction of the residual effect of treatments for kharif rice and levels of N for sunflower on the seed yield of sunflower was significant during 1990-91 and mean of two years (Table 4.51). Residual effect of green leaf manure at 10 t per ha + 75 kg N per ha through urea registered significantly superior seed yield at both the N levels for sunflower (590 and 693 kg per ha at zero and 31 kg N per ha respectively). Seed yield due to the residual effect of green leaf manure at 10 t per ha + 75 kg N per ha through urea and no fertilizer N for sunflower was higher (590 kg per ha) compared to 100 kg N each through urea (476 kg per ha), GCU (492 kg per ha) and URP (493 kg per ha) and it was on par with 100 kg N per ha through USG (573 kg per ha) and 31 kg N per ha for sunflower. The remaining treatments at zero N level for sunflower registered significantly lower seed yield. The mean seed yield of two years also followed similar trend.

Table 4.51 Interaction effect of residual fertility status of kharif rice and nitrogen levels on the seed yield and total biomass of sunflower

Treatments	Seed yield (q/ha)			Total Biomass (t/ha)		
	1990-91			Mean		
	0 kg	31 kg	0 kg	31 kg	0 kg	31 kg
	-----N/ha-----					
GLM at 10 t per ha + 75 kg N through urea	590	693	768	876	2.66	2.97
100 kg N through urea	431	476	609	667	2.18	2.39
100 kg N through GCU	461	492	630	687	2.24	2.45
100 kg N through USG	522	573	697	750	2.52	2.69
100 kg N through URP	449	493	630	674	2.30	2.45
Comparison of sub plot means at the same level of main plot means	S.E.m± CD at 5%		S.E.m±		CD at 5%	
	11	33	10	29	0.02	0.07
Comparison of main plot means at same or differ- ent level of sub plot means	19	59	14	40	0.03	0.11
GLM - Green leaf manure	GCU - Gypsum coated urea			USG - Urea super granules		
URP - Urea rock phosphate						

4.5.12 Stalk yield of sunflower

Stalk yield differed significantly during both the years and mean of two years. Maximum stalk yield was recorded with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea (2456 kg per ha in 1989-90 and 1531 kg per ha in 1990-91 and mean of 1993 kg per ha). This was followed by the residual effect of 100 kg N per ha through USG (2309 kg per ha in 1989-90 and 1448 kg per ha in 1990-91 and mean of 1879 kg per ha) (Table 4.50).

Addition of N to sunflower increased the stalk yield significantly during both the years. The increase in stalk yield with 31 kg N per ha for sunflower was 136 kg per ha in 1989-90, 155 kg per ha in 1990-91 and mean of 145 kg per ha over zero fertilizer N (Table 4.50).

4.5.13 Total biomass of sunflower

The total biomass during both the years as well as their mean differed significantly among the different treatments. Residual effect of green leaf manuring at 10 per ha + 75 kg N through urea registered significantly higher total biomass (3.46 t per ha in 1989-90 and 2.17 t per ha in 1990-91 and mean of 2.82 t per ha), followed by N through USG at 100 kg per ha (3.21 t per ha in 1989-90, 2.00 t per ha in 1990-91 and mean of 2.60 t per ha) (Table 4.50).

Nitrogen at 31 kg per ha for sunflower recorded maximum total biomass of 3.14 t per ha in 1989-90, 2.04 t per ha in 1990-91 and mean total biomass of 2.59 t per ha compared to zero N (mean of 2.38 t per ha) (Table 4.50).

Total biomass yield of sunflower crop was significantly influenced by the residual effect of treatments for kharif rice and levels of N for sunflower (Table 4.51). Interaction of the residual effect of green leaf manure at 10 t per ha + 75 kg N per ha through urea and zero N per ha for sunflower registered higher biomass yield (2.66 t per ha) compared to the residual effect of 100 kg N each per ha through urea (2.39 t per ha), GCU (2.45 t per ha) and URP (2.45 t per ha) and was on par with 100 kg N through USG (2.69 t per ha) at 31 kg N per ha for sunflower. Maximum biomass yield was registered with the residual effect of green leaf manure at 10 t per ha + 75 kg N per ha through urea and 31 kg N per ha for sunflower (2.97 t per ha). The remaining treatments at zero N level gave significantly lower biomass yield.

4.5.14 Harvest index

During 1989-90 harvest index with the residual effect of N through urea at 100 kg N per ha in three splits was maximum (30.41) and was on par with 100 kg N per ha through GCU (29.63). While during 1990-91, harvest index

was maximum with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea (29.66) and was on par with the residual effect of rest of the treatments except with N through urea at 100 kg per ha for rice (25.00). The mean harvest index was also maximum with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea (29.53) (Table 4.50).

Harvest index did not differ due to N levels for sunflower crop during both the years (Table 4.50).

4.5.15 Oil per cent of sunflower seeds

Oil per cent was significantly higher (43.3) during 1989-90 with the residual effect of N through USG at 100 kg per ha which was on par with the rest of the treatments except with the residual effect of green leaf manuring at 10 t per ha + 75 kg N through urea (40.9). Oil per cent during 1990-91 and the mean oil per cent of seeds were not influenced by the residual effect of sources of N for rice. However oil per cent of seeds was higher with 100 kg N per ha through USG (Table 4.52).

Oil per cent of seeds was significantly influenced by N application for sunflower. The increase in oil per cent with 31 kg N per ha was 1.7 and 1.6 per cent during 1989-90 and 1990-91 respectively over zero fertilizer N application (Table 4.5

Table 4.52 Oil per cent and oil yield of sunflower as influenced by the residual fertility status of rice with nitrogen levels

Treatments	Oil Percent		Oil yield(kg/ha)			
	1989-90	1990-91	Mean	1989-90	1990-91	Mean
GLM at 10 t per ha + 75 kg N through urea	40.9	39.4	40.2	416	252	334
100 kg N through urea	42.8	38.0	40.4	355	173	264
100 kg N through GCU	42.1	39.2	40.6	357	186	272
100 kg N through USG	43.3	39.9	41.6	392	218	305
100 kg N through URP	41.9	38.9	40.4	352	184	268
S.E.m±	0.6	0.7	0.5	8	7	5
CD at 5%	1.7	-	-	25	20	15
<u>Nitrogen levels</u>						
0 kg N/ha	41.4	38.3	39.8	350	188	269
31 kg N/ha	43.1	39.9	41.5	399	218	308
S.E.m±	0.2	0.2	0.1	4	2	2
CD at 5%	0.5	0.5	0.3	12	5	6
GLM - Green leaf manure	GCU - Gypsum coated urea					
USG - Urea super granules	URP - Urea rock phosphate					

4.5.16 Oil yield of sunflower

Oil yield of sunflower was significantly influenced by the residual effect of sources of N for rice. Maximum oil yield of 416 kg per ha was obtained with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha for rice during 1989-90 which was on par with the residual effect of 100 kg N per ha through USG (392 kg per ha). Oil yield during 1990-91 and mean of two years was also significantly higher with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea (252 kg per ha in 1990-91 and mean of 334 kg per ha) followed by 100 kg N per ha through USG (218 and 305 kg per ha respectively) (Table 4.52).

Nitrogen application for sunflower significantly increased the oil yield. During both the years the oil yield was significantly higher with 31 kg N per ha (399 kg per ha in 1989-90, 218 kg per ha in 1990-91 and mean of 308 kg per ha) compared to zero fertilizer N for sunflower (mean of 269 kg per ha) (Table 4.52).

Interaction of the residual effect of kharif rice treatments and levels of N for sunflower was significant during 1990-91 and mean of two years (Table 4.53). The residual effect of green leaf manure at 10 t per ha + 75 kg N per ha

Table 4.53 Interaction effects of residual fertility status of kharif rice and nitrogen levels on the oil yield of sunflower (kg/ha)

Treatments	1990-91		Mean of two years	
	0 kg	31 kg	0 kg	31 kg
	----- N/ha -----			
GLM at 10 t per ha + 75 kg N through urea	228	278	305	364
100 kg N through urea	160	185	246	282
100 kg N through GCU	176	197	252	292
100 kg N through USG	205	231	290	321
100 kg N through URP	170	197	253	283
	<u>S.E.m₊</u>	<u>CD at 5%</u>	<u>S.E.m₊</u>	<u>CD at 5%</u>
Comparison of sub plot means at the same level of main plot means	3.99	12.04	4.95	14.29
Comparison of main plot means at same or diff- erent level of sub plot means	7.33	22.52	6.32	18.30
GLM - Green leaf manure	GCU - Gypsum coated urea			
USG - Urea super granules	URP - Urea rock phosphate			

through urea and zero fertilizer N for sunflower produced equal or superior oil yield (228 kg per ha in 1990-91 and mean of 305 kg per ha) compared to the residual effects of rest of the kharif rice treatments and 31 kg N level for sunflower (mean oil yield was 282, 292, 321 and 283 kg per ha with the residual effect of 100 kg N through urea, GCU, USG and URP for rice at 31 kg N for sunflower respectively). The oil yield with the residual effect of 100 kg N per ha through USG and zero fertilizer N for sunflower was second highest (205 kg per ha in 1990-91 and mean of 290 kg per ha). The lowest oil yield was recorded with the residual effect of 100 kg N through urea.

4.5.17 Total biomass of rice-sunflower sequence

Total biomass of the rice-sunflower sequence during 1989-90, 1990-91 and mean over two years were significantly different due to sources of N. Hundred kg N through USG recorded significantly highest total biomass during both the years (17.65 and 15.82 t per ha during 1989-90 and 1990-91 respectively and mean of 16.73 t per ha) which was on par with green leaf manuring at 10 t per ha + 75 kg N through urea (17.56 and 15.53 t per ha in 1989-90 and 1990-91 respectively and mean of 16.55 t per ha). Lowest total biomass of the sequence was recorded with hundred kg N per ha through URP

Table 4.54 Total biomass production of rice-sunflower sequence as influenced by sources and levels of nitrogen

Treatments	Total biomass (t/ha)		
	1989-90	1990-91	Mean
GLM at 10 t per ha + 75 kg N through urea	17.56	15.53	16.55
100 kg N through urea	15.66	14.55	15.11
100 kg N through GCU	16.31	14.84	15.58
100 kg N through USG	17.65	15.82	16.73
100 kg N through URP	15.47	13.96	14.72
S.E.m _t	0.24	0.31	0.19
CD at 5%	0.74	0.95	0.56
<u>Nitrogen levels</u>			
0 kg N/ha	16.43	14.83	15.63
31 kg N/ha	16.64	15.04	15.84
S.E.m _t	0.02	0.01	0.01
CD at 5%	0.05	0.04	0.03

GLM - Green leaf manure

GCU - Gypsum coated urea

USG - Urea super granules

URP - Urea rock phosphate

(15.47 t per ha in 1989-90 and 13.96 t per ha in 1990-91 and mean of 14.72 t per ha) followed by 100 kg N per ha through urea (mean of 15.11 t per ha) (Table 4.54).

Between the N levels for sunflower, the total biomass was significantly higher with 31 kg N per ha compared to zero fertilizer N for sunflower. The increase in total biomass was same (0.21 t per ha) during both the years (Table 4.54).

Interaction of the residual effect of treatments for kharif rice and levels of N for sunflower on the mean total biomass of rice-sunflower sequence was significant (Table 4.55). Residual effect of 100 kg N through USG, green leaf manure at 10 t per ha + 75 kg N per ha as urea registered significantly higher total biomass yield of the sequence at both N levels. Biomass yield with 100 kg N per ha through USG and no fertilizer N for sunflower (16.65 t per ha) was equal or superior to rest of the treatments at 31 kg N level. It was highest with 100 kg N through USG and 31 kg N per ha for sunflower (16.82 t per ha). Rest of the treatments viz. 100 kg N through urea, GCU or URP recorded lower biomass yield at zero fertilizer N for sunflower.

4.5.18 Nitrogen, phosphorus and potash uptake by sunflower

Nitrogen uptake by sunflower was significantly higher with the residual effect of green leaf manure at 10 t per ha + 75 kg N per ha through urea for rice during both the years

Table 4.55 Interaction effect on mean total biomass production as influenced by residual effect of sources and levels of nitrogen (t/ha)

Treatments	0 kg N/ha	31 kg N/ha
GLM at 10 t per ha + 75 kg N through urea	16.39	16.70
100 kg N through urea	15.00	15.21
100 kg N through GCU	15.47	15.68
100 kg N through USG	16.65	16.82
100 kg N through URP	14.64	14.79
	<u>S.E.m_t</u>	<u>CD at 5%</u>
Comparison of sub plot means at the same level of main plot means	0.02	0.07
Comparison of main plot means at same or different level of sub plot means	0.19	0.57
GLM - Green leaf manure	GCU - Gypsum coated urea	
USG - Urea super granules	URP - Urea rock phosphate	

(55.6 kg per ha in 1989-90 and 44.6 kg per ha in 1990-91 and mean of 50.1 kg per ha). During 1989-90 the N uptake by sunflower with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea (55.6 kg per ha) was on par with 100 kg N per ha through URP and USG (53.8 and 53.3 kg per ha respectively). Nitrogen uptake with the residual effect of USG during 1990-91 and mean of two years was the next highest to green leaf manuring (40.9 and 47.1 kg per ha respectively) (Table 4.56).

Nitrogen uptake was also favourably influenced by the N application for sunflower. The uptake of N was 54.8 kg per ha in 1989-90, 40.1 kg per ha in 1990-91 and the mean of 47.5 kg per ha with 31 kg N per ha compared to no fertilizer N for sunflower (mean of 43.0 kg per ha) (Table 4.56).

Interaction of the residual effect of kharif rice treatments and levels of N for sunflower on the uptake of N by sunflower was significant during both the years (Table 4.57). Residual effect of green leaf manure at 10 t per ha + 75 kg N per ha at both the N levels for sunflower registered higher N uptake (mean of 46.2 and 53.9 kg per ha with zero and 31 kg N per ha respectively). Nitrogen uptake due to residual effect of green leaf manure at 10 t per ha + 75 kg N per ha through urea and 100 kg N per ha through USG at no fertilizer N level

Table 4.56 NPK uptake by sunflower as influenced by residual fertility status of Kharif rice and nitrogen levels for sunflower (kg/ha)

Treatments	Nitrogen			Phosphorus			Potassium		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean	1989-90	1990-91	Mean
LM at 10 t per ha + 5 kg N through urea	55.6	44.6	50.1	19.9	9.6	14.8	89.3	56.7	73.0
00 kg N through urea	47.6	36.2	41.9	15.4	7.9	11.7	77.3	50.8	63.9
00 kg N through GCU	47.1	37.3	42.2	15.1	8.1	11.6	86.7	52.1	69.4
00 kg N through USG	53.3	40.9	47.1	16.5	8.6	12.6	81.8	55.7	68.8
00 kg N through URP	53.8	32.2	44.9	17.4	7.9	12.6	84.0	44.5	64.3
.Em±	0.9	0.7	0.6	0.4	0.2	0.2	1.8	1.1	1.0
D at 5%	3.0	2.3	1.8	1.2	0.5	0.6	5.4	3.2	3.0
<u>Nitrogen levels</u>									
kg N/ha	48.1	37.9	43.0	15.5	8.2	12.1	79.0	46.9	63.0
1 kg N/ha	54.8	40.1	47.5	18.3	8.7	13.2	88.5	56.9	72.8
.Em±	0.4	0.2	0.2	0.2	0.1	0.1	1.0	0.6	0.5
D at 5%	1.3	0.7	0.7	0.5	0.2	0.3	3.0	1.7	1.6
LM - Green leaf manure	GCU - Gypsum coated urea			USG - Urea super granules					
RP - Urea rock phosphate									

for sunflower were at par (mean of 46.2 and 46.9 kg per ha respectively) and was equal or superior to N uptake by 100 kg N per ha each through urea, GCU and USG at 31 kg N level for sunflower. The N uptake due to 100 kg N per ha through URP at 31 kg N per ha for sunflower was superior during 1989-90, while it was not so during 1990-91 and in the pooled data of two years.

Phosphorus uptake with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea for rice was maximum (19.9 and 9.0 kg per ha in 1989-90 and 1990-91 respectively and mean of 14.8 kg per ha). During 1989-90 and the mean P uptake with 100 kg N per ha through USG and URP were at par (mean of 12.6 kg per ha in both the treatments). While during 1990-91, P uptake with 100 kg N through USG was superior (8.6 kg per ha) over 100 kg N per ha through URP (7.9 kg per ha) (Table 4.56).

Phosphorus uptake with 31 kg N per ha was significantly higher (18.3 and 8.7 kg N per ha during 1989-90 and 1990-91 respectively and the mean of 13.2 kg per ha) compared to no fertilizer N for sunflower (Table 4.56).

Phosphorus uptake of sunflower due to interaction of the residual effect of kharif rice treatments and levels of N for sunflower was significant during both the years (Table 4.57

Table 4.57 Interaction effects of residual fertility status of rice and nitrogen levels on the NPK uptake by sunflower (kg/ha)

Treatments	1989-90		1990-91		Mean	
	0 kg	31 kg	0 kg	31 kg	0 kg	31 kg
	N/ha					
<u>Nitrogen</u>						
GLM at 10 t per ha + 75 kg N through urea	51.5	59.7	40.9	48.3	46.2	53.9
100 kg N through urea	45.7	49.5	36.1	36.3	40.9	42.9
100 kg N through OCU	41.5	52.7	36.3	38.2	38.9	45.5
100 kg N through USG	53.1	53.5	40.7	41.1	46.9	47.3
100 kg N through URP	48.4	59.2	35.2	37.1	41.8	48.1
	S.E.m _t	CD at 5%	S.E.m _t	CD at 5%	S.E.m _t	CD at 5%
Sub plot means at the same level of main plot	0.94	2.8	0.5	1.5	0.5	1.5
Main plot means at same or different level of sub plot	1.19	3.6	0.8	2.5	0.7	2.1
<u>Phosphorus</u>						
GLM at 10 t per ha + 75 kg N through urea	17.4	22.5	8.9	10.4	13.1	16.4
100 kg N through urea	13.7	17.2	7.8	8.0	10.7	12.6
100 kg N through OCU	14.5	15.7	8.0	8.1	11.2	11.9
100 kg N through USG	15.9	17.2	8.3	8.9	12.1	13.0
100 kg N through URP	15.9	18.9	7.8	7.9	11.9	13.4
	S.E.m _t	CD at 5%	S.E.m _t	CD at 5%	S.E.m _t	CD at 5%
Sub plot means at the same level of main plot	0.4	1.1	0.1	0.4	0.2	0.6
Main plot means at the same or different level of sub plot	0.5	1.5	0.2	0.6	0.2	0.7
<u>Potassium</u>						
GLM at 10 t per ha + 75 kg N through urea	86.9	91.8	53.5	59.8	70.2	75.8
100 kg N through urea	77.8	76.3	44.4	57.2	61.2	66.8
100 kg N through OCU	79.5	93.8	48.6	55.6	64.1	74.7
100 kg N through USG	81.9	81.6	51.7	59.6	66.8	70.6
100 kg N through URP	69.0	99.0	36.3	52.7	52.7	75.9
	S.E.m _t	CD at 5%	S.E.m _t	CD at 5%	S.E.m _t	CD at 5%
Sub plot means at the same level of main plot	2.2	6.7	1.2	3.7	1.3	3.7
Main plot means at the same or different level of sub plot	2.4	7.2	1.4	4.2	1.4	3.9
GLM - Green leaf manure	OCU - Gypsum coated urea		USG - Urea super granules			
URP - Urea rock phosphate						

It was maximum due to the residual effect of green leaf manure at 10 t per ha + 75 kg N through urea at both the N levels (mean of 13.1 and 16.4 kg per ha at zero and 31 kg N per ha respectively). Residual effect of green leaf manure at 10 t per ha + 75 kg N through urea and zero N for sunflower (mean of 13.1 kg per ha) was equal or superior in P uptake over the rest of the treatments except green leaf manure at 10 t per ha + 75 kg N per ha through urea (mean of 16.4 kg per ha) at 31 kg N per ha for sunflower during both the years. The residual effects of the remaining kharif rice treatments at no fertilizer N for sunflower registered lower P uptake during both the years.

Potassium uptake differed significantly during both the years as well as the mean K uptake. Maximum K uptake was recorded with green leaf manuring at 10 t per ha + 75 kg N per ha through urea (89.3 kg per ha in 1989-90, 56.7 kg per ha in 1990-91 and mean of 73.0 kg per ha). The lowest K uptake was recorded with the residual effect of 100 kg N per ha through urea (77.3 kg per ha) during 1989-90, while during 1990-91, 100 kg N per ha through URP recorded lowest K uptake (44.5 kg per ha). There was no significant difference in the mean of K uptake between 100 kg N per ha each through urea or URP (Table 4.56).

Significantly higher K uptake was recorded with 31 kg N per ha for sunflower (88.5 kg per ha in 1989-90 and 56.9 kg per ha in 1990-91 and mean of 72.8 kg per ha) over no fertilizer N application (Table 4.56).

Interaction of the residual effect of kharif rice treatments and N levels for sunflower on the uptake of potassium was significant during both the years (Table 4.57). Residual effect of green leaf manure at 10 t per ha + 75 kg N per ha through urea and zero N level for sunflower on K uptake (mean of 76.2) was equal or superior over all the treatments except with the residual effect 100 kg N per ha through URP and 31 kg N per ha for sunflower during 1989-90, while in 1990-91 it was on par with the residual effects of 100 kg N per ha each through urea, GCU and URP and 31 kg N per ha for sunflower. The mean K uptake due to interaction of green leaf manure at 10 t per ha + 75 kg N through urea and zero N level for sunflower was on par (70.2 kg per ha) with the residual effect of 100 kg N through USG (70.6 kg per ha) and was superior to 100 kg N through urea (66.8 kg per ha) at 31 kg N level for sunflower. The remaining treatments at zero N level for sunflower recorded significantly lower K uptake during both the years except the residual effect of 100 kg N through USG at zero N level for sunflower during 1990-91.

4.5.19 Change in fertility status of soil after harvest of rice and sunflower

Organic carbon content and available N, P_2O_5 and K_2O status of the soil after harvest of rice and sunflower were significantly influenced by different treatments. Organic carbon content of the soil was not significantly different among the treatments after harvest of rice but it differed significantly after harvest of sunflower. Available P_2O_5 differed significantly during both the years after harvest of rice, and also after harvest of sunflower during 1989-90. Available K_2O differed significantly during 1989-90 after harvest of rice and during 1990-91 after harvest of sunflower. The mean of organic carbon, available P_2O_5 and K_2O differed significantly both after harvest of rice and sunflower.

Among the treatments, green leaf manuring at 10 t per ha . 75 kg N per ha through urea recorded maximum organic carbon content and available N, P_2O_5 and K_2O after harvest of rice as well as sunflower. Mean organic carbon content N, P_2O_5 and K_2O after harvest of rice were 1.35 per cent, 329, 62 and 469 kg per ha respectively, while after harvest of sunflower the mean organic carbon content and available N, P_2O_5 and K_2O were 1.12 per cent 252, 96, 577 kg per ha respectively. Lowest organic carbon content and available P_2O_5 and K_2O was recorded

Table 4.58 Organic carbon (%) and available nutrient status of soils after harvest of rice and sunflower

Treatments	After harvest of rice			After harvest of sunflower		
	1989-90	1990-91	Mean	1989-90	1990-91	Mean
GLM at 10 t per ha + 75 kg N through urea						
Organic carbon (%)	1.39	1.31	1.35	1.11	1.13	1.12
Available N (kg/ha)	300	358	329	244	260	252
" P ₂ O ₅ (")	60	64	62	83	109	96
" K ₂ O (")	490	449	469	530	624	577
100 kg N through urea						
Organic carbon (%)	1.25	0.76	1.01	0.83	0.96	0.90
Available N (kg/ha)	265	305	285	232	252	242
" P ₂ O ₅ (")	51	48	49	51	84	68
" K ₂ O (")	427	431	429	507	565	536
100 kg N through GCU						
Organic carbon (%)	1.28	0.69	0.99	0.71	0.96	0.84
Available N (kg/ha)	290	312	301	222	250	236
" P ₂ O ₅ (")	51	44	47	61	94	78
" K ₂ O (")	413	404	408	460	574	517
100 kg N through USG						
Organic carbon (%)	1.18	0.73	0.96	0.74	0.91	0.82
Available N (kg/ha)	299	315	307	234	240	237
" P ₂ O ₅ (")	53	46	49	66	92	79
" K ₂ O (")	399	364	382	474	574	524
100 kg N through URP						
Organic carbon (%)	1.26	0.74	1.00	0.81	1.01	0.91
Available N (kg/ha)	250	256	253	200	240	220
" P ₂ O ₅ (")	55	62	58	74	104	89
" K ₂ O (")	406	434	420	488	561	525
S.E.m.						
Organic carbon	0.05	0.06	0.04	0.05	0.02	0.03
Available P ₂ O ₅	1.3	3.1	1.7	4.9	8.7	4.4
" K ₂ O	19.0	25.0	15.7	20.0	14.4	16.2
CD at 5%						
Organic carbon	-	-	0.12	0.15	0.06	0.08
Available P ₂ O ₅	4.2	9.2	5.2	15.0	-	13.1
" K ₂ O	58.6	-	47.3	-	44.3	47.3

Initial status : Organic carbon 0.60% and available N, P₂O₅ and K₂O 266, 23 and 229 kg per ha respectively

GLM - Green leaf manure GCU - Gypsum coated urea USG - Urea super granules URP - Urea rock phosphate

after harvest of sunflower with 100 kg N per ha through USG, urea in three splits and GCU respectively (mean organic carbon of 0.82 per cent and 68 and 517 kg per ha of available P_2O_5 and K_2O respectively). Available N was lowest after harvest of sunflower with 100 kg N through URP (220 kg per ha). There was increase in organic carbon content available N, P_2O_5 and K_2O of the soil with green leaf manuring at 10 t per ha + 75 kg N through urea after harvest of rice (mean of 1.35, 329, 62 and 469 kg per ha organic carbon, available N, P_2O_5 and K_2O respectively) and organic carbon, available P_2O_5 and K_2O after harvest of sunflower (mean of 1.12 per cent, 96 and 577 kg per ha respectively) over the initial values of 0.60 per cent organic carbon and 23 and 229 kg per ha available P_2O_5 and K_2O respectively. Thus there was improvement in the soil fertility status due to green leaf manuring at 10 t per ha + 75 kg N per ha through urea compared to the remaining treatments (Table 4.58)

4.6.1 Economics of the premonsoon crops, rice and sunflower crops grown in sequence under two levels of nitrogen

The gross income per ha of the S.rostrata-rice-sunflower sequence was maximum during both the years (Rs.20968 and 19336 during 1989-90 and 1990-91 respectively, and mean of Rs.20152). Similarly the net income and benefit-cost ratio were also maximum. The net income was Rs.10384 in 1989-90 and Rs.8752

Table 4.59 Economics of the premonsoon crops-rice-sunflower sequence as influenced by the crops grown and levels of nitrogen

Treatments	Gross income (Rs.)		Net income (Rs.)		Benefit-cost ratio	
	1989-90	1990-91	Mean	1989-90	1990-91	Mean
Rice	16102	14871	15487	5126	4075	4601
Soybean	17678	17050	17364	6919	6291	6605
<u>Sesbania rostrata</u>	20968	19336	20152	10384	8752	9568
Sunhemp	20022	18279	19151	9438	7695	8567
Rice + Sunhemp	18842	17154	17998	8062	6374	7218
Rice + <u>S. rostrata</u>	18853	17352	18103	8073	6572	7323
Rice + Soybean	17734	16147	16941	6866	5279	6073
Fallow	15149	13960	14555	5550	4361	4956
<u>trogen levels</u>						
0 kg N/ha	16716	15447	16082	6270	5001	5636
30 kg N/ha	18581	17035	17808	7795	6249	7022

1.49 1.36 1.42
1.64 1.59 1.61
1.98 1.83 1.90
1.89 1.73 1.81
1.75 1.59 1.67
1.75 1.61 1.68
1.63 1.48 1.56
1.58 1.45 1.51
1.60 1.48 1.54
1.72 1.58 1.65

in 1990-91 and mean of Rs.9568. The benefit-cost ratio was 1.98 and 1.83 in 1989-90 and 1990-91 respectively and the mean of 1.90. The increase in net income of S.rostrata-rice-sunflower over maize-rice-sunflower was Rs.5258 in 1989-90 and Rs. 4677 in 1990-91. The next highest gross and net income and benefit-cost ratio were registered with sunhemp-rice-sunflower sequence. The lowest gross income was registered with fallow-rice-sunflower(Rs.15149 in 1989-90 and Rs.13960 in 1990-91), while the lowest net income (Rs.5126 in 1989-90 and Rs.4075 in 1990-91) and benefit-cost ratio (1.49 in 1989-90 and 1.36 in 1990-91) were recorded with maize-rice-sunflower. Among the intercropping treatments followed by rice-sunflower, maize + S.rostrata-rice-sunflower recorded higher gross and net income as well as benefit-cost ratio (mean of Rs.18103, Rs.7323 and 1.68 respectively) (Table 4.59).

Between 50 and 100 kg N per ha, the gross and net income and benefit-cost ratio were maximum with 100 kg N per ha for rice in the sequence. The mean increase of gross and net income and benefit-cost ratio were Rs.1726, Rs.1386 and 0.11 respectively over 50 kg N per ha (Table 4.59).

The interaction effect of crops grown and levels of N applied on the economics of the sequence is given in the Table 4.60. It is based on the mean yield data of two years. It was observed that the gross income, net income and

Table 4.60 Economics of the premonsoon crops-rice-sunflower sequence as influenced by the interaction effects of crops grown and N levels

Treatments	Gross income(₹.)			Net income(₹.)			Benefit-cost ratio		
	50 kg	100 kg		50 kg	100 kg		50 kg	100 kg	
	----- N/ha -----								
Maize	14813	16154		4007	5008		1.37	1.45	
Soybean	16414	18325		5825	7396		1.55	1.68	
<u>Sesbania rostrata</u>	19407	20903		8993	10149		1.86	1.94	
Sunhemp	18299	20002		7885	9248		1.76	1.86	
Maize + Sunhemp	16828	19165		6218	8215		1.59	1.75	
Maize + <u>S. rostrata</u>	17276	18920		6666	7970		1.63	1.73	
Maize + Soybean	16024	17856		5326	6818		1.50	1.62	
Fallow	13775	15338		4346	5569		1.46	1.57	

INDEX

Gross income at 50 Kg N / ha	a
Net income "	a
Gross income at 100 Kg N / ha	b
Net income "	b

Treatments

1. Maize
2. Soybean
3. *Sesbania rostrata*
4. Sunhemp
5. Maize + Sunhemp
6. Maize + *S. rostrata*
7. Maize + Soybean
8. Fallow (no preceding crop)

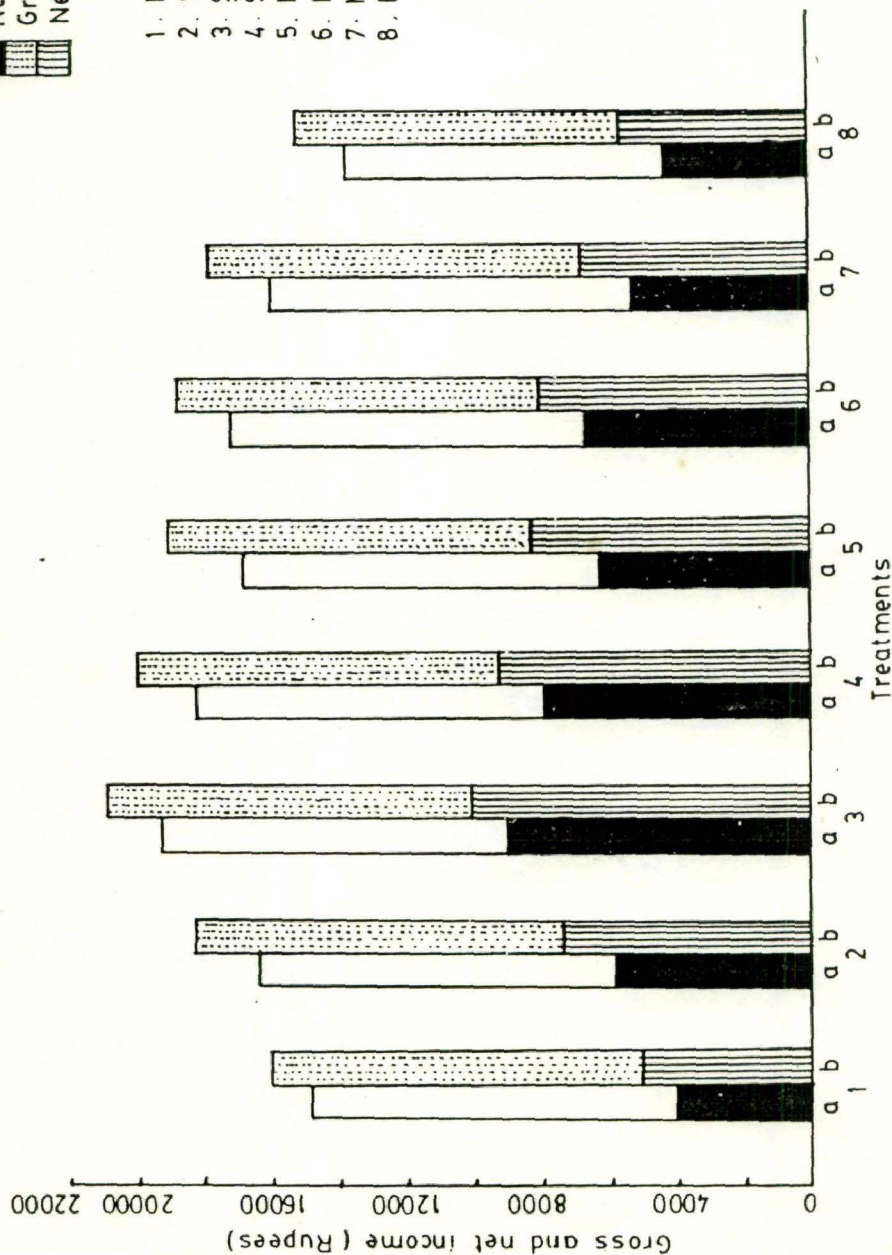


FIG. 4.9. GROSS AND NET INCOME OF RICE - SUNFLOWER SEQUENCE AS INFLUENCED BY THE INTERACTION EFFECT OF CROPS GROWN AND NITROGEN LEVELS.

benefit-cost ratio were maximum with S.rostrata-rice-sunflower in conjunction with 100 kg N per ha (Rs.20903 per ha, Rs.10149 per ha and 1.94 respectively), which was followed by sunhemp-rice-sunflower sequence. The gross income was lowest with fallow-rice-sunflower in conjunction with 50 kg N per ha (Rs.13775). But the net income^{and}/benefit-cost ratio were lowest with maize-rice-sunflower in conjunction with 50 kg N per ha (Rs.4007 per ha and 1.37). Among the intercropping treatments also maize + sunhemp-rice-sunflower in conjunction with 100 kg N per ha gave maximum gross and net income as well as benefit-cost ratio (Rs.19165, Rs.8215 and 1.75) followed by maize + S.rostrata-rice-sunflower (Rs.18920, Rs.7970 and 1.73). While maize + S.rostrata-rice-sunflower in conjunction with 50 kg N per ha gave more gross and net returns and benefit-cost ratio (mean of 17276, 6666 and 1.63 respectively) compared to other intercropping treatments followed by rice-sunflower at 50 kg N level. The gross and net income with S.rostrata-rice-sunflower sequence at 50 kg N level for rice was superior (Rs. 19407, and Rs.8993 respectively) over all the premonsoor crops and fallow treatments except S.rostrata and sunhemp followed by rice-sunflower at 100 kg N level for rice. The benefit-cost ratio of S.rostrata-rice-sunflower sequence at 50 kg N per ha for rice was equal or superior to rest of the treatments at 100 kg N level. Sunhemp-rice-sunflower sequence at 50 kg N per ha for rice was next best in respect of economics

4.6.2 Economics of rice-sunflower sequence as influenced by sources and levels of nitrogen

The gross income was maximum with green leaf manuring at 10 t per ha + 75 kg N per ha through urea (Rs.28357 in 1989-90 and Rs.23206 in 1990-91 and mean of Rs.25782). This was followed by 100 kg N per ha through USG. But the net income (Rs.18043 and Rs.12901 in 1989-90 and 1990-91 respectively) and the benefit-cost ratio (2.77 and 2.27 during 1989-90 and 1990-91 respectively) were higher with 100 kg N per ha through USG followed by green leaf manuring at 10 t per ha + 75 kg N per ha through urea. The gross and net income as well as the benefit-cost ratio were lowest with 100 kg N per ha through URP (mean of Rs.21893, 12016 and 2.22 respectively) (Table 4.61).

With the addition of 31 kg N per ha for sunflower, the gross income increased by Rs.684 in 1989-90 and Rs.526 in 1990-91 over no fertilizer N. The increase in net income was to the extent of Rs.470 and Rs.312 during 1989-90 and 1990-91 respectively. But the benefit-cost ratio did not vary much (mean of 2.38 with 31 kg N and 2.36 with zero N per ha) (Table 4.61).

The interaction effects on the economics of rice-sunflower sequence as influenced by the sources and levels of N is presented in Table 4.62. The gross income was

Table 4.61 Economics of the rice-sunflower sequence as influenced by the sources of N for rice and levels of N for sunflower

Treatments	Gross income(Rs.)		Net income (Rs.)		Benefit-cost ratio				
	1989-90	1990-91	Mean	1989-90	1990-91	Mean			
<u>Source of Nitrogen for rice</u>									
GM at 10 t per ha + 5 kg N through urea	28357	23206	25782	17650	12499	15075	2.65	2.17	2.41
50 kg N through urea	25573	19813	22693	15697	9937	12817	2.59	2.01	2.30
50 kg N through GCU	26321	20867	23594	16445	10991	13718	2.67	2.11	2.39
50 kg N through USG	28219	23077	25648	18043	12901	15472	2.77	2.27	2.52
50 kg N through URP	24447	19338	21893	14571	9462	12016	2.47	1.96	2.22
<u>Nitrogen levels for sunflower</u>									
kg N/ha	26238	20997	23618	16243	11002	13623	2.62	2.10	2.36
1 t kg N/ha	26922	21523	24222	16713	11314	14014	2.64	2.11	2.38
<u>Legend</u>									
GM - Green leaf manure	GCU - Gypsum coated urea		USG - Urea super granules						
RP - Urea rock phosphate									

higher with green leaf manuring at 10 t per ha + 75 kg N per ha as urea for rice and 31 kg N for sunflower (Rs.26287 per ha) followed by 100 kg N as USG for rice and 31 kg N for sunflower (Rs.25900 per ha). But the net income was highest with 100 kg N per ha as USG for rice and 31 kg N per ha for sunflower (Rs.15617 per ha) followed by green leaf manuring at 10 t per ha + 75 kg N per ha for rice and 31 kg N for sunflower (Rs.15473 per ha). The gross and net income were lowest with 100 kg N per ha through URP for rice and no fertilizer N for sunflower (Rs. 21682 and Rs.11913 per ha). The gross income with green leaf manuring at 10 t per ha + 75 kg N through urea (Rs.25276), 100 kg N per ha through USG (Rs. 25397) at no fertilizer N for sunflower differed marginally and were superior to 100 kg N per ha through urea, GCU and URP at 31 kg N level for sunflower. The net income also followed similar trend. The benefit-cost ratio with 100 kg N per ha through USG was equal or superior to all the treatments at 31 kg N per ha for sunflower.

DISCUSSION

V. DISCUSSION

In an effort to study the cropping pattern for rice based farming under tank irrigated system, two field experiments were conducted namely use of green manure crops for rice culture and also the efficient sources of nitrogen to rice and its residual effects on succeeding crop in the University Farm of Agricultural Sciences, Bangalore, Hebbal during 1989-90 and 1990-91. The results obtained in these experiments are discussed separately in this chapter.

5.1 Influence of weather on crop growth

The weather condition was normal during both the years in respect of maximum and minimum temperature, relative humidity, evaporation, sunshine and wind velocity. Large deviations in the pattern of rainfall was observed during 1990-91 as depicted in fig.3.2. Heavy rains occurred during the month of July 1989-90 adversely affected the growth of sunhemp and S.rostrata. Hence the biomass yields of sunhemp and S.rostrata were lower during 1989-90. However the growth and yield of rice was not affected by the weather during the period of study. Growth and yield of sunflower were better during 1989-90 than during 1990-91. This might be due to the genetic impurity of the seeds used during 1990-91.

5.2 Status of the quality of irrigation water

The quality of irrigation water during both the years indicated that the water contained high amount of bicarbonates and sodium which affected the initial growth of green manure and rice crops. However, it was not so in case of sunflower indicating its tolerance. Water contained enough of nitrates and traces of ammonia. The nitrate had little influence on the growth of rice as rice needed ammonical form of nitrogen. The effect of irrigation water on crop remained unchanged for all the treatments.

5.3 Experiment 1

Effect of premonsoon crops grown and levels of N on growth, yield, economics and soil fertility status of rice-sunflower sequence

5.3.1 Biomass production and nitrogen removal of premonsoon crops

The biomass yield of sunhemp and S.rostrata were higher compared to soybean, sunhemp and S.rostrata recorded higher drymatter production per plant compared to soybean. Similarly the plant height of sunhemp and S.rostrata was higher than soybean. This is well depicted in plates 2, 3 and 4. It is well recognised that sunhemp being a popular green manure crop, grows luxuriously under normal conditions than soybean crop. Its succulancy promotes growth faster than the soybean.

This trend was observed by several workers and the results are in conformity with those of Singh et al. (1981a), Bharadwaj et al. (1981), Meelu and Morris (1988), Sharma and Mittra (1988), Beri et al. (1989) and Salam et al. (1989). Morris et al. (1989) and Herrera et al. (1989). However when grown with maize crop the plant height and dry weight per plant of maize was lower in maize + S.rostrata, while S.rostrata alone recorded higher total biomass. This was due to competition between maize and S.rostrata. The vigorous growth of S.rostrata might have adversely affected the plant height and dry weight per plant through reduction in growth and biomass yield of maize. Similar results were obtained with maize + sunhemp (Plate 5 and 6). In maize + soybean system, there was no such tangible competition among the crops (Plate 7). Hence the biomass yield of maize was least affected, inspite of this, the total biomass yield of maize + S.rostrata was maximum. S.rostrata seemed to have compensated the loss in biomass yield of maize in the system. In Philippines the system of growing Indigo as intercrop with food or fodder crop is in vogue. After harvest of food or fodder crop indigo is allowed to grow and incorporated as green manure. The beneficial effects of green manures such as S.cannabina and others for the second crop of rice were emplified by Carangal et al. (1988) and Chen (1988).

Sole maize as well as intercropped one was found to exhaust NPK from the soil. Being a cereal crop, the depletion of nitrogen was greater than leguminous green manures. Green manures could derive part of their nitrogen requirement from atmospheric N through Rhizobial N fixation. According to an estimate, S.rostrata could fix 200-300 kg nitrogen per hectare. (Dreyfus and Dommergues, 1980 and 1981; Dreyfus et al., 1983; Rinaudo and Moudiongui, 1987; Rinaudo et al., 1988a; Morris et al., 1989; Herrera et al., 1989 and Salam et al. (1989). Numerous investigators testified the potentiality of S.rostrata for its versatility of N-fixation which will be quite useful to succeeding crop. In the present study accumulated nitrogen in the above ground parts of sunhemp, S.rostrata and soybean was of the order of 193.74, 177.95 and 39.93 kg N per ha, while in case of intercropped sunhemp, S.rostrata and soybean it was 55.82, 54.83 and 29.51 kg per ha respectively. Despite the higher uptake of nitrogen by S.rostrata the status of soil nitrogen and organic carbon content were higher than those of plots grown with maize. The leaf fall and residues substantially contributed towards higher organic carbon content of soil after harvest of S.rostrata, sunhemp and soybean. The NPK uptake of soybean was lowest because of poor growth and low biomass yield compared to other crops. Greater uptake of NPK by S.rostrata, sunhemp and also intercropped S.rostrata

and sunhemp could largely be attributed to better growth of crop and biomass production as well as their inherent ability to fix atmospheric N through stem and root nodules of S.rostrata and root nodules of sunhemp as discussed earlier. Even the available status of soil phosphorus and potassium were adequate. Hence crops grown during premonsoon period could able to accumulate more NPK. The NPK removed by green manures were returned to the soil as they were incorporated at the time of puddling for rice. The mineralisation of green manure by host of micro organisms would release not only NPK but also would favourably interact with the native soil nitrogen resulting in greater supply of NPK to succeeding crop. Khare and Rai (1968) also reported the greatest contribution of nitrogen by Sesbania. Further soybean, cowpea and greengram stood in the order of merit. The present findings are in consonance with those of Singh (1984) and Anon (1986e and d).

5.3.2 Direct effect of premonsoon crops on the growth, yield and total biomass of rice

Grain yield of rice obtained by S.rostrata green manuring was superior to other treatments which were on par with sunhemp green manuring as depicted in fig.4.2. There was an additional grain yield of 833 and 851 kg per ha by S.rostrata green manuring over fallow-rice in 1989-90 and 1990-91 respectively. There was similar increasing trend in

respect of straw and biomass yield of rice. These findings were in agreement with those of Beri and Meelu (1981), Meelu and Rekhi (1981), Bharadwaj (1982), Rinaudo et al. (1983), Betti et al. (1985), Diack (1986), Anon. (1986d and e), Rinaudo and Moudiongui (1987). Ranvir Singh et al. (1988) attributed increased yield of rice due to green manuring. The lowest grain and straw yields and total biomass were recorded with maize-rice and fallow-rice treatments.

Biomass yield is the sum of grain and straw yields. The grain yield was largely dependent on the yield parameters. Which in turn depend on the growth parameters. Relationship of number of grains and number of panicles per hill have been contributory factors as reported by several researchers viz. Pillai, 1971; Koyana and Niamsrichand, 1973 and Subbaiah et al. (1983). Thimmegowda (1985) contended that adequate nutrient supply to plants would help in development of panicle and larger number of spikelets per panicle. Due to better nutrition there was concurrent increase in photosynthesis and enhancement in the translocation of photosynthates to panicles from the plant parts contributing towards larger yields. In the present study also, there was adequate nutrition through green manuring S. rostrata and sunhemp in conjunction with fertilizer nitrogen. This was favourably reflected through large number of effective tillers per hill, 1000 grain weight,

panicle length, and the filled grains per panicle and were superior over other treatments as depicted in fig.4.1. There was significant reduction in the production of chaffy grains. On the other hand lowest number of effective tillers per hill, poor in 1000 seed weight, in panicle length, and also in the number of filled grains were recorded with maize-rice (9.2, 22.5, 16.6 and 51.9 respectively) and fallow-rice (10.0, 22.7, 17.1 and 56.9 respectively). This was attributed to inadequate supply of nutrients for rice crop. The preceeding maize crop caused greater depletion of available NPK but not so in fallow-rice treatment. In the rest of the treatments, nutrients were supplied to soil through green manures grown either as sole or as inter crop with maize. Grain and straw yields, and total biomass of rice were significantly higher with 100 kg fertilizer N alone per ha. This was obvious due to the fact that nitrogen supply in rice appeared to be exitical. Growth parameters like dry weight per hill, LAI and plant height were also far better with 100 kg N supply per ha. The results of the present study finds credence in the work of De Datta (1981) and Subbaiah et al. (1983).

Rice after Sesbania rostrata when grown in conjunction with 100 kg N per ha gave maximum yield (4498 and 4679 kg per ha in 1989-90 and 1990-91 respectively). Further it is

significant to observe that the grain yield of rice with S.rostrata green manure grown in conjunction with 50 kg fertilizer N per ha (4265 kg per ha in 1989-90 and 4419 kg per ha in 1990-91) showed high degree of superiority over 100 kg inorganic N alone (3721 kg per ha in 1989-90 and 3862 kg per ha in 1990-91). This was followed by sunhemp green manure with 50 kg N per ha. Similar findings were reported by Rekhi and Meelu (1983), Khind et al. (1985), Joseph (1986), Rana et al. (1988), Mahapatra and Sharma (1989), Kalidurai and Kannaiyan (1990). In another study Camara and Diara (1986) contended that 50 per cent of the fertilizer N could be saved by S.rostrata green manuring. Ravindra et al. (1989) stated that the rice yields with green manure in conjunction with 30 per cent of the inorganic N was higher than 100 kg N alone. The mineralisation of green manures by host of microbes under adequate soil and moisture conditions would enhance the availability of nutrients. The prevailing reduced conditions in submerged rice enhanced the supply of several nutrients to crops. Significantly, green manures improve the physical, chemical and biological conditions of the soils promoting the productivity of soils. The biomass as well as nutrient contribution by soybean was relatively lower compared to S.rostrata and sunhemp. As such the yield of rice with soybean as green manure crop in conjunction with 100 kg N per ha was on par with S.rostrata or sunhemp

green manuring with 50 kg of fertilizer N per ha. Fallow-rice with 50 kg N per ha recorded lower grain yield.

Interaction effects of crops grown and levels of N on tiller number per hill at 60 days after planting and panicle length was maximum with S.rostrata green manuring for rice along with 100 kg fertilizer N per ha. It is significant to note that the number of tillers with premonsoon S.rostrata green manure and 50 kg N per ha for rice was superior or equal to the number of tillers produced with intercropped green manures, maize, soybean or fallow treatments at 100 kg N level. Panicle length of rice also followed same trend. However, some of the yield attributes such as number of tillers at harvest, panicle length, number of filled grains were not significantly influenced.

Growth of rice was the cumulative effect of dry matter accumulation per hill at different growth stages. Growth of rice at maturity stage with S.rostrata green manure at 50 and 100 kg fertilizer N per ha and premonsoon fallow followed by 100 kg fertilizer N per ha for kharif rice is depicted in plates 11, 12 and 13. Dry weight per hill was greater at 30 and 60 days after planting, and at harvest with S.rostrata-rice followed by sunhemp-rice, while it was least with maize-rice and fallow-rice. There was improvement in tiller number

and plant height with green manuring sole crop of S.rostrata or sunhemp for rice as compared to premonsoon maize crop followed by rice or fallow-rice treatments. LAI was maximum with S.rostrata green manuring followed by sunhemp green manuring. While it was the least with maize-rice and fallow-rice at 30 and 60 DAP of rice. Higher LAI helped in trapping of more solar radiation for photosynthesis. Hence the drymatter distribution in leaves and stem at 30 and 60 DAP, shoot and panicle at harvest were higher with S.rostrata-rice followed by sunhemp-rice while it was least with maize-rice. Takahashi et al. (1986) also reported improvement in the growth parameters following Sesbania sp. and soybean.

Application of fertilizer N at 100 kg per ha alone improved the plant height, LAI, tillers per hill which in turn increased drymatter per hill. Singh and Misra (1968) also noticed steady increase in dry weight of rice with increase in N.

Interaction effects of premonsoon crops and levels of N on the drymatter production at 30 and 60 DAP was significant. Incorporation of premonsoon grown S.rostrata or sunhemp for kharif rice and addition of 50 kg fertilizer N was found superior or equal in drymatter production per hill of rice compared to the incorporation of intercropped green manure crops with maize, fallow and sole fodder maize followed by kharif rice at 100 kg fertilizer N level. The drymatter

accumulation in leaves at 30 DAP and tiller number per hill during 1990-91 also followed similar trend. Plant height, LAI, drymatter distribution at 60 DAP and at harvest were not affected significantly due to interaction of crops grown and N levels. The differences in the growth of kharif rice due to S.rostrata green manure at 50 kg fertilizer N per ha and fallow-rice at 100 kg fertilizer N per ha can be observed in Plate 12 and 13.

5.3.3 Growth and yield of sunflower as influenced by the residual fertility status of rice

Seed and straw yields of sunflower obtained with the residual fertility status after S.rostrata-rice and sunhemp-rice were maximum (Fig.4.4). The possible explanation was due to superiority of growth and yield parameters, reflected as a consequence of residual fertility. There was substantial enhancement in the fertility status in regard to organic carbon and available NPK status of the soil after harvest of rice.

Growth of sunflower crop as indicated by the plant height, total dry weight at 50 DAS and at harvest were significantly improved with the residual fertility of S.rostrata (Plate 14) followed by sunhemp. The better growth of crop might be attributed to increased LAI with the

residual effect of S.rostrata followed by sunhemp. Greater amount of LAI enhanced the effectiveness of solar radiation for photosynthesis. Higher photosynthesis resulted in more growth. There was greater amount of drymatter distribution in leaves at 50 DAS and leaves and stem at harvest. The enhancement in LAI and drymatter distribution in different plant parts promoted the growth of sunflower. This was reflected in higher dry weight of sunflower at harvest with S.rostrata-rice-sunflower (41.19 g per plant) as compared to maize-rice-sunflower (20.95 g per plant) and with fallow-rice-sunflower(22.98 g per plant). The crop stand of sunflower with the residual effects of S.rostrata and fallow treatments at 50 kg N level can be observed in Plate 14 and 15.

The better growth parameters i.e. dry weight, LAI and plant height was reflected on the yield parameters of sunflower. The diameter of the head, filled seeds per head, per cent filled seeds per head, seed weight per head and 1000 seed weight were superior due to the residual fertility of S.rostrata green manuring followed by sunhemp(Fig.4.3). Without the practice of green manure as followed in case of maize-rice-sunflower or fallow-rice-sunflower, the yield parameters were lower in degree. The head size was larger with the residual fertility status S.rostrata and sunhemp

green manuring (mean of 10.8 and 10.3 cm respectively), while with maize-rice-sunflower or fallow-rice-sunflower it was smaller (mean of 6.2 and 6.7 cm respectively). This was also true in case of filled seeds per head, percentage of filled seeds and seed weight per head (mean of 245, 76.8 per cent and 8.05 g per head respectively) with the residual fertility status of S.rostrata followed by sunhemp. The least was with maize-rice-sunflower (180, 53.7 per cent and 4.89 g per head) followed by fallow-rice-sunflower. The effectiveness of yield attributes improved the seed yield. There was enhancement in the extra yield of 300 kg per ha of sunflower over fallow-rice-sunflower and over maize-rice-sunflower it was 352 kg per ha. Residual effects of green manures on the succeeding crops was also reported by several other earlier workers viz. Sharma and Mittra (1988), Mahapatra and Sharma (1989), Chakravorty et al. (1988) and Bouldin (1988), Morris et al. (1989) and Diekman et al. (1991). It may be explained from the fact that the lowest seed yield with maize-rice-sunflower was due to low status of available N and organic carbon content of the soil.

The seed and straw yields of sunflower obtained as a consequence of residual effect of 100 kg fertilizer N was higher and resulted in an extra seed yield of 59 kg per ha and, 98 kg per ha in respect of straw yield. The growth and yield parameters of sunflower were better due to residual

effect of 100 kg N added per ha for rice. The concurrent increase in total dry weight (369 g per plant) was mainly ascribed to increase in plant height and larger accumulation of drymatter, LAI recorded was also more.

Residual fertility status resulted from growing of S.rostrata along with applied 100 kg N per ha improved significantly the straw yield of sunflower as well as the total biomass. This was ascribed to enhanced growth of sunflower resulting in higher drymatter production per plant. On the contrary the straw yield and total biomass production of sunflower were lower with the residual effect of maize grown for fodder or no green manure in conjunction with 50 kg N per ha. It resulted in poor growth of crop recording lower dry weight per plant. Interaction effects of residual fertility status of green manure and 100 kg fertilizer nitrogen were significant and positive and caused to enhance the diameter of the head and per cent of filled seed. This trend was inconspicuous with the residual fertility status of maize with 50 kg fertilizer N. Similarly the oil yield of sunflower significantly improved with the residual fertility of S.rostrata (mean of 332 kg per ha). The increase in oil yield per ha over maize-rice-sunflower and fallow-rice-sunflower was of the order of 168 and 150 kg per ha respectively (Fig.4.4). Since the crop growth was

remarkably improved due to residual effects of S.rostrata along with fertilizer nitrogen applied, reflection was noticed in the oil per cent. As a consequence the oil yield of sunflower was significantly greater than those recorded in treatments on residual effects of maize and applied nitrogen. Similarly the oil yield with the residual effect of 100 kg inorganic N alone was also encouraging (increase of 32 kg per ha) over 50 kg N per ha. This had culminated in higher growth rate coupled with higher oil content resulting in higher oil yield per ha.

5.3.4 Total biomass of crops grown in sequence as influenced by the premonsoon crops and N levels for rice and their residual fertility on succeeding sunflower crop

Total biomass production of sunhemp-rice-sunflower sequence was maximum (mean of 34.4 t per ha) followed by S.rostrata-rice-sunflower (mean of 32.1 t per ha). Least total biomass yield of the sequence was observed with fallow-rice-sunflower. This was attributed to the higher biomass yields of sunhemp and S.rostrata due to more drymatter production per plant in 60 days. Results of the experiments conducted at IRRI, Philippines also indicated higher biomass yield of S.rostrata (Anon., 1986d and e). In the treatments involving premonsoon crops there was an additional biomass production. In intercropping treatments there was reduction

~ x x

in biomass yield of maize due to vigorous growth of S.rostrata and sunhemp in the early stages. The loss in biomass yield of maize was compensated by sunhemp and S.rostrata. The biomass yield of rice with S.rostrata green manuring was maximum (10.76 and 10.34 t per ha respectively). Similarly the biomass yield of sunflower was maximum with the residual effects of S.rostrata and sunhemp (2.37 and 2.31 t per ha respectively). The least biomass of rice and sunflower were noticed with maize-rice-sunflower and fallow-rice-sunflower (mean of 1.43 and 1.59 t per ha respectively). Better growth of individual crops in the sequences and additional yield of premonsoon crops was responsible for higher biomass yield of the sequence.

The residual effect of inorganic N at 100 kg N per ha also increased the total biomass yield of the sequence. There was a mean increase of biomass yield of rice by 1.16 t per ha, and sunflower by 0.16 t per ha over 50 kg N per ha. Thus the higher yields of individual crops resulted in more biomass yield of the sequence.

5.3.5 Economics of growing premonsoon crops-rice-sunflower in sequence

The practice of growing green manure crops like S.rostrata increased the farm income through benefit-cost ratio of the sequence followed in the study. There was net profit of

Rs.9568 per ha with the cost-benefit ratio of 1:1.9 (Fig.4.9). This trend was also seen in sunhemp green manuring. Further residual effects of S.rostrata green manuring along with 100 kg fertilizer N per ha extended the net benefit of Rs.10,149 per ha. It was significant to observe that larger economic benefits were derived from application of 50 kg fertilizer nitrogen along with incorporation of green manures rather than at 100 kg fertilizer nitrogen. This trend was inconspicuous in case of maize + soybean-rice system. Similar observations were reported by Bharadwaj et al. (1981).

5.3.6 Uptake of NPK by sequential crops and changes brought about in fertility status of soil as influenced by incorporation of premonsoon green manure crops and N levels in rice-sunflower sequence

The uptake of nitrogen by sunhemp was higher (193.74 kg per ha) than S.rostrata (177.95 kg per ha). Possibly due to higher biomass production and N fixing potential of these crops. The biomass yield of sunhemp was greater (21.82 t per ha) than S.rostrata (19.01 t per ha). Several workers also contended greater accumulation of N in S.rostrata and sunhemp. This was revealed in the works of Khare and Rai (1968), Khind et al. (1982), Bharadwaj et al. (1981), Singh (1984) and Palaniappan (1990). On the other hand soybean recorded lowest accumulation of nitrogen. This was attributed to low biomass production

of soybean (Khare and Rai, 1968; Watanabe, 1984; Anon., 1986 and Chapman and Myers, 1987).

The available nitrogen status of soil after harvest of S. rostrata (mean of 285 kg per ha) was higher than fallow (mean of 236 kg per ha). While there was slight reduction in available N after harvest of sunhemp and soybean. The higher N content of sunhemp and S. rostrata did not deplete the available N status of the soil. Being legumes, they could fix atmospheric nitrogen through nodules. This was widely discussed by Dreyfus and Dommergues (1980 and 1981), Dreyfus et al. (1983), Rinaudo and Moudiongui (1987) and Rinaudo et al. (1988). The organic carbon content of soil was higher after harvest of green manure crops, while it was least after maize. This may be due to addition of residues during the growth of green manures. Greater uptake of nitrogen by rice was observed with the residual effect of S. rostrata green manuring (mean of 173 kg per ha) followed by sunhemp green manuring and the lowest with the residual effect of maize. The interaction effects of rice with S. rostrata green manuring in conjunction with 100 kg N per ha in the uptake of nitrogen was higher (mean of 185 kg N per ha) than sunhemp green manuring. The lowest N uptake by rice was observed on residual effect of maize crop. It was obvious that maximum N removal of rice was due to higher biomass production (mean of 10.76 t per ha)

compared to maize-rice (7.57 t per ha). These findings were in support of the work of Beri and Meelu (1981), Meelu and Rekhi (1981), Rinaudo et al. (1983), Mahapatra et al. (1987), Biswas (1988) and Ravindra et al. (1989). Lower removal of N by rice due to residual effect of maize in conjunction with 50 kg N per ha was linked with low fertility status of the soil as evidenced by low organic carbon contents (0.95 per cent) and also depletion of available N of the soil. The work of Purushothaman (1979) testified the adverse effect of sorghum or maize on rice crop. De et al. (1983) emphasised the efficacy of leguminous crops over fodder maize.

The soil organic carbon content and available N status were higher after harvest of rice grown on green manured soils with S. rostrata (0.96 per cent and 242 kg per ha). But it was lower after harvest of rice in maize-rice sequence (0.85 per cent organic carbon and 220 kg available N per ha). However the differences in available N status immediately after harvest of rice were marginal. It is quite obvious due to the prevalence of submergence in rice culture, where in mineralisation of organic matter was slower. This may probably be due to spurt in the bacterial population immediately after harvest of rice. As a result the available N in the soil was immobilized by micro-organisms. So there were no large differences in available N content of the soil even in

green manured plots. But there was a significant improvement in organic carbon content of the soil possibly due to slow mineralization of the added organic matter through green manuring.

Nitrogen uptake of rice with the addition of 100 kg N per ha was higher. Perhaps this was due to enhancement in the mineralisation and adequate supply of N resulted in better growth through higher biomass production of rice (mean of 9.62 t per ha).

Sunflower removed maximum N with the residual fertility of S.rostrata (mean of 51.3 kg per ha) followed by the residual fertility status of sunhemp (44.6 kg per ha) and least with the residual effect of maize (26.8 kg per ha) followed by fallow-rice-sunflower (29.6 kg per ha). This was due to highest biomass yield of sunflower in S.rostrata-rice-sunflower (mean of 2.37 t per ha) followed by sunhemp-rice-sunflower (mean of 2.21 t per ha), while the least biomass yield was recorded with maize-rice-sunflower (mean of 1.43 t per ha).

The organic carbon content of the soil after harvest of sunflower crop in S.rostrata-rice-sunflower sequence improved markedly. The next superior treatment was sunhemp-rice-sunflower. While the organic carbon content of the soil diminished after maize-rice-sunflower sequence. In the

The uptake of phosphorus and potassium was greater by sunhemp and S.rostrata respectively. The initial P_2O_5 and K_2O status of the soil was adequate (56 and 218 kg per ha respectively). The leguminous crops have greater ability to mobilise to cause greater uptake, the consequence of which was reflected on the succeeding crop. The biomass yield of sunhemp and S.rostrata was higher than other crops. Hence there was greater uptake of P and K. This trend was in consonance with those reported by Gu and Wen (1981) and Singh (1984). Higher K removal of S.rostrata was due to high K per cent of S.rostrata (Appendix 7) next to fodder maize. Gu and Wen (1981) reported that the legumes have the ability to absorb inaccessible K in the soil.

The plant available phosphorus in soil was maximum (56 kg per ha) after fallow treatment as there was no P_2O_5 depletion from soil, while it was lowest after harvest of maize (22 kg per ha). Even though the removal of P was higher by sunhemp followed by S.rostrata the soil available P_2O_5 was not depleted heavily. It may be due to addition of leaves and organic residues during the growth of green manures which upon decomposition released organic acids which might have brought fixed P into available form. The available K_2O of the soil was highest after soybean harvest (mean of 214 kg per ha) and was least after S.rostrata (mean of 156 kg per ha) followed

by maize (mean of 160 kg per ha) and maize + S.rostrata . This suggests the greater ability of sole crop of S.rostrata and intercropped S.rostrata for higher K uptake.

Rice green manured with S.rostrata removed maximum P and K while in maize-rice system, it was lowest. With the application of 100 kg N per ha, P and K removal by rice increased by 11 and 27 kg per ha respectively. Green manuring S.rostrata in conjunction with 100 kg N per ha registered highest uptake of P and K (62 and 130 kg per ha respectively), while lowest was with maize-rice in conjunction with 50 kg N per ha. S.rostrata being a green manure crop with high biomass production could able to have greater uptake of P and K by rice. The lowest total biomass was noticed with maize-rice. Similarly the higher biomass yield of rice fertilised with 100 kg fertilizer N per ha was responsible for more P_2O_5 and K_2O removal. The biomass production of rice grown on residual fertility status of S.rostrata green manuring did not differ significantly with the one grown by additional application of 100 kg N per ha.

There was build up of phosphorus in soil after S.rostrata rice (62 kg per ha), while it was inconspicuous after maize-rice (49 kg per ha). Such trend was reported by Subbiah and Manikar (1964). Lowest uptake of P by rice as well as low

Phosphorus and potassium removal of sunflower was higher in S.rostrata-rice-sunflower sequence followed by sunhemp-rice-sunflower, while it was least in case of maize-rice-sunflower. Greater production of biomass is responsible for such trend with sunflower.

Status of available phosphorus and potash increased substantially after harvest of S.rostrata-rice-sunflower followed by sunhemp-rice-sunflower on the other hand maize-rice-sunflower sequence marginally improved the available P_2O_5 and K_2O in the soil. Gu and Wen (1981), Singh et al. (1981), Singh (1984) also reported increase in available P_2O_5 due to green manuring. Similar findings were reported by Nagarajiah et al. (1989) and Swarup (1987). Over the seasons, practice of green manuring caused to improve the organic carbon and available NPK status of soil. Similar results were obtained by Sharma and Mittra (1988).

5.4 Experiment 2

Effect of sources of nitrogen and levels of nitrogen on the growth, yield, economics and soil fertility status of rice-sunflower sequence

5.4.1 Sources of nitrogen on the growth and yield of rice

The application of 100 kg N per ha through USG caused to maximise the grain and straw yields of rice followed by green leaf manure applied at 10 t per ha with 75 kg

fertilizer N per ha as urea. The lowest grain and straw yields were recorded with treatment of 100 kg N per ha through URP (Fig.4.6). The findings are in consonance of Anon.(1984a), Rao (1984), Singh and Prasad (1985). This was further reiterated by Padalia and Manna (1986), Sharma and Subbaiah (1986), Singh and Sangliena (1987), Sharma and Roy (1988). In the experiments of AICARP at different centres rice yields were superior with USG. The enhancement of rice yields with USG may be attributed to the better growth of rice resulted in improvement in yield parameters. The crop stand of rice as influenced by green leaf manures and 75 kg N per ha as urea, 100 kg N per ha as USG and 100 kg N per ha as urea is depicted in Plates 16, 17 and 18. It was observed that the total dry weight per hill was significantly higher at 30 and 60 DAP of rice over other treatments. But at 90 DAP and at harvest of rice, the dry weight per hill was statistically non significant among the treatments tested. The distribution of drymatter in different plant parts i.e. in leaves, stem at 30 and 60 DAP and in panicle and shoot at harvest was higher in USG treatment followed by green leaf manuring. This may possibly be due to continuous supply of NH_4^+ form of N due to placement of USG in the reduced zone. Perhaps there was also less loss of nitrogen. Rao (1984), Singh and Sangliena (1987) also reported that the flood water contained less concentration of N. Rice yields recorded by the application of green leaf manure at 10 t per ha + 75 kg N as urea ranked second in the order. The superiority

of this treatment was associated with continuous release of nutrients through mineralization of organic matter supplied as green manures. In addition, green manures added with 75 kg N per ha through urea ensured the adequate supply of nitrogen to crop. This was sufficient to meet till the nutrients are released by green manures through mineralisation process by host of microorganisms. This trend was reflected in the works of Singh (1971), Reddi et al. (1972), Williams et al. (1972), Lin (1975), Majumdar and Chakraborty (1977), Soundarpandian and Laxminarayanan (1986) and Ishikawa (1988).

Leaf area index was maximum with 100 kg N per ha through USG followed by green leaf manuring at 30, 60 and 90 DAP. The superiority of LAI was due to enlargement of leaf area per hill. Larger leaf area was associated with more number of tillers and leaves per hill. The significance of LAI is an index of higher photosynthetic activity resulted through the efficient utilisation of solar radiation for photosynthesis. As a consequence the drymatter production per hill was higher with USG followed by green leaf manuring for rice.

The significant increase in growth parameters favourably reflected on the yield parameters and concomitantly on yield. Number of panicles per hill, number of filled grains per panicle and panicle length were significantly higher with

100 kg N per ha through USG followed by green leaf manuring (Fig.4.5). Sharma et al. (1985), Sharma and Roy (1988) reported more number of panicles per hill, spikelets per panicle with the use of USG as N source for rice. Reddi et al. (1972) also attributed to improvements in yield parameters of rice due to glyricidia green leaf manuring. The number of unfilled rice grain was quite lower with the use of USG followed by green leaf manuring. Conversely there was better filling of grains due to adequate supply of photosynthates by the source. The straw yield also increased with the use of USG followed by green leaf manuring. The enhancement in straw yield was related to higher drymatter production per plant through higher plant height and more number of tillers per hill.

5.4.2 Growth and yield of sunflower as influenced by the residual fertility status of rice with nitrogen levels

Seed and straw yields of sunflower resulted from the residual effect of green leaf manuring was significantly higher followed by the residual effect of USG. There was a perceptible increase in seed yield of sunflower by 184 kg over the residual effect of urea alone (Fig.4.8). The significance of green manuring to crop lies in its efficacy in causing greater residual effects on succeeding crop owing to its slow release of nutrients through mineralisation processes and it is far superior to

inorganic fertilizers. Further its influence was reflected on more drymatter production per plant. The residual effect of green leaf manuring for rice improved the yields of succeeding wheat crop (Anon., 1990b and 1991b). Morris et al. (1989), Diekmann et al. (1991) observed the residual effect of green manuring on the second crop of rice. The findings are in conformity with those of Nair and Singh (1971), Mahapatra et al. (1974), Mangal Prasad and Rajendraprasad (1980), Sharma and Roy (1988). The reason for more dry weight per plant obtained from residual effects of green manure was due to more plant height and LAI (0.66). Duraiswamy and Palaniappan (1988) reported increase in plant height, LAI and drymatter of rice in rice-rice sequence. The distribution of dry weight both in leaves and stem at 50 DAS coinciding with flowerbud formation stage was also maximum. Which was linked with organic carbon content and available N status of the soil, also increased with green leaf manuring. At harvest the dry weight per head increased substantially with the residual effect of green leaf manuring. Enhancement in the uptake of nutrients and translocation of photosynthates to the head resulted in large sized heads per plant. But the treatment differences were statistically non significant.

The growth of sunflower crop under residual fertility of green leaf manure at 10 t per ha + 75 kg N per ha through

urea and 100 kg N per ha through urea alone are depicted in Plates 19 and 20. Improvements in the growth parameters of sunflower showed positive influence on the yield characters and finally on yield. Improvement on the size of the head, 1000 seed weight, number of filled seeds per head, per cent filled seeds as well as seed weight per head were prime parameters accrued to residual fertility of green leaf manuring followed by the residual fertility of USG (Fig.4.7). Large sized heads caused to form more number of seeds as indicated by the more number of filled seeds per head and per cent filled seeds per head with the residual fertility of green leaf manuring. The seed weight per head was also higher in this treatment. This might be attributed to better filled seeds. The cumulative effect of these factors was favourably reflected on the seed yields.

Seed and straw yields of sunflower were significantly superior by the addition of N at 31 kg per ha over no fertilizer N for sunflower. The growth of sunflower as indicated by the dry weight per plant and its distribution in leaves and stem at 50 DAS, and at harvest in heads and shoot was significantly higher compared to no fertilizer N. Similarly the LAI was also superior. The increase in LAI was 0.17 over no fertilizer N. As stated earlier increase in LAI helped in efficient utilisation of solar radiation which enhanced the photosynthesising surface.

Yield parameters such as diameter of the disc, number of filled seeds per head, per cent filled seeds and seed weight per head were higher with the additional use of 31 kg fertilizer N for sunflower. This promoted the growth and yield parameters for higher seed yield of sunflower.

Seed yield of sunflower with the residual effect of green leaf manuring at 10 t per ha + 75 kg N per ha through urea in conjunction with 31 kg N per ha was maximum.

Interaction effects of total dry weight at harvest and drymatter of stem at 50 DAS differed significantly. The superiority of growth as indicated by the dry weight per plant at harvest with the residual effect of green leaf manuring in conjunction with 31 kg N per ha for sunflower improved the yield parameters viz., number of filled seeds and per cent filled seeds. Similar trend of lesser magnitude was observed with the residual fertility status of 100 kg N per ha as USG in conjunction with 31 kg N per ha for sunflower. However the treatment differences were statistically non significant.

Oil yield of sunflower was largely influenced by the residual fertility status of rice and applied N levels as depicted in Fig.4.8. The highest oil yield of sunflower was recorded with the residual fertility status of green leaf manuring followed by residual fertility status of USG. The

interaction of the residual effect of green leaf manuring in conjunction with 31 kg N per ha for sunflower gave the highest oil yield of 364 kg per ha which was on par with the residual effect of USG with 31 kg fertilizer N for sunflower. The increase in oil yield was ascribed to increase in seed yield per ha with the residual effect of green leaf manuring as well as with USG. With the addition of N to sunflower, there was an increase in oil per cent and also in seed yield. Hence there was increase in oil yield with the addition of fertilizer N at 31 kg per ha for sunflower. The interaction effect of residual fertility status of green manure and sources of nitrogen on the oil yield differed significantly and it was mainly attributed to seed yield differences resulting from different treatments. However, there was no statistically significant differences in the oil per cent due to interaction of residual fertility status resulted from green manure and different sources of N on sunflower.

5.4.3 Total biomass production of rice and sunflower as influenced by the sources and levels of N

Total biomass of rice-sunflower sequence with 100 kg N as USG was highest. This was mainly due to higher biomass production of rice. But the biomass yield of succeeding sunflower crop ranked second among the treatments. However the biomass yield of rice alone contributed substantially in

enhancing the total biomass yield of the system as a whole. Green leaf manuring at 10 t per ha + 75 kg N per ha as urea ranked second in respect of total biomass production of the sequence. Although the biomass yield of the succeeding sunflower crop was maximum its contribution to raise the total biomass of the sequence was least.

Addition of 31 kg N per ha for sunflower improved the total biomass yield of the sequence possibly due to adequate supply of nitrogen to sunflower. In regard to interaction effects, the residual effect of 100 kg N per ha through USG was marked in producing the maximum total biomass yield when applied with 31 kg fertilizer N per ha while, the lowest value was recorded with residual effects of 100 kg N per ha through URP. where in no fertilizer N was supplied to sunflower. The second highest yield of total biomass was recorded with green leaf manuring of rice crop and with 31 kg N per ha for sunflower. The highest biomass yield of the sequence of rice-sunflower was due to more biomass yield of rice crop alone in the rice crop fertilized with 100 kg N as USG and sunflower with 31 kg N per ha. The differences in total biomass production of rice and sunflower among the treatments were statistically significant. However, the contribution of biomass yield of rice was not only substantial but also major one in producing larger differences.

5.4.4 Economics of the rice-sunflower sequence as influenced by the sources and levels of N

The gross income of rice-sunflower system was highest with green leaf manuring at 10 t per ha + 75 kg N per ha as urea (Fig.4.10). This was mainly due to higher productivity of sunflower which fetched higher price. But in terms of net income and benefit-cost ratio, the treatment with 100 kg N per ha as USG was higher and viable. This might be due to higher cost of green manure as well as its application compared to USG as nitrogen sources. An additional cost of Rs. 531 per ha was incurred for green manuring. But the differences in gross income accrued by application of green leaf manuring with 75 kg fertilizer N per ha increased marginally over USG and the additional income generated could not widen the benefit-cost ratio of the system. The economic value resulted due to increase in rice yield was Rs.725 per ha while with sunflower, it was Rs.891 per ha. Hence the cost of green leaf manure alone including cutting, transportation and incorporation to the field costed more leading to lower benefit-cost ratio in the system. Supply of fertilizer N to sunflower crop increased the gross and net income. But it failed to widen the benefit-cost ratio of the system.

Interaction of the residual effect of treatments for kharif rice and levels of N for sunflower on gross income

was higher with green leaf manuring of rice in conjunction with 31 kg N per ha for sunflower (Rs.26285 per ha). Because of the higher cost of cultivation (Appendix-3), the benefit-cost ratio was lower (2.43) than 100 kg N per ha applied as USG for rice previously and 31 kg N per ha applied later to sunflower crop (2.52). But USG applied to previous crop of rice and 31 kg N per ha for sunflower ranked second in respect of gross income (Rs.25900 per ha) while the net income was maximum (Rs.15617 per ha). It was obvious for its low cost of application. Kulhare (1991) also reported higher returns with USG than 150 to 200 kg conventional urea. The results of the present study reiterated the findings cited above.

5.4.5 NPK uptake by crops and changes brought about in soil fertility as influenced by the sources and levels of N in rice-sunflower sequence

The NPK uptake of rice was maximum with 100 kg N per ha as USG. The mean NPK removal was 223, 66 and 144 kg per ha respectively. This was followed by green leaf manuring in respect of N and K and 100 kg N as GCU in respect of P uptake. The available status of NPK was maximum after green leaf manuring for rice at the rate of 10 t per ha + 75 kg N as urea. The NPK uptake of rice with USG as sources of N was greater because of higher biomass production. This was due to better growth of rice crop as discussed earlier

The maximum amount of NPK removal by sunflower might be a contributory factor to produce more biomass yield of sunflower due to better growth. Residual effect of green manures on the succeeding crops was also reported by several workers (Chakravorty et al., 1988; Bouldin, 1988; Morris et al., 1989; Mahapatra and Sharma, 1989; Mahapatra and Pradan, 1990; Anon., 1990b and 1991b, Diekmann et al., 1991).

5.5 Future line of work

1. There is need to study the possibility of growing short duration pulses or vegetables under residual fertility of kharif rice with minimal fertilizer application.
2. There is need to findout level of fertilizer NPK required to produce both optimum and maximum yield of rice in relation to the actual quantity of green manure turned into the soil.
3. There is need to study the change in physical characters of the soil due to incorporation of green manures.
4. There is need to study the effect of green manures and cropping system on the long term soil fertility.

SUMMARY

VI. SUMMARY

In an effort to fit in the appropriate sequence of crops in rice based system, two field experiments were conducted in the University Farm at Main Research Station, Hebbal during 1989-90 and 1990-91. The first field experiment mainly consisted of raising crops like maize for fodder, soybean, S.rostrata and sunhemp for green manure purpose in sole and inter cropping system as premonsoon crops intended to utilize them as manure for better stand of rice crop. It also included studies on contribution of nitrogen of these crops to rice and subsequent residual effects on succeeding crop of sunflower. The second field experiment was carried out to study the direct and residual effects of different sources of fertilizer nitrogen in rice-sunflower sequence. The results of the studies are summarised as under;

- * Among the premonsoon crops tested, the total biomass of crop was in the following decreasing order: Sunhemp (21.82 t per ha) > S.rostrata (19.01 t per ha) > Maize (10.94 t per ha) > Soybean(4.34 t per ha).
- * Intercropping of these crops resulted in the biomass production in the following order; Maize + S.rostrata (11.44 t per ha) > Maize + Sunhemp (11.20 t per ha) > Maize + Soybean (9.06 t per ha).

- * The influence of incorporation of these green manures on the production of total biomass of rice was significant and the magnitude of enhancement in biomass was in the following order; S.rostrata (10.76 t per ha) > Sunhemp (10.34 t per ha) > Soybean (9.32 t per ha) as sole crops and in case of intercrops, maize + S.rostrata (9.14 t per ha) > Maize + Sunhemp (8.85 t per ha) > Maize + Soybean (8.36 t per ha).
- * The grain yield of rice was significantly improved due to applied green manures along with nitrogen at 50 and 100 kg N per ha. The maximum grain yield of rice (4465 kg per ha) which was recorded in S.rostrata was on par with sunhemp green manure (4363 kg per ha). Sesbania rostrata or sunhemp incorporation in conjunction with 50 kg fertilizer N gave higher yields over 100 kg N alone in maize-rice and fallow-rice treatments. Hence 50 kg fertilizer N per ha could be substituted by use of these green manures. The pattern of straw yield of rice followed similar trend as observed in grain yield.
- * The seed yield of sunflower obtained on residual fertility status after rice crop was also improved. It was quite significant with S.rostrata (783 kg per ha) and sunhemp (713 kg per ha). The residual effects of applied N at 100 kg per ha produced higher seed yield of sunflower over 50 kg N per ha.

over the premonsoon fallow, maize, soybean, and intercropped S.rostrata, sunhemp and soybean treatments.

- * Residual fertility status accrued by S.rostrata on total dry weight per plant, dry weight of stem, number of leaves, shoot of sunflower was superior to sunhemp. Similar residual effects of applied 100 kg N per ha on these parameters were observed.
- * The diameter of the head, number of filled seed per head, seed weight per head were also improved by the residual fertility status of S.rostrata. The interaction effect of S.rostrata with 50 kg N applied/ha was significant than at 100 kg N per ha alone.
- * The pattern of uptake of N and P by premonsoon crops grown was in the following order. Sunhemp > S.rostrata > Maize but uptake of K was higher with S.rostrata.
- * Incorporation of S.rostrata or sunhemp resulted in maximum NPK uptake by rice. Similarly, 100 kg fertilizer N per ha for rice removed maximum NPK by rice. The interaction effects of green manuring with fertilizer N produced similar trend in removal of NPK as that of grain and straw yields.
- * Similar trend was exhibited by succeeding crop of sunflower in the uptake of NPK. The significant feature of NPK uptake by sunflower was manifested by the application of N at 50 kg per ha for rice in respect of soybean, S.rostrata and sunhemp green manures rather than at 100 kg fertilizer N alone

- * The response of rice to different sources of N at 100 kg per ha revealed the superiority of USG over 75 kg N per ha along with 10 t green leaf manure per ha and least with 100 kg N as URP in respect of biomass production (12.34 t per ha) and grain yield of rice (4882 kg per ha). Similar trend was observed in straw yield of rice.
- * The different sources of nitrogen applied to rice produced differential response. The excellent performance of USG in enhancing total drymatter, drymatter of leaves, stems and LAI over 75 kg fertiliser N with 10 t green manure per ha was observed. But the trend was reverse with the number of tillers.
- * Yield parameters of rice was remarkably improved by the application of 100 kg N per ha through USG over 75 kg fertiliser N along with 10 t per ha green manure.
- * USG at 100 kg N per ha was a superior source for the uptake of NPK by rice.
- * The residual effects of USG at 100 kg N and 75 kg fertiliser N with 10 t green leaf manure per ha coupled with zero and 31 kg N per ha applied to sunflower were significant in improving sunflower yields. The biomass and seed yield of sunflower were remarkably enhanced by the treatment of 75 kg fertilizer N with 10 t green manure per ha over

100 kg N per ha through USG with and without addition of nitrogen to sunflower crop. Similar significant trend was also noticed in oil yield.

- * The total dry weight and drymatter per plant of sunflower were improved by residual fertility status of 75 kg N per ha with 10 t green manure per ha. Dry weight of leaves, stems and total drymatter accumulation in plants were also enhanced. The impact of 31 kg N per ha applied to the sunflower over the residual fertility status accrued by 75 kg fertilizer N and 10 t per ha green leaf manure was significant.
- * Sunflower crop produced larger sized heads, more number of filled seeds, maximum seed weight per head, 1000-seed weight due to residual fertility status of 75 kg fertiliser N with 10 t green manure per ha. These yield parameters were further improved when incorporated with 31 kg fertilizer N per ha to sunflower crop.
- * Uptake of NPK by sunflower was enhanced by residual fertility of 75 kg N per ha with 10 t green manure per ha. It was further stepped up by the addition of 31 kg fertilizer N per ha to sunflower crop.
- * The fertility status of soils of experimental site was depleted by raising premonsoon crops without additions of any fertilizers. Subsequent upon their incorporation to

soils as source of green manure along with fertilizer nitrogen improved the fertility status of soils in respect of organic carbon, and available N, P_2O_5 and K_2O . There was buildup of available status of P_2O_5 and K_2O and organic carbon in soils after harvest of sunflower.

- * As regards different sources of nitrogen to rice crop, there was slight depletion in organic carbon and available N status in soil but concomittent increase in available P_2O_5 and K_2O in treatment of 75 kg fertilizer N with 10 t green manure per ha. Buildup of P_2O_5 and K_2O was quite evident after harvest of sunflower crop as they were uniformly applied.
- * The gross and net income and benefit-cost ratio were spectacular with S.rostrata-rice-sunflower sequence (Rs.20152, 9568 and 1.90 respectively). Interaction of S.rostrata green manure and 50 kg N level produced superior gross and net income (19407 and 8993 per ha) compared to 100 kg fertilizer N in maize-rice, soybean-rice, maize + sunhemp-rice, maize + S.rostrata-rice, maize + soybean-rice and fallow-rice sequences.
- * There was larger benefit (Rs.15472 per ha) in rice-sunflower sequence of crop by the application of 100 kg N per ha through USG eventhough the treatment 75 kg N per ha with 10 t per ha green leaf manure recorded maximum gross income. It was primarily due to high cost of handling of green manures.

Practical application of the study

1. The two years results have vividly indicated that green manure crop of S.rostrata or sunhemp could be grown successfully as premonsoon crops in tank irrigated areas.
2. Incorporation of S.rostrata or sunhemp would contribute enough nitrogen for the rice crop. Fifty per cent of the fertilizer N could be saved without causing any reduction in rice yield.
3. In situations where in situ green manuring is not possible, farmers could use USG as an efficient N source or may follow integrated N management using green leaf manuring at 10 t per ha with 75 kg N as urea in rice-sunflower sequence.
4. Sesbania rostrata and sunhemp leave enough residual fertility after kharif rice as indicated by the performance of succeeding sunflower crop. Hence there is possibility for taking a short duration oilseed/pulse crop under residual soil fertility status of kharif rice green manured by S.rostrata or sunhemp.

REFERENCES

VII. REFERENCES

- ALAZARD, D. and BECKER, M., 1987, Aeschynomene as a green manure for rice. Plant and Soil, 101(1): 141-143.
- ANONYMOUS, 1978, Cropping systems programme-testing of cropping patterns, Pangasinan tests. IRRI Annual Report for 1978, Philippines, 350-365.
- ANONYMOUS, 1979, Annual Research Communication Report, Agron. and Soil Sci., Konkan Krishi Vidya Peeth, Dapoli, Maharashtra.
- ANONYMOUS, 1980, CRI Annual Report for 1980, CRI, Cuttack, Orissa, p.55.
- ANONYMOUS, 1982, IRRI Research Highlights for 1981. IRRI, Philippines, p.114-115.
- ANONYMOUS, 1983a, AICARP Annual Report for 1981-82. ICAR, New Delhi.
- ANONYMOUS, 1983b, CRI Annual Report for 1983. CRI, Cuttack, p. 101-102.
- ANONYMOUS, 1984a, AICRP Research Highlights for 1984, Directorate of Rice Research, Hyderabad-500030, p.18-20.
- ANONYMOUS, 1984b, IRRI Annual Report for 1983, IRRI, Philippines, p.407-415.
- ANONYMOUS, 1984c, IRRI Annual Report for 1984, IRRI, Philippines, p.419.

- ANONYMOUS, 1985-86, Mahatma Phule Agril. Univ. Annual Report for 1985-86, Mahatmaphule Agril.Univ., Rahuri Dist., Ahmednagar, p.41.
- ANONYMOUS, 1985, AICARP Annual Report for 1983-84, ICAR, New Delhi and UAS Bangalore, India, pp.122-133 and 232-281.
- ANONYMOUS, 1986a, AICARP Annual Report for 1984-85, ICAR, New Delhi and UAS Bangalore, India, pp. 125-139 and 221-268.
- ANONYMOUS, 1986b, CRRI, Annual Report for 1986. ICAR, CRRI, Cuttack, p.87-126.
- ANONYMOUS, 1986c, DRR Research Highlights 1986, Directorate of Rice Research, Hyderabad, Andhra Pradesh.
- ANONYMOUS, 1986d, IRRI Highlights of 1985 Accomplishments and Challenges, IRRI, Philippines, p.44-58.
- ANONYMOUS, 1986e, IRRI Annual Report for 1985, IRRI Los Banos, Laguna, Philippines, p.403-408.
- ANONYMOUS, 1987a, AICARP Annual Report for 1985-86, ICAR and UAS, Bangalore.
- ANONYMOUS, 1987b, IRRI Annual Report for 1986, Los Banos, Philippines, p.345-364.
- ANONYMOUS, 1987c, Proceedings of the 7th Annual workshop held from Dec. 29, 1986 to Jan. 2, 1987 of AICARP, ICAR, p.34-38.

- ANONYMOUS, 1989, Agricultural Situation in India, Directorate of Economics and Statistics, Dept. of Agricultural and Cooperation, Ministry of Agriculture, Govt. of India, Vol. XLIV (9).
- ANONYMOUS, 1990a, AICARP Annual Report for 1986-87, AICARP, ICAR, Directorate of cropping system research, Modipuram, Meerut, India.
- ANONYMOUS, 1990b, AICARP Annual Report for 1987-88, ICAR, Directorate of cropping system research, Modipuram, Meerut, India.
- ANONYMOUS, 1991a, Agricultural Situation in India, Directorate of Economics and Statistics, Department of Agricultural and Cooperation, Ministry of Agriculture, Govt. of India, Vol. XLV(10).
- ANONYMOUS, 1991b, AICARP Annual Report for 1988-89, ICAR, Directorate for cropping system research, Modipuram, Meerut, India.
- ANTIL, R.S., SINGH, D., KUMAR, V. and SINGH, M., 1988, Effect of different preceeding crops on yield and nitrogen uptake by rice. Indian J. Agron., 33(4): 380-384.
- * AOAC, 1975, Methods of Analysis, Benjamin Fronklin Station, Washington DC.
- ARUNIN, S., DISSATAPORN, C., ANULUXTIPAN, Y. and NANA, D., 1988, In "Green manure in Rice Farming", IRRI, Los Banos, Laguna, Philippines, pp. 83-95.

- * ARWOOTH NALAMPANG, 1978, Varietal screening for development of cropping systems preceeding and following rainfed low land rice in Thailand. Report of the VII Cropping System Working group sponsered by the IRRI held during Oct. 1978 at Los Banos, Laguna, Philippines, p.48-51.

- BALACHANDRAN,G.K., SASIDHAR,V.K. and SHANTHAKUMARI,G., 1977, Production potential and economics of seven rice-based crop rotations. Agric. Res.J. Kerala, 17: 113-115.

- * BANTILAN,R.T., BANTILAN,C.C. and GARRITY,D.P., 1989, Indigofera tinctoria(L.) as a green manure in rainfed rice-based cropping systems "Saturday seminar paper, 1st July, IRRI, Los Banos, Laguna, Philippines.

- * BARLOW,C., JAYASURIYA,S. and PRICE,E.C., 1981, Farm level impact of new cropping systems a case study in Philippines,IRRI, Los Banos, Laguna, Philippines, pp. 43-45.

- * BELTRANE,R., DES,L.F. and TAYLOR,T.C., 1981, Soybeans - An option for increasing the potentiality of low land rice. Lavoura Arroreiva,32: 22-24.

- BERI,V. and MEELU,O.P., 1979, Effect of time of burrying of dhaincha, Sesbania aculeata on nitrogen economy in paddy. IRRI Newsl.,4(1): 22.

- BERI,V. and MEELU,O.P., 1981, Substitution of nitrogen through green manure in rice. Indian Fmg.,31(2): 3-4.

- BERI,V., MEELU,O.P. and KHIND,C.S., 1989, Biomass production, N accumulation, symbiotic effectiveness and minerali- zation of green manures in relation to yield of Wetland rice. Trop. Agric. (Trinidad), 66: 11-16.

- BHARADWAJ, K.K.R., 1982, Effect of the age and decomposition period of dhaincha on the yield of rice. Indian J. Agron., 27(3): 284-285.
- BHARADWAJ, S.P., PRASAD, S.N. and SINGH, G., 1981, Economizing 'N' by green manures in rice-wheat rotation. Indian J. agric. Sci., 51(2): 86-90.
- * BHATTI, H.M., YASIN, M. and RASHID, M., 1985, In "Nitrogen and the Environment" (N.Malik, ed.) pp. 275-284. NIAB, Faizalaba Pakistan.
- BIN, J., 1983, Utilization of green manure for raising soil fertility in China. Soil Sci., 135: 65-69.
- * BISWAS, T.K., 1988, Ph.D Thesis, Indian Agricultural Research Institute, New Delhi.
- BOULDIN, D.R., 1988, In "Green manure in rice-farming" IRRI, Los Banos, Laguna, Philippines, pp. 151-163.
- BREDERO, T.J., 1973, Green manuring and N and P supply of swamp rice. Nigerian Agric. J., 10(2): 248-257.
- * CAMARA, I. and DIARA, H., 1986, Paper presented at the IFS-CRDI-ORSTOM Workshop Biological Improvement of soil fertility 15-19, March, Dakar.
- * CARANGAL, V.R., TENGGU, P.L., MIAH, N.I. and TOPALINGARM, A., 1988, "Proceedings of the crop-Animal Systems Research Workshop, 15-19 August" pp. 435-451, Serdang, Malaysia.

CHESNIN, L. and YEIN, C.M., 1950, Turbidometric determination of available sulphur, Proc. Soil Sci. Soc. Am., 15: 149-150.

DEBNATH, N.C. and HAJRA, J.N., 1972, Transformation of organic matter in soil in relation to mineralization of carbon and nutrient availability. J. Indian Soc. Soil Sci., 20: 95-102.

*De DATTA, S.K., 1978, Fertilizer management for efficient use in wetland rice soils. IRRI Soils and Rice, Los Banos, Philippines, p.671-701.

De DATTA, S.K., 1981, Principles and practices of rice production. A Willey - Inter Science Publication.

De, R., YOGESWARA RAO, Y. and ALI, W., 1983, Grain and fodder legumes as preceeding crops affecting the yield and N economy of rice. J. agric. Sci. Camb., 101: 463-466.

DEV, G., BRAR, J.S. and DHILLON, N.S., 1978, Fertilizer requirements for different yield target of paddy based on soil test values in tropical and brown soils. Fert. News, 23(11): 35.

*DIACK, M., 1986, Paper presented at the IFS-CRDI-ORSTOM Workshop on Biological improvement of soil fertility, March 15-16 Dekar.

*DIEKMANN, K.H., De DATTA, S.K. and OTTOW, J.C.G., 1991, Plant and Soil (under publication).

GHAI, S.K., RAO, D.L.N. and BATRA, F., 1988, Nitrogen contribution to wetland rice by green manuring with *Sesbania* spp. in an alkaline soil. Biol. Fertl. Soils, 6(1): 22-25.

GHOSH, A.B., BAJAJ, J.C., REHANUL HASAN, and DHYAN SINGH, 1983, Soil and water testing methods - A laboratory Manual, Soil testing laboratory, Div. of Soil Sci. and Agric. Chem. IARI, New Delhi.

GOMEZ, A.A. and ZANDSTRA, H.G., 1982, Research strategy for rice based cropping system in Rice Research Strategies for the future, IRRI, Los Banos, Laguna, Philippines, p. 381-393.

* GUO, Z.Q., 1982, Study on the development of a soybean-rice cultivation system, Chinese Oil Crops, No.1: 22-25.

* GU, R., and WEN, Q., 1981, In "Paddy Soils", Science Press, Beijing, pp. 207-219.

HAMID, A., ZANDSTRA, H.G. and PAULSEN, G.M., 1981, Growth of dry seeded wetland rice as affected by preceeding crops and nitrogen fertilizer 73rd Annual Meeting of Am. Soc. Agron., Agron. Abstracts.

* HERRERA, W.T., VEJPAS, C., GARRITY, D.P., SOMPASEW, V., and THONGPAN N., 1989, Paper presented at the IRRI Saturday Seminar, April 15, IRRI, Philippines.

HUKKERI, S.B., KULKARNI, K.R. and SHARMA, O.P., 1978, Production potential of food grain crops grown in intensive cropping sequences with adequate inputs. Agric. Situation in India, 33 : 289-291.

- ISHIKAWA,M., 1988, Green manure in rice farming, IRRI, Los Banos, Laguna, Philippines, pp.45-64.
- JACKSON,M.L., 1973, Soil Chemical Analysis, Prentice Hall of India, Pvt. Ltd., New Delhi.
- JAIN,T.C. and RAMASUBBA REDDY, G., 1981, Performance of different crops with residual moisture in vertisols. Indian J. agric. Sci., 51: 181-184.
- JAKHRO,A.A. and FAROQUE,G., 1982, Number of tillers, nitrogen concentration and grain yield of kharif rice crops as influenced by dubari crops and nitrogen level. IRRI Newsl., 7(6): 22-23.
- JHA,K.P., 1980, Intercropping of legumes with rice on uplands. CRRI Annual Report, 1980, Cuttack, pp. 83-85.
- JOSEPH,P.A., 1986, Daincha as an organic source of nutrients for rice. Agric. Res. J. Kerala, 24: 80-92.
- JOY,P.P., RAJARAM,K.P. and JAMES,K.I., 1986, A rice-grain legume cropping system. IRRI Newsl., 11(6): 33.
- KALIDURAI,M. and KANNAIYAN,S., 1990, Effect of Sesbania and Azolla on rice grain and straw yields. IRRI Newsl., 15(2): 26.
- * KATYAL,J.C., 1977, Soil Biol. Biochem., 9: 259-266.
- * KHAN,S.A., 1983, Growth and yield performance of Rabi crops under rainfed conditions following rice and jute at different topographical situations, Ph.D Thesis, BCKV, Kalyani.

- KHARE, N.K. and RAI, M.M., 1968, Effect of symbiotic fixation of N by leguminous crops. J. Indian Soc. Soil Sci., 16: 111-114.
- KHIND, C.S., MEELU, O.P. and BERI, V., 1982, Efficiency of green manure substituted for applied nitrogen in rice. IRRI Newsl., 7(2): 20.
- KHIND, C.S., MEELU, O.P. and BERI, V., 1983, Age of dhaincha, green matter and nitrogen economy in rice. IRRI Newsl., 8(2): 7.
- KHIND, C.S., JOSAN, A.S. and BERI, V., 1985, Nitrogen release from Sesbania green manure and effect of time of application on N fertilizer on lowland rice. IRRI Newsl., 10(4): 26-27.
- KOYAMA, T. and NIAMSRICHAND, N., 1973, Soil - plant nutrition studies in tropical rice. IV. The effect of different levels of nitrogenous fertilizer application on plant growth, grain yield, and nitrogen utilization by rice plants. Soil Sci. Plant Nutr., 19: 265-274.
- KULHARE, P.S., 1991, Study of optimum dose of nitrogen and comparative economics of levels and sources of nitrogen in rice. Curr. Res., 20(5): 95-97.
- KULKARNI, K.R., 1979, Cropping Systems Research under the AICARP, Report of the 8th Cropping systems working group meeting sponsored by the Dept. of Agric. and IRRI, Philippines, pp. 313-329.

MANDAL, B.K. and RAO, M.V., 1979, Studies on multiple cropping involving cotton and rice on medium land of coastal Orissa. Oryza, 16(2): 85-90.

MANGAL PRASAD and RAJENDRA PRASAD, 1980, Nitrogen management and its economics in rice-wheat rotation. Indian J. Agron., 25: 608-613.

MARTIN, W.E., SALISBERY, R.L., MARTIN, B., PETERSEN, R.T., 1971, Answering the riddle of poor safflower after rice banded phosphorus may be the solution. California agric., 25(9): 4-6.

MEELU, O.P., 1981, Integrated use of fertilizers and manures in cropping sequence. Indian Fmg., 31: 75.

MEELU, O.P. and MORRIS, R.A., 1984, Integrated management of plant nutrients in rice and rice based cropping systems. Fert. News, 29(12): 65-70.

MEELU, O.P., BERI, V., SHARMA, K.N., JALOTA, S.K. and SANDHU, B.S., 1979, Influence of paddy and corn in different rotations on wheat yield, nutrient removal and soil properties. Plant and Soil, 51: 51-77.

MEELU, O.P. and MORRIS, R.A., 1988, In "Sustainable Agriculture - Green manure in Rice Farming", IRRI, Los Banos, Laguna, Philippines, pp. 209-222.

MEELU, O.P. and REKHI, R.S., 1981, Fertilizer use in rice based cropping system in Northern India. Fert. News, 26: 16-22.

- MEELU, O.P. and REKHI, R.S., 1983, Substitution of N through green manuring mung straw in rice. Indian Fmg., Sept.83, p. 11-13.
- MEELU, O.P., FURROC, R.E., DIZON, M.A., MORRIS, R.A. and MARQUESES, E.P., 1985, Evaluation of different green manures on rice yield and soil fertility. Paper presented at the Annual convention of the crop Science Society of the Philippines, 8-10 May Central Luzon State Univ., Hurnoz, Nueva Ecija.
- * MEELU, O.P., REKHI, R.S., BRAR, J.S. and KATYAL, J.C., 1983, Proceedings of FAI-NR Seminar on fertilizer use efficiency Naya Nangal, India, p.47-59.
- * MELHUISH, F.J., MUIRHEAD, W.A. and HIGGINS, M.L., 1976, Current views on effects of cropping history on nutrient availability in irrigated soils. Paper presented at the Australian Soil Sci. Soc. Conf., May 1976, Wagg, p.4.
- MISRA, A., 1978, "Rice-based cropping systems in moderate to heavy rainfall areas having no irrigation Heavy rainfall areas". Proceedings of the National Symposium on increasing Rice yields in kharif organised by IRRI, Cuttack Feb. 8-11, 1978, ICAR, CRRI, Cuttack, p.334-336.
- MISRA, A. and MISRA, H.C., 1975, Effect of legumes on associated and subsequent crops. Indian J. Genetics, 35: 237-241.
- MOORTHY, B.T.S. and JHA, K.P., 1980, Economics of double cropping on rainfed uplands of coastal Orissa. Oryza, 17: 52-54.

- * MORRIS, R.A. and MEELU, O.P., 1985, In Wetland soils: Characterization, classification and utilization", pp 321-345. IRRI, Los Banos, Laguna, Philippines.
- * MORRIS, R.A., FUROC, R.E. and DIZON, M.A., 1984, The contribution of a short duration green manure crop to rice grain yield and N uptake. IRRI Saturday Seminar 19 May, IRRI Philippines.
- MORRIS, R.A., FUROC, R.E. and DIZON, M.A., 1936a, Rice responses to a short-duration green manure. I Grain yield. Agron. J., 78(3): 409-412.
- MORRIS, R.A., FUROC, R.E., RAJBHANDARI, N.K., MARQUESES, E.P. and DIZON, M.A., 1989, Rice responses to waterlog - Tolerant Green manures. Agron. J., 81 : 803-809.
- * NAGARAJIAH, S., 1988, In "Sustainable Agriculture - Green manure in Rice Farming", IRRI, Los Banos, Laguna, Philippines, pp. 193-208.
- NAGARAJIAH, S. and NIZAR, B.M., 1982, Trop. Agric. (Srilanka), 138: 69-80.
- NAGARAJIAH, S., NEUE, H.U., and ALBERTO, M.C.R., 1989, Effect of Sesbania, Azolla and rice straw incorporation on the kinetics of NH_4 , K, Fe, Mn, Zn and P in some flooded rice soils. Plant and Soil, 116: 37-48.
- NAIR, P.K.R., SINGH, A. and MODGAL, S.C., 1973, Maintenance of soil fertility under intensive multiple cropping in Northern India. Indian J. agric. Sci., 43(3):250-255.

- * PALANIAPPAN, SP., SIDDESWARAN, K., and REDDY, S.N., 1990, In "International Symposium on Natural Resources Management for a sustainable agriculture", p.220, New Delhi.
- PALANIAPPAN, SP., THIRUNAVUKKARASU, D.R. and SUBBAIAH, E., 1978, Studies on multiple cropping in Wetlands. Madras agric. J., 65: 230-232.
- PARIS, T.R. and PRICE, F.C., 1979, Report on the workshop on cropping systems Research in Asia, p.1-74.
- PATEL, C.S. and MISRA, G.N., 1979, Efficiency of different forms of urea in transplanted rice (Kharif). Annu. Report. for 1979, CRRI, Cuttack, Orissa, India, p.606.
- PATEL, E.B., 1979, Note on the performance of different winter crops after rainfed rice. Indian J. Agric. Sci., 49: 748-750.
- PATIL, C.B. and THAKRE, H.S., 1978, Comparative performance and economics of different Rabi crops after kharif paddy. Indian J. Agron., 23: 77-78.
- PATRA, S.S. and BARIK, T., 1988, Production potential and economics of rice-based relay cropping systems. IRRI Newsl., 13(6): 48.
- * PEREIRA, J.C., MASCARENHAS, H.A. and HIROCE, R., 1979, Bragantia, 38: 9.

- PETERSEN, R.T., SAILSBERY, R.L. and MARTIN, W.E., 1972, Poor grain sorghum production after rice improved by phosphorus banded near seed. California agric., 26(3): 5-6.
- * PILLAI, K.G., 1971, Studies on the productive efficiency of nitrogen for rice variety 'Jaya' at different levels and timings of nitrogen application under two systems of water management, Ph.D Thesis, I.A.R.I., New Delhi.
- PILLAI, K.G. and VAMADEVAN, V.K., 1978, Studies on irrigated nutrient system for rice. Fert. News, 23(8): 11-14.
- PIPER, C.S., 1966, Soil and Plant Analysis, Hans Publishers, Bombay.
- PRASAD, M. and RAO, M.V., 1976, Annual Report of CRRI, Cuttack, Orissa, India, p.117-118.
- PRASAD, M. and RAO, M.V., 1980, Multiple cropping on rainfed uplands with rice as main crop. Oryza, 17(3): 163-168.
- * PRASAD, R. and De DATTA, S.K., 1979, Increasing fertilizer nitrogen efficiency in wetland rice. Nitrogen and Rice, IRRI, Los Banos, Philippines.
- PRASAD, R. and PALANIAPPAN, S.P., 1987, Pulse crop residue as N source in rice based cropping system. IRRI, Newsl., 12: 31
- PRATAP REDDY, G., KRISHNAMURTHY, K. and PILLAI, K.G., 1981, Annual Report of CRRI, Cuttack, Orissa, India.
- * PURUSHOTHAMAN, S., 1979, Studies on rice-based multiple cropping systems, Ph.D Thesis, TNAU, Coimbatore, India.

RAJAGOPALAN and PANALISAMY, S., 1986, A suitable cropping system for Thambiraparanj region in Tamil Nadu. IRRI Newsl., 11(5): 43.

* RAJENDRA PRASAD, T.V.P., 1985, Management of Pulses in rice-based cropping systems, M.S. Thesis, TNAU, Coimbatore, India.

RANA, D.S., SINGH, H., SHARMA, K.N., and BHANDARI, A.L., 1988, Economy of fertilizer nitrogen through green manuring in rice (Oryza sativa). Indian J. Agric. Sci., 58: 848-849.

RANVIR SINGH, SINGH, B.P., KUMAR, B. and CHAND, D., 1988, Sesbania rostrata a promising source of biofertilizer. Seeds and Farms, 14(4): 9-10.

RAO, D.V.K., RAO, T.S. and MURTHY, P.K., 1961, Green manures as sources of N to rice grown in regurs of the Nizam sagar Project area. Indian Soc. Soil Sci., 9: 119-123.

RAO, M.V., 1979, Indian Cropping patterns for possible use in rainfed lowlands. In Rainfed lowland rice. IRRI, Los Banos, Philippines, pp. 275-283.

RAO, M.V., 1984, Production Technology for low lands with reference to fertilizer management, Paper presented at the seminar on rice productivity, IFFCO Ltd., 27th April, Puri, Orissa, India.

RAVINDRA, B., NAIDU, B.S., DEVI, T.G. and GOWDA, S.N.S., 1989, Sesbania rostrata - a lower cost source of N for rice. IRRI Newsl., 14(2): 29.

- * ROGER, P.A. and WATANABE, I., 1986a, In "Nitrogen Economy of flooded rice soils" (S.K. De Datta and W.H. Patrick, Jr. eds) Martinus Nijhoff, The Hague, pp. 39-77.
- ROGER, P.A. and WATANABE, I., 1986b, Technologies for utilizing biological nitrogen fixation in wetland rice, potentialities, current usage and limiting factors. Fert. Res., 9: 39-77.
- SADANANDAN, N. and MAHAPATRA, I.C., 1973a, Studies on multiple cropping - balance sheet of N in various cropping patterns. Indian J. Agron., 18: 323-327.
- SADANANDAN, N. and MAHAPATRA, I.C., 1973b, A study on the effect of multiple cropping on the phosphorus content of upland alluvial soils. Agric. Res. J. Kerala, 10: 165-168.
- SADANANDAN, N. and MAHAPATRA, I.C., 1974, Influence of multiple cropping on the water stable aggregates of upland Rice soils. Agric. Res. J. Kerala, 12: p.14-18.
- SADANANDAN, N. and MAHAPATRA, I.C., 1976, Study of the change in exchangeable potassium in soil due to multiple cropping in upland rice areas. Indian J. Agron., 21: 405-407.
- SAHU, B.N. and NAYAK, B.C., 1971, Soil fertility investigation under continuous application of ammonium sulphate alone and in combination with organic manure in Bhubaneswar long term fertility trial, pages 873-879 in Proceedings of an international symposium on soil fertility evaluation. Indian Society of Soil Science, New Delhi, India.

SAHU, P.N., PADHI, A.K. and HOTA, A.K., 1988, A rice-grain legume cropping system for South coastal Orissa, India. IRRI Newsl., 13(6): 46.

SALAM, M.A., HAMEED, S.M.S., SIVAPRASAD, P., TAJUDDIN, E. and THOMAS, Y., 1989, Performance of Sesbania rostrata in acid soils. IRRI Newsl., 14(4): 33-34.

SASIDHAR, V.K. and SADANANDAN, 1980, Comparative performance of rice in various multiple cropping patterns. Indian J. Agron., 25: 398-402.

SHARMA, A.R. and MITTRA, B.N., 1988, Effect of green manuring and mineral fertilizer on growth and yield of crops in rice-based cropping on acid lateritic soil. J. Agric. Sci. Camb., 110: 605-608.

SHARMA, R.P. and ROY, R.K., 1988, Effect of urea-based N sources in rice-wheat sequence. IRRI Newsl., 13(3): 28.

SHARMA, S.K. and SUBBAIAH, S.V., 1986, Annual Report for 1986, CRRI, Cuttack, Orissa, India, p.124.

SHARMA, S.K., SHARMA, C.M. and CHAKOR, I.S., 1988, Effect of industrial and organic wastes and Lantana incorporation on soil properties and yield of rice. Indian J. Agron., 33(2): 225-226.

SHARMA, S.K., SUBBAIAH, S.V. and TANIYAMA, T., 1985, Annual Report for 1985, CRRI, Cuttack, Orissa, India.

SHARMA, S.N. and PRASAD, P., 1980, Nutrient (NPK) removal in Rice-wheat rotation. Fertilizer News, 25(10): 34-36.

- SINGH, N.T., 1984, Green manures as sources of nutrients in rice production. In: Organic matter and rice, IRRI, Los Banos, Laguna, Philippines, pp. 217-227.
- SINGH, N.T., SINGH, R. and VIG, A.C., 1981a, Yield and water expense of cowpea, clusterbean and sesbania as summer green manures in semi-arid regions of Punjab. Indian J. Agric. Sci., 51: 417-421.
- SINGH, P.K., PANIGRAHI, B.C. and SATAPATHY, K.B., 1981b, Comparative efficiency of azolla, blue green algae and other organic manures in relation to N and P availability in a flooded rice soil. Plant and Soil, 62: 35-44.
- SINGH, S. and PRASAD, R., 1985, Studies on nitrification inhibitors DCD for increasing efficiency of N applied to rice. J. agric. Sci. Camb., 104: 425-428.
- SINGH, S., PRASAD, R. and ISHWARAN, 1984, New Nitrogen carriers for rice. Madras agric. J., 71(6): 371-374.
- SINGH, Y., SINGH, B., KHIND, C.S. and MEELU, O.P., 1986, Response of flooded rice to green manure. IRRI Newsl., 13(4): 23-24.
- SINGH, Y., SINGH, B., MASKINA, M.S. and KHIND, C.S., 1987, Applying nitrogen with Sesbania, IRRI Newsl., 12(3): 49.
- SOUNDARPANDIAN, A. and LAKSHMINARAYANAN, T., 1986, Response of rice varieties to sources of N under long term experimentation. Oryza, 23(2): 109-112.

- SREENIVASULU, K., 1980, Cropping pattern studies with rice and ragi as base crops followed by niger as a cash crop. Annu. Report 1980, CRRI, Cuttack, pp. 53-54.
- SUBBAIAH, E. and SREERANGASWAMY, S.R., 1978, A suitable multiple cropping for pondicherry region. Madras agric. J., 65: 477-480.
- SUBBAIAH, S.V. and SHARMA, S.K., 1988, Effect of modified urea on rice yield. IRRI Newsl., IRRI, Philippines, p.27-28.
- SUBBAIAH, S.V., PILLAI, K.G. and SINGH, R.P., 1983, Effect of complementary use of organic and inorganic sources of N on the growth, N-uptake and grain yield of rice variety 'Rasi'. Indian J. agric. Sci., 53: 325-329.
- SUBBARAYALU, N., 1980, Cropping system approach Proc. Symp. on Recent Trends on Farming System in India, HAU, Hissar.
- SUBBIAH, B.V. and ASIJA, G.L., 1956, A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci., 25: 259-60.
- SUBBIAH, B.V. and MANNIKAR, N.D., 1964, Selection of green manure crops for uptake of sub soil phosphorus studies with P_{32} . Indian J. Agric. Sci., 34: 21-27.
- SUNDARRAJ, N., NAGARAJU, S., VENKATARAMU, M.N. and JAGANNATH, M.K., 1972, Design and Analysis of Field Experiments, UAS, Bangalore, Misc. Series No.22.

- * SU, N.R., 1983, Country report, République of China, pages 99-111, In Recycling organic matter in Asia for fertilizer use. Asia productivity organisation, Tokyo, Japan.
- SWARUP, A., 1987, Effect of pre-submergence and green manuring (Sesbania aculeata) on nutrition and yield of wetland rice on a sodic soil. Biol. Fertl. Soils, 5(3):203-208.
- * TAKAHASHI, H., SASIPRAPA, V. and BANGALIANA, S., 1986, Effect of preceeding upland crop on the growth and yield of rice I. Effect of different upland crops, Tech. Bull., Tropical Agricultural Research Centre, Japan, No. 20, 130-136.
- * TANDON, H.L.S., 1978, Fertilizer use under different soil and cropping systems, Lecture for the 20th short course in soil testing held at I.A.R.I., New Delhi, on Nov. 1978.
- THIMMEGOWDA, S., 1985, Studies on soil fertility management and moisture utilization in rice-based cropping systems under tank irrigation, Ph.D Thesis, UAS, Bangalore.
- TIWARI, B.P. and BISEN, C.R., 1971, Green manuring of wheat with and without fertilizers. Indian J. of Agron., 16(1): 40-42.
- TIWARI, K.N., PATHAK, A.N. and TIWARI, S.P., 1980a, Fertilizer management in cropping system for increased efficiency. Fert. News., 25(3): 3-20.
- TIWARI, K.N., TIWARI, S.P. and PATHAK, A.N., 1980b, Studies on green manuring of rice in double cropping system in a partially reclaimed saline sodic soil. Indian J. Agron. 25 : 136-145.

- TYAGI, S.C., SHARMA, D.L. and NATHANI, C.P., 1982, Effect of different cropping patterns on the physical properties of medium black soils of Rajasthan. Curr. Agric., 6(3-4): 172-176.
- VELU, V., SARVANAN, A. and RAMANATHAN, K.M., 1987, Efficacy of different sources of nitrogen on lowland rice in Kullankar area of Cauvery Delta. Madras Agric. J., 74(10-11): 488-89.
- VENKATA RAO, B.V. and GOVINDARAJAN, S.V., 1960, Influence of green manures on phosphate utilization by crops. J. Indian Soc. Soil Sci., 8P 145.
- WATANABE, I., 1984, In "Organic matter and rice" pp. 229-234, IRRI, Los Banos, Laguna, Philippines.
- WATSON, D.J., 1952, The physiological basis of variation in yield. Adv. Agron., 4: 101-145.
- WILLET, I.R., MUIRHEAD, W.A. and HIGGINS, M.L., 1977, The effects of rice growing on soil phosphorus immobilization. Aust. J. Expt. agric. and Anim. Husb., 18(91): 270-275.
- WILLIAMS, W.A., MORSE, M.D. and RUCKMAN, J.E., 1972, Burning vs incorporation of rice crop residues. Agron. J., 64: 467-468.
- YADAHALLI, Y.H., JAYARAM, G., VISWANATH, S.R. and SHIVASHANKAR, G., 1975, Soybean, cowpea and blackgram can be grown with advantage after rice under tank irrigation. Curr. Res., 4 : 168-169.
- ZANDSTRA, H.G., 1980, Effects of soil moisture and texture on the growth of upland crops after wetland rice. Paper presented at the cropping systems conference, March, 3 to 8, 1980, IRRI, Philippines.

APPENDICES

APPENDIX-1

(a) Unit cost of inputs, labour etc. used for computing cost of cultivation

Details	Unit Price
<u>Seeds</u>	
Sunhemp (Rs/kg)	5.00
Soybean (Rs/kg)	8.00
<u>S.rostrata</u> (Rs/kg)	23.80
Fodder maize (Rs/kg)	6.60
Rice (Rs/ha)	5.20
Sunflower(Rs/ha)	23.80
<u>Fertilizers</u>	
Urea (Rs/100 kg)	314.00
Single super phosphate (Rs/100 kg)	128.00
Muriate of potash (Rs/100 kg)	175.00
Zinc sulphate (Rs/kg)	12.10
Rhizobium (Rs/150 g)	7.00
Green manure(Rs/t)	100.00
<u>Plant protection chemicals</u>	
Monocrotophos (Rs/lit)	280.00
Carbendizium(Rs/kg)	328.00
Labour(Rs/day)	15.00
Irrigation charges	150.00
Rental value of land(Rs/ha)	12.50

(b) Quantity of labour used for different crops per ha

Crops grown	Labour used (man days)
1. Fodder maize	30
2. Soybean	25
3. <u>S.rostrata</u>	30
4. Sunhemp	30
5. Rice	191
6. Sunflower	109

(c) Unit price of produce

Details	Cost/Unit
Maize fodder (Rs/t)	150
Rice grain (Rs/kg)	2.60(Pushpa) 2.30(Mangala)
Rice straw(Rs/kg)	0.40
Sunflower seeds(Rs/ha)	9.00
Sunflower straw(Rs/ha)	0.20

APPENDIX-2

Cost of cultivation of crops grown in Experiment-1

Crops grown	Premonsoon crops	Rice		Sunflower		Total cost of sequence			Mean
		50 kg N/ha	100 kg N/ha	50 kg N/ha	100 kg N/ha	50 kg N/ha	100 kg N/ha	100 kg N/ha	
Maize	1377	6083	6423	3346	3346	10806	11146		10976
Soybean	1160	6083	6423	3346	3346	10589	10929		10759
<u>S. rostrata</u>	985	6083	6423	3346	3346	10414	10754		10584
Sunhemp	985	6083	6423	3346	3346	10414	10754		10584
Maize + Sunhemp	1181	6083	6423	3346	3346	10610	10950		10780
Maize + <u>S. rostrata</u>	1181	6083	6423	3346	3346	10610	10950		10780
Maize + Soybean	1269	6083	6423	3346	3346	10698	11038		10868
Fallow	-	6083	6423	3346	3346	9429	9769		9599
Mean		6083	6423	3346	3346	10446	10786		10616

APPENDIX-3

Cost of cultivation of crops grown in experiment-2

Treatments	Rice	Sunflower		Total cost of the sequence			Mean
		-----		-----			
		0 kg N/ha	31 kg N/ha	0 kg N/ha	31 kg N/ha	31 kg N/ha	
GLM at 10 t per ha + 75 kg N through urea	7254	3346	3560	10600	10814	10707	
100 kg N through urea	6423	3346	3560	9769	9983	9876	
100 kg N through GCU	6423	3346	3560	9769	9983	9876	
100 kg N through USG	6723	3346	3560	10069	10283	10176	
100 kg N through URP	6423	3346	3560	9769	9983	9876	
Mean				9995	10209		
GLM - Green leaf manure						GCU - Gypsum coated urea	
USG - Urea super granules						URP - Urea rock phosphate	

APPENDIX-4

Composition of grain and straw as influenced by sources of nitrogen

Treatments	Nitrogen		Phosphorus		Potassium							
	Grain	Straw	Grain	Straw	Grain	Straw						
	89-90	90-91	89-90	90-91	89-90	90-91						
M at 10 t per ha + kg N per ha through urea	1.81	1.73	1.76	1.18	0.56	0.76	0.15	0.40	0.52	0.52	1.18	1.61
10 kg N through urea	1.81	1.47	1.47	1.39	0.71	0.53	0.15	0.41	0.48	0.49	1.23	1.50
10 kg N through GCU	1.58	1.55	1.80	1.23	0.68	0.65	0.15	0.47	0.61	0.45	1.04	1.40
10 kg N through USG	1.83	1.81	1.59	1.21	0.65	0.69	0.16	0.47	0.47	0.55	0.94	1.84
10 kg N through URP	1.80	1.63	1.27	1.42	0.68	0.50	0.15	0.44	0.53	0.51	1.04	1.73

M - Green leaf manure

UG - Urea super granules

GCU - Gypsum coated urea

URP - Urea rock phosphate

APPENDIX-5

Composition of sunflower as influenced by residual fertility status of rice with nitrogen levels
(Per cent)

Treatments	Nitrogen			Phosphorus			Potassium					
	Seeds			Seeds			Seeds					
	89-90	90-91	Straw	89-90	90-91	Straw	89-90	90-91	Straw			
GLM at 10 t per ha + 75 kg N for rice with zero N for sunflower	3.47	3.38	0.79	1.47	1.01	0.70	0.33	0.36	0.83	1.05	3.55	3.19
GLM at 10 t per ha + 75 kg N for rice with 31 kg N/ha for sunflower	3.37	3.14	0.94	1.62	1.47	0.72	0.27	0.33	0.82	1.09	3.07	3.19
100 kg N/ha through urea with zero N for sunflower	3.43	3.28	1.02	1.67	1.01	0.70	0.31	0.37	0.78	1.11	3.91	3.02
100 kg N/ha through urea with 31 kg N/ha for sunflower	3.40	3.43	1.02	1.37	1.01	0.67	0.43	0.33	0.79	1.11	3.51	3.57
100 kg N/ha through GCU with zero N for sunflower	3.43	3.19	0.72	1.67	1.05	0.75	0.31	0.36	0.84	1.11	3.72	3.44
100 kg N/ha through GCU with 31 kg N/ha for sunflower	3.57	3.14	1.00	1.62	0.97	0.70	0.34	0.33	0.77	1.11	4.10	3.57
100 kg N/ha through USG with zero N for sunflower	3.29	3.23	1.10	1.76	0.99	0.72	0.32	0.33	0.77	1.05	3.34	3.49
100 kg N/ha through USG with 31 kg N/ha for sunflower	3.26	2.94	0.97	1.57	0.99	0.72	0.34	0.31	0.82	1.13	3.13	3.49
100 kg N/ha through URP with zero N for sunflower	3.46	3.23	1.00	1.57	1.49	0.65	0.34	0.37	0.78	1.43	3.09	2.27
100 kg N/ha through URP with 31 kg N/ha for sunflower	3.37	3.23	1.44	1.47	0.99	0.70	0.35	0.31	0.77	1.05	4.39	3.28
GLM - Green leaf manure	GCU - Gypsum coated urea			USG - Urea super granules								
URP - Urea rock phosphate												

APPENDIX-6

Composition of grain and straw of rice as influenced by crops grown with nitrogen levels

Treatments	(Per cent)													
	Nitrogen						Phosphorus						Potassium	
	Grain		Straw		Grain		Grain		Straw		Grain		Straw	
	89-90	90-91	89-90	90-91	89-90	90-91	89-90	90-91	89-90	90-91	89-90	90-91	89-90	90-91
Maize-Rice with 50 kg N per ha to rice	1.99	1.72	1.03	1.07	0.54	0.64	0.21	0.40	0.53	0.50	0.76	1.54		
Maize-Rice with 100 kg N per ha to rice	1.99	1.89	1.03	1.30	0.66	0.72	0.22	0.42	0.57	0.63	1.02	1.87		
Soybean-Rice with 50 kg N per ha to rice	1.85	1.76	1.52	1.39	0.66	0.58	0.24	0.33	0.47	0.40	1.04	1.62		
Soybean-Rice with 100 kg N per ha to rice	2.17	1.91	1.62	1.47	0.66	0.68	0.27	0.40	0.56	0.53	1.40	1.86		
Sebania rostrata-Rice with 50 kg N per ha to rice	1.91	1.65	1.69	1.31	0.50	0.93	0.25	0.47	0.45	0.53	0.97	1.60		
Sebania rostrata-Rice with 100 kg N per ha to rice	2.09	2.05	1.25	1.34	0.63	0.95	0.25	0.47	0.48	0.64	1.23	1.72		
Sunnemp-Rice with 50 kg N per ha to rice	1.72	1.72	1.17	1.39	0.58	0.59	0.17	0.30	0.55	0.42	1.02	1.17		
Sunnemp-Rice with 100 kg N per ha to rice	1.93	1.81	1.38	1.55	0.63	0.61	0.22	0.40	0.57	0.63	1.43	1.53		
Maize + Sunhemp-Rice with 50 kg N per ha to rice	1.78	1.91	1.10	1.20	0.54	0.61	0.19	0.35	0.48	0.57	1.00	1.48		
Maize + Sunhemp-Rice with 100 kg N per ha to rice	2.08	2.08	1.35	1.21	0.60	0.71	0.23	0.40	0.49	0.63	1.04	1.65		
Maize + S. rostrata-Rice with 50 kg N per ha to rice	1.97	1.61	1.03	1.13	0.62	0.52	0.21	0.34	0.47	0.54	0.84	1.32		
Maize + S. rostrata-Rice with 100 kg N per ha to rice	1.96	1.89	1.52	1.27	0.64	0.57	0.21	0.42	0.52	0.54	1.07	1.53		
Maize + Soybean-Rice with 50 kg N per ha to rice	1.86	1.63	1.13	1.29	0.54	0.65	0.21	0.32	0.45	0.55	0.96	1.55		
Maize + Soybean-Rice with 100 kg N per ha to rice	2.22	1.73	1.52	1.50	0.73	0.70	0.23	0.49	0.61	0.62	0.99	1.66		
Fallow-Rice with 50 kg N per ha to rice	1.91	1.92	1.50	1.16	0.63	0.73	0.24	0.37	0.52	0.58	1.26	1.38		
Fallow-Rice with 100 kg N per ha to rice	1.98	1.94	1.54	1.55	0.63	0.80	0.25	0.47	0.54	0.62	1.47	1.62		

APPENDIX-7

Composition of stem and leaves of premonsoon crops

	(Per cent)					
	Nitrogen		Phosphorus		Potassium	
	1989-90	1990-91	1989-90	1990-91	1989-90	1990-91
Maize	2.10	2.20	0.597	0.224	1.775	2.08
Soybean	2.98	2.63	0.519	0.365	1.414	0.84
Sunhemp	2.97	2.90	0.363	0.245	1.183	0.86
<u>Sesbania rostrata</u>	3.10	3.15	0.276	0.341	1.197	1.74
<u>Pongamia pinnata</u>	3.69	3.69	2.410	2.410	2.420	2.42

APPENDIX-3

Composition of seeds and straw of sunflower as influenced by residual fertility status of rice crop

Treatments	Nitrogen			Phosphorus			Potassium		
	Seeds			Seeds			Seeds		
	89-90	90-91	89-90	90-91	89-90	90-91	89-90	90-91	89-90
	Seeds	Straw	Seeds	Straw	Seeds	Straw	Seeds	Straw	Seeds
Maize-Rice with 50 kg N per ha to rice	3.13	3.28	1.11	1.52	1.01	0.70	0.36	0.31	0.95
Maize-Rice with 100 kg N per ha to rice	3.40	3.38	1.16	1.52	1.01	0.75	0.38	0.37	0.95
Soybean-Rice with 50 kg N per ha to rice	3.46	3.14	1.11	1.41	0.84	0.72	0.41	0.32	0.97
Soybean-Rice with 100 kg N per ha to rice	3.71	3.53	1.13	1.57	1.05	0.73	0.43	0.36	0.99
Sesbania rostrata-Rice with 50 kg N per ha to rice	3.40	3.48	1.25	1.67	0.88	0.76	0.37	0.32	0.96
Sesbania rostrata-Rice with 100 kg N per ha to rice	3.57	3.58	1.53	1.67	1.15	0.78	0.41	0.36	1.07
Sunhemp-Rice with 50 kg N per ha to rice	3.43	3.31	1.11	1.52	1.03	0.70	0.37	0.36	0.94
Sunhemp-Rice with 100 kg N per ha to rice	3.43	3.58	1.27	1.62	1.13	0.72	0.38	0.39	0.97
Maize + Sunhemp-Rice with 50 kg N per ha to rice	3.35	3.23	0.97	1.57	0.96	0.70	0.32	0.33	0.85
Maize + Sunhemp-Rice with 100 kg N per ha to rice	3.40	3.43	1.16	1.72	1.05	0.77	0.37	0.36	0.96
Maize + <i>S. rostrata</i> -Rice with 50 kg N per ha to rice	3.48	3.23	0.95	1.42	1.01	0.72	0.31	0.35	0.86
Maize + <i>S. rostrata</i> -Rice with 100 kg N per ha to rice	3.51	3.43	1.19	1.47	1.03	0.75	0.41	0.36	0.92
Maize + Soybean-Rice with 50 kg N per ha to rice	3.01	3.14	0.99	1.62	1.01	0.70	0.34	0.35	0.85
Maize + Soybean-Rice with 100 kg N per ha to rice	3.15	3.33	1.16	1.72	1.05	0.72	0.37	0.36	0.90
Fallow-Rice with 50 kg N per ha to rice	3.24	3.18	0.99	1.52	1.01	0.70	0.34	0.31	0.77
Fallow-Rice with 100 kg N per ha to rice	3.57	3.48	1.11	1.57	1.03	0.75	0.38	0.37	0.94

(Per cent)

ಕೃಷಿ ವಿಶ್ವವಿದ್ಯಾಲಯ
ವಿಶ್ವವಿದ್ಯಾಲಯ ಗ್ರಂಥಾಲಯ
ಕಾ. ಕೃ. ವಿ. ಕೆ., ಬೆಂಗಳೂರು-65.

29 SEP 1992

Th. 2820

