WATER AND NUTRIENT MANAGEMENT IN RICE ON SANDY LOAM SOIL

A DISSERTATION

Submitted in partial fulfilment of the requirements for the award of the degree

of

MASTER OF ENGINEERING

in

IRRIGATION WATER MANAGEMENT

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CANDIDATE'S DECLARATION

I hereby declare that the dissertation titled "**WATER AND NUTRIENT MANAGEMENT IN RICE ON SANDY LOAM SOIL**" which is being submitted in partial fulfilment of the requirements for the award of Master's degree of Engineering in **Irrigation Water Management** at Water Resources Development Training Centre (WRDTC), University of Roorkee, Roorkee, is an authentic record of my own work carried out during the period of 16th July to 31st December 2000, under the supervision and guidance of **Dr. S. K. Tripathi**, Professor, WRDTC, University of Roorkee.

The matter embodied in this dissertation has not been submitted by me for the award of any other degree.

Place : Roorkee

Dated : 31·12·2000

(UMRAO SINGH RAJPUT)

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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SYNOPSIS

The basic objectives of this experiment

(i) to determine the crop evapotranspiration (E_{TC}) and crop coefficient (K_C) of rice,

(ii) to test the effect of irrigation application on growth and production of rice,

(iii) to test the effect of nitrogen application on growth and production of rice on sandy loam soil.

To achieve the above objectives the experiment was laid out in factorial design and carried out during Kharif 2000 on Demonstration Farm of WRDTC located in the Campus of the University of Roorkee.

The experiment consisted of 3 irrigation levels, 3 fertiliser treatments and 3 replications and laid down in factorial design.

Observations were recorded at 20 days interval regarding growth and development, i.e., plant height, tiller number, leaf area index, dry weight and rooting depth in each of the treatments. Yield attributes (earhead/m^2), test weight of grain size etc. were recorded at the time of harvest. Grain quality is being analysed. The data recorded were analysed in factorial design using INDOSTAT GS.

Daily weather data was also recorded from the agrometerological lab at WRDTC Demonstration Farm and analysed for computing reference evapotranspiration by modified Penman.

E_{TO} was calculated by Modified Panman Method by using the daily weather data was recorded from the agromat station and E_{TC} was calculated by using the 3 number lysimeters embedded in the field. Lysimeters were saturated and flooded to 15 mm depth of water. Water level was maintained daily by adding or removing the water to the level of pointer fixed in the lysimeters.

The crop coefficients were developed daily dividing actual evapotranspiration (E_{Ta}) by evapotranspiration of a reference crop recorded at 10 days interval throughout the growing period.

In general the study shows that the under soil climatic condition of Roorkee the rice improved productivity with nitrogen application @ 150 kg/ha and there is no effect of irrigation level.

The results indicated that there was a linear increase in the value of crop coefficient from transplanting to flowering. The minimum was recorded as 0.72 in the beginning whereas the maximum was 2.17.

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ABBREVIATIONS

ANOVA	Analysis of Variance
cv.	Crop Variety
DAP	Diammonium Phosphate
d.f.	Degree of Freedom
dat	Days after Transplanting
Ec	Electrical conductivity (mmhos/cm^2 at 20°C)
E_{TO}	Evapotranspiration of reference crop (mm)
E_p	Pan Evapotranspiration (mm)
E_{TC}	Evapotranspiration of crop (mm)
ER	Effective Rainfall
F	Fertiliser
F_1	50 kgs N/ha
F_2	100 kgs N/ha
F_3	150 kgs N/ha
FYM	Farm Yard Manure
FAO	Food and Agricultural Organisation
fg	Field grains/earhead
gm	Grams
GY	Grain yield
gl	Grain length
gtw	Grain kernel test weight
gw	Grain width
ha	Hectare
I	Irrigation
I_1	40 mm/irrigation

I_2	80 mm/irrigation
I_3	120 mm/irrigation
IWUE	Irrigation Water Use Efficiency
K_c	Crop coefficient
ktw	Kernel test weight
kl	Kernel length
kw	Kernel width
K_2O	Potassium oxide
LAI	Leaf Area Index
MOP	Murata of Potash
N	Nitrogen
N.S.	Not Significant
P_2O_5	Phosphorus
q/ha	Quintals/hectare
r	Correlation coefficient
Sig	Significant
str y	Straw yield
TWUE	Total Water Use Efficiency
Z_2SO_4	Zinc sulphate

INTRODUCTION

Rice is the most important crop of India and second most important crop of world. The rice is grown in India on 31% of the total area under food grains.

Rice is a wet season crop. It is mainly grown under assured rainfall or irrigation. There has been significant improvement in quality as a result of special stress laid on development of fine and superfine varieties under a special food grains development programme. Coarse varieties are being replaced by superior varieties as they fetch better price in the market.

There has been a marked improvement in productivity of rice under the successive plan periods. The all India average yield of rice was 771 kg/ha in 1949-50 which increased to 1471 kg/ha in 1986-87. Currently, the yield is placed at 1750 kg/ha but it is still very much below the average yield of 5600 kgs/ha in Egypt, 6000 kgs/ha in Korea and 5800 kgs/ha in Japan.

Uttar Pradesh, West Bengal, Bihar, Orissa, Madhya Pradesh and Assam cover about two thirds of the total area under rice but account for only half the total rice produced in the country. These states suffer from poor infrastructural facilities, low input use, poor production technology and dependence on monsoon.

Rice researchers in the past five decades have focussed on the development of varieties suitable for irrigated land and paid little attention to the development of rice for rain fed regions which constitute almost 70 percent of rice growing area in India.

IARI has also developed some new varieties of short duration superfine and exportable varieties of Basmati rice, suitable for cultivation in the North and North West India. These are ready for harvest within 100 to 110 days. This allows a farmer to sow wheat as a Rabi crop on the same land after harvesting the rice crop.

These varieties include Pusa-33, Pusa-169, Pusa-205 and Pusa-basmati-1, Semi dwarf, non lodging and giving almost double the yield, i.e., 5 to 7 tonnes per hectare in 135-145 days to that of traditional Basmati.

In view of the above facts a field study entitled, "Irrigation and Nutrient Management in Rice on Sandy Loam Soil", was undertaken with following objectives.

(1) To test the irrigation application on growth and production of rice on sandy loam soil.

(2) To test the nitrogen application on growth and application of rice on sandy loam soil.

(3) To determine the crop evapotranspiration (E_{TC}) and crop coefficient (K_c) of rice grown in lysimeters.

Chapter 2

REVIEW OF LITERATURE

2.1 YIELD, YIELD ATTRIBUTES AND QUALITY

Agarwal S. K. et al. (1990) conducted a field experiment during 1983-84 and 1985-86 on upland transplanted rice and their residual effect on wheat, at the Crop Research Farm, Pura, C.S. Azad University of Agriculture and Technology, Kanpur, indicated that slow release N fertilisers and nitrification inhibitors were found significantly superior over prilled urea. Root zone placement (5-6 cm deep) of urea-supergranules at 120 kg N/ha significantly increased yield and yield attributes of rice and N recovery in upland alluvial soils. The response of sources of N was in the order of USG > GCU > NCCU > CACU > PU in both years.

Ahmed A. A. et al. (1992) carried out a field experiment during 1987-88 and 1988-89 to study he efficiency of 4 sources of nitrogen in rice (Oryza sativa L.) and their residual effect on wheat (Triticum aesitivum L. emend. Fiori & Paol). Urea supergranules @ 120 Kg N/ha recorded the maximum grain yield (47.2 q/ha) of 'Jaya' rice. The residual effect of N was reflected in the maximum grain yield (17.08 q/ha) and N uptake (46.62 kg/ha) by wheat with the application of neemcake-coated urea @ 120 kg N/ha to preceding rice. Urea subgranules @ 120 kg N/ha applied to preceding rice proved superior (Rs. 8,706.65; 1.94) to neem cake-coated (Rs. 8,217; 1.88) and prilled urea (Rs. 6,701.35; 1.56) in respect of net return/ha and benefit : cost in rice-wheat sequence.

Ahuja et al. (1995) reported information on the morphology and physiology: growing area and production; quality characteristics; cultivar improvement; production technology; disease and pest management; and the marketing and export of Basmati rice is presented. Basmati rice is grown once in a year in the Punjab region of Pakistan and in Haryana, Uttar Pradesh and the Punjab region of

India. The best quality rice comes from Haryana. The major constraints are in the production and processing of the grain and in aspects of marketing. This bulletin will be useful for development agencies, industry, farmers, students and scientists.

Antil R. S. et al. (1989) conducted a field experiment at Rice Research Station, Kaul, Kurukshetra (Haryana) during the kharif seasons of 1981 and 1982. Grain yields and N uptake in grains and straw increased significantly with increasing nitrogen levels up to 120 kg N/ha. Grain yield and N uptake were highest when preceding crop was dhaincha followed by moong, maize and fallow. The optimum doses of N in rice were 73.6, 66.3, 152.4 and 151.6 kg N/ha after dhaincha, moong, maize and fallow, respectively. The preceding crops did not affect N concentration in rice.

Balasubramaniyam P. et al. (1989) reported that the studies were carried out at the Tamilnadu Agricultural Coimbatore in Rabi 1986, Kharif 1987 and Rabi 1987 to find out the influence of organic and inorganic N with varied population on growth and grain yield of rice, though the effect of organic manuring differed with seasons, incorporation of green manure at 12.5 t/ha benefited the growth and yield of rice. Difference in yield due to varied population was minimum. N rates increased the yield significantly up to 150 kg/ha.

Bali A. S. et al. (1994) conducted a field experiment during 1986 and 1987 to study the control of weeds in transplanted rice (Oryza sativa L.) at 2 locations under Kashmir conditions. The results indicate that butachlor formulation was closely followed by benthiocarb and hand weeding (20 and 30 days after transplanting) in reducing dry matter of weeds with average weed-control efficiency of 81.7 and 82.1% at Khudwani and Larnoo stations respectively. Applications of butachlor @ 1.5 kg ai/ha recorded 97.0 and 135.2% incrase in the mean grain yield compared with unweeded check but was on par with a benthiocarb and hand weeding (20 and 20 days after transplanting) treatments at Khudwani and Larnoo stations respectively. The grain yield had a highly negative but significant correlation with dry weight of weeds during both the years at both the stations.

Bali and Uppal (1995) conducted an experiment during Kharif (monsoon) season of 1989 and 1991 to study the response of rice cv. Basmati-370 to initial submergence duration (5, 10, 15 or 20 days), irrigation (2 or 4 days after disappearance of ponded water) and transplanting dates (10 or 30 July) on a non-cracking soil at Ludhiana, India. Transplanting on 10 July improved growth and yield attributes favourably and gave 8.4% higher grain yield than transplanting on 30 July. Initial continuous submergence for 15 days after transplanting increased grain yield by 11.5 and 4.1% compared with 5 and 10 initial submergence duration, respectively. Irrigation 2 days after disappearance of ponded water increased growth and yield attributes thereby causing significant increase in grain yield by 7.6% compared with irrigation 4 days after disappearance of ponded water. In crease in initial submergence and irrigating at shorter intervals increased water use and leaf water potential but decreased canopy temperature.

Bali and Uppal (1995) carried out field experiment during rainy season of 1980 and 1981 to study yield of Basmati rice as influenced by different water management practice under two dates of transplanting, viz., 10 and 30 July. Water management practice included 4 initial submergence durations of 5 days, 10 days and 15 days and 20 days and 2 subsequent irrigation levels of irrigation at 2 days and 4 days after infiltration of the previously ponded water.

Bhagat et al. (1991) conducted a field trials in 1989-90 on clay loam soil rice cv. Ranbir Basmati and Basmati-370 seedlings transplanted at 30, 40, 50 or 60 days after sowing gave average grain yields of 2.63, 2.37, 1.91 and 1.40 t/ha, respectively. Basmati-370 gave an average yield of 2.35 t/ha compared with 1.91 t from Ranbir Basmati. Number of days to 50% flowering and numbers of sterile spikelets/panicle increased with age of seedling at transplanting and plant height at maturity, number of panicle/m, panicle length, panicle weight, number of fertile spikelets/panicle and 1000-grain weight decreased.

Bhattacharyya H. C. et al. (1992) conducted a field experiment during the rainy seasons of 1986 and 1987 at New Delhi, to study the response of 'Pusa 33' and 'Pusa 312' direct-seeded rice (Oryza sativa L.) to level and time of N application under irrigated upland conditions. 'Pusa 312' rice was taller and showed more tillers, heavier panicles, grain yield (37.62-41.75 q/ha) and N uptake than 'Pusa 33' in both the years. Increased levels of N increased the growth, yield components, yield and N uptake up to 80 kg/ha. Application of N in 4 equal spits, viz., as basal or at seedling stage, at tillering, panicle-initiation and heading stages, could not exert any significant influence on plant height, tiller and panicle production compared with those in 3, omitting the last one at the heading stage. However, panicle weight, grain yield and N uptake were significantly higher in 4 splits, irrespective of the time of application the first split. The time of application of the last split at heading, had marked effect, whereas the time of the first split either basal or at seedling stage, did not show varied effect.

Biswas and Tewatia (1991) reported that the rice productivity in India has almost doubled largely due to increase in HYVs coverage, irrigated area and fertiliser use. The pace of growth in rice productivity has however, been slow due to wide variation in agroclimatic conditions and various technical and socio-economical constraints. The paper deals with the production performance and major constraints in rice production. Future strategies to increase rice production in the country have been suggested.

Biswas and Prasad (1991) reported that India has entered into the era of multi nutrient deficiency and use. Widespread deficiencies of five initials plant nutrients NPK, S and Zn are well documented, and their use to optimum crop yield has become essential. Nitrogen deficiency is universal. So is also crop response to its application. Study of the effects of interaction of different nutrients used is more relevant and useful now. The paper deals with mainly the positive interaction of different essential plant nutrients used in Cereals, Pulses and Oilseeds. Needs for the future have also been suggested.

Bisht et al. (1991) tested the performance of the newly released varieties Pusa Basmati 1, Kasturi and HKR228 was compared with the local control Basmati 370 at 60, 90 and 120 kg N/ha. Urea was applied in 3 splits : ½ basal, ¼ at tillering and ¼ at 1 week before panicle initiation. The basmati varieties, Pusa Basmati 1 and Kasturi, showed no differential response to N but had higher yields than the control. Kasturi and HKR228 produced almost similar mean yields (3.3 and 3.4 t/ha, respectively) which were significantly higher than those of Pusa Basmati 1 (3 t/ha). N response was significant up to 90 kg N/ha.

Chandra (1997) evaluated the performance of twelve scented Basmati rice varieties viz., Basmati 370, Kapurthala Basmati, Ranbir Basmati, Dehraduni basmati, IET 11347, IET 8579, Pusa 615, Madhuri, CBII, Dubraj, Kalimuch and Gaurav under two dates of planting (25th July and 11th August 1991 and 25th July and 5th Sept. in 1992) during wet seasons at the Central Rice Research Institute, Cuttack. July 25th planted crop produced significantly higher grain yield (10 to 12%) than 5th September (1991) and 11th August (1992) planted crop. Out of 12 varieties, four varieties gave higher yield, five varieties gave lower yield and three varieties produced similar yield under normal and late plantings. Orissa state in coastal area also produce scented rice during the wet season and could give reasonably fair yield when compared to 3.5 to 4.0 t/ha from the traditionally scented rice area.

Chilukuri and Rani (1999) reported multilocational trials for export quality high yielding Basmati rice. Data comprising of three components, viz. (i) grain yield, (ii) physico-chemical characteristics and (iii) panel test scores were collected during kharif 1993 and 1994. A methodology for analysing such data of both quantitative and qualitative nature was developed by giving rating and/or weights to physico-chemical characters, panel member scores and data components. On the basis of panel test scores, weighted and unweighted indices were constructed. The cultures identified from these indices in both the years were same. Pusa Basmati-1 was identified as the best entry, followed by IET 13548 and IET 13549. The presently developed analytical method confirmed the results of mental discrimination in the earlier two years. The quantitative analyses of pooled data on grain yield, physico-chemical characteristics and panel test scores could be adopted for identifying the export quality high yielding Basmati rices.

Debnath and Basak (1985), reported that the application of the two rock phosphates from Purulia and Mussourie could not cause any significant increase in the yield of grain, straw or total dry matter, while basic slag increased the yields significantly and was at par with single super phosphate. No benefit was derived over to application of higher dose of P in comparison with lower dose. However, P content (%P) in the plant at panicle initiation stage was significantly higher in the plots received phosphates. The concentrations of plant P under different treatments were in the order : superphosphate > basic slag > Mussourie rock phosphate > Purulia rock phosphates > control.

Dinesh et al. (1997) studied on the effects of planting date and spacing were in 12 Basmati rice varieties at Cuttack, Orissa, in alluvial soils during the wet seasons of 1991-92. Dates of planting were 25 July 1991, 5 September 1991, 25 July 1992 and 11 August 1992, and planting densities were 20 cm x 15 cm (33 hills/m^2) and 15 cm x 15 cm (44 hills/m^2). Yields of rough rice were significantly higher for the 25 July planting and outyielded rice planted on 5 September 1991 and August 1992 by 10% and 12%, respectively. When transplanted late, 4 varieties gave higher yields, 5 gave lower yields and 3 gave similar yields. States like West Bengal and Orissa can also produce scented rice during the wet season, giving reasonably good yields compared with yields of 3.5-4.0 t/ha obtained from traditional scented-rice growing areas. The highest head rice recovery was obtained from Dubraj (61.48%) and the lowest from CBII (32.9%). Late planted crops (11 August) gave a higher head rice recovery than early-planted crops (25 July) during 1992.

Dhiman et al. (1995) conducted field trials in the rainy seasons of 1990-91 at Kaul, Haryana, 30, 40 and 50-d-old seedlings of scented dwarf rice cv Haryana Basmati-1 (HKR 228) were planted at 15 x 15 or 20 x 15 cm spacing on 15 or 25 July or 5 Aug. Grain yield decreased with delay in planting date, was unaffected by spacings and was highest with 30-d-old seedlings. With the early planting date younger seedlings gave higher yields, whereas with the later planting dates older seedlings gave higher yields.

Ghosh B. C. et al. (1991) conducted a field experiment in a typical low land situation in farmers's field during the wet season 1986, to determine the effect of seed rate and N fertiliser under intermediate deep water condition (15-60 cm water depth). The result showed that with the addition of N the grain yield increased significantly in both the varieties. The interaction effect of varieties and N fertilizer on grain yield showed that the traditional variety 'Tilakachari' responded in respect of grain yield only up to 30 kg N/ha, whereas the semi dwarf variety 'CR 1018' responded up to 60 kg/ha. The increase in grain yield was due to higher number of ear-bearing tillers and grains/panicle. In plots treated with N fertiliser the plants were vigorous and greater portion of plant parts remained above the water surface, resulting in low tiller mortality. With the increase in seed rate from 200 to 400 seeds/m^2, there was an increase in grain yield by 0.65 tonne/ha. Under intermediate deep water situation determination of seeding density of direct-seeded rice depended on fertiliser application. To obtain similar yield, much higher seed rate would be required in the absence of any fertiliser than when N fertiliser was used. Seeding density of 400 seeds/m^2 used under a condition of no fertiliser produced similar yield as that of using 300 seeds/m^2 with N fertiliser 60 kg/ha.

Goswami and Rattan (1992) reported the maintenance of soil health is an essential pre-requisite for sustaining agricultural productivity. Anthropogenic activities including and involving intensive agricultural devoid of supplementation of sufficient organic, imbalance use of chemical fertiliser, over-irrigation leading to secondary salinisation, etc., have constantly degraded soil health. Attempt has been made in this article to examine the causes and effects of such deterioration on growing plants and soil environment and suggest remedies to cure sick wherever possible.

Gupta A. K. et al. (1991) conducted a field experiment on sandy loam soil of research farm, Jabalpur, during the rainy seasons of 1987-88, to cultivate the performance of dwarf and tall cultivers of early-medium maturing (115 days) indica rice of the four spacings the closet spacing (10 cm x 10 cm) produced the highest grain yield (25.86 q/ha), which was nearly equal to the widest spacing proved significantly superior in respect of yield to the rest 2 spacings (15 cm x 10 cm and 20 cm x 10 cm). Though the individual hill under wide spacing showed superior growth and yield contributing characters than that under close spacing, the grain yield per unit area was greater in latter than in former as a result of more number of productive tillers per unit area. But the widest spacing (15 cm x 15 cm) proved equally well to closest one in this regard, because available resources were efficiently utilized by each hill due to square pattern of planting.

Hazarika and Sarkar (1996) conducted a field experiment in the kharif season of 1992 on a moderately well drained silt loam (Type Ustochrept) at New Delhi to study the 15N recovery from urea by flooded rice cv. Basmati-1. The N was applied at 60, 120 or 180 kg/ha, entirely as urea, mud ball urea of calcium carbide coated urea, or half as urea and half as FYM or green manure (45 day-old Sesbenia aculeata). Green manure + urea registered the highest recovery of Fertiliser N by rice and lowest N loss. The application of calcium carbide coated urea reduced the N loss and increased the fertiliser N recovery by rice. The loss of Fertiliser N increased with increasing rate of urea application. All the sources of N influenced N uptake and grain yield of rice but the variations among the sources were not significant.

Jee R. C. et al. (1989) conducted a field experiment at Regional Research Station, Ranital during Rabi 1985-86 in a sandy loam soil with pH 6.8, organic carbon 0.45%, 11 and 280 kg/ha of available P_2O_5 and K_2O respectively. All the treatments recorded significantly higher grain yield than the control. However, maximum uptake and yields were recorded with USG applied 7 DAT at 90 kg/ha which was significantly more than all other treatments except its application at 60 kg N /ha and LCU at 90 kg N/ha applied in three splits in the ratio of ¼ : ½ : ¼ at TP, 15 DAT and PI stages respectively. The later two also did not differ significantly. Panicles/m^2 and the grains/panicle were also influenced in a similar way which ultimately reflected the final yield. Also, the grain yield obtained from USG applied at 60 kg N/ha was significantly higher than PU at 90 kg N/ha applied in three splits.

Kalita and Gogoi (1994) conducted field experiments with rice at Jorhat during late (kharif rainy season of 1987-1988 on loamy sand soil. The treatments comprising to cultivators, viz. 'Culture 1' and 'Rangadararia' (a local tall avriety), 2 seedling method, viz., CaO_2 smeared pre-germinated seeds and pre-germinated seeds, were allocated in combination in main plots and 3 weed control measures, viz., Butachlor @ 1.5 kg/ha as pre emergence, weed control and weedy check, in subplots of split plot design with 3 replications. In weeds free plot hand weeding was done 20 and 40 days after seeding.

Kohle S. S. et al. (1989) reported that a field experiment was conducted in a split plot design at indian Institute of Technology, Kharagpur (W.B.) during two crop seasons (1982-83 and 1983-84) to assess the relative efficacy of slow release N-fertilizers and nitrification inhibitors in a rice-wheat rotation. The treatments comprised of the combination of different forms of slow release N-fertilisers in main plots and three levels of nitrogen and a control in subplots. The fertilizers were applied to rice and the residual effects were studied in the ensuing wheat crop. The soil was acid lateritic sandy clay loam. The full quantity of nitrogen was applied as basal except in case of urea and neem-cake coated urea where, 50% of N was applied as basal at transplanting through prilled urea (PU) and NCU respectively and remaining N was applied through ordinary urea in two equal splits. A basal dose of 60 kg/ha each of P_2O_5 as single super phosphate and K_2O as muriate of Potash was applied to both the crops in 1982-83 in 1983-84 the doses were 60 kg P_2O_5 and 50 kg/ha K_2O in both the crops. Rice cultivators Pusa 2-21 during 1982-83 and Pusa-33 in 1983-84 and wheat variety Sonalika in both the years was used. Grain yield of rice increased significantly with the increase in N-levels during both the years. In case of different forms of slow release N-fertilisers, highest grain yield of 40.7 q/ha was obtained with root zone placement of urea super-granules as compared to 38.7, 38.4 and 37.9 q/ha with prilled urea.

Krishnaiah (1998) reported that in rice (Oryza sativa L.) varietal improvement had been largely through pureline selection before fifties. Inter varietal hybridization programme was the first serious to break the yield barrier in tropical rice. A breakthrough in breeding was witnessed with concept of semi-dwarf, now lodging plant type. Special breeding programmes were also launched to develop varieties, suited to rainfed uplands, shallow low lands, semi-deep and deep water areas as well as problem soils. The All-India Co-ordinated Rice Improvement project played a key role in rapid material generation and varietal identification suitable for varied situations. The mechanism of inter-discipline based multiplication testing facilitated development of agro-ecology-specific varietal and matching production technology. This model has helped to evolve more than 528 high-yielding, dwarf rice varieties and enabled us to achieve a record production of 82 million tonnes of milled rice during 1994-95, ensuring self-sufficiency in rice. Eleven rice hybrids have been released so far for commercial cultivation. The fine grain and aromatic rice helped increase rice export. India exported 5.5 million tonnes rice valued at Rs. 30000 million. The article deals with the present rice scenario in India.

Kulmi G. S. (1992) carried out a field experiment during the rainy (kharif) seasons of 1984-85 at Jabalpur which revealed that decreasing profuse weed growth increased the biomass production, leaf area index, net assimilation rate, crop-growth rate, relative growth rate and harvest index, resulting in higher grain yield of rice (Oryza sativa L.). The cultural method and post-emergence application of herbicides resulted in better growth and biomass production, leading to higher grain yield compred with pre-emergence applciation of herbicides. Rotary weeding at 35 days after transplanting recorded the highest grain yield, followed by hand weeding at 40 days after transplanting, pretilachlor @ 1.0 kg/ha and piperophos @ 1.25 kg/ha as post-emergence, although yield differences were not significant when compared with the unweeded control. Among herbicides, pretiachlor @ 1.0 kg/ha resulted in the highest grain yield, followed by piperophos @ 1.25 kg/ha. Oxadiazon @ 1.0 kg/ha pre-emergence caused severe phytotoxicity (25.33%) to the rice crop and recorded poor growth and biomass production and resulted in significantly lower yield compared with the unweeded control.

Matiwade P. S. et al. (1994) conducted an experiment during 1989-90 to study the influence of green manuring of Serbania rostrata on rice (Oryza sativa L.) at Mugad Green-Manuring of S. rostrata alone resulted in higher grain yield (5207 kg/ha) than that realized with the application of 100% N (5053 kg/ha) required by rice crop. The highest grain yield (6585 kg/ha) was recorded with green manuring of S. rostrata along with the application of 100% N. The other yield components followed the same trend during both the seasons.

Mishra S. S. et al. (1991) conducted a field experiment during 1983-84 and 1984-85 to find out the effect of nitrogen and weed management on nitrogen use efficiency in rice-wheat sequence. The N uptake in rice at harvest was significantly higher under chemical weeding. Among sources of n, urea supergranules proved significantly superior to neem cake-coated urea and prilled urea. The grain yield

(35.8 q/ha) of rice was higher at 100 kg N/ha and urea supergranules proved significantly superior to prilled urea of neemcake-coated urea chemical and hand weeding were at par. In succeeding wheat also, significantly higher grain yields were recorded under hand-weeding and chemical weeding than under weedy check. The N uptake in wheat was the highest under hand weeding. The carry over effect of neem cake-coated urea @ 100 kg N/ha applied to the rice crop produced the highest grain yield of wheat. But apparent N recovery in wheat decreased significantly with an increase in N level applied to preceeding rice crop. The N sources neemcake-coated urea and urea supergranules proved superior to prilled urea in rice wheat sequence.

Mohapatra et al. (1997) undertook the study in the Bhanjanagar and Belanghuntha blocks of Ganjam district covering four villages namely Lalsingh, Chhedabhuin, Marcipat and Debulunda two in each block respectively. Sample respondents of 120 farmers 40 each from marginal, small and big farmer categories were selected following a multistage randomised sampling technique. The farmers were personally interviewed through a structured and pretested schedule for studying the perception and adoption behaviour of farmers towards improved packages of rice cultivation. From the findings it is observed that the farmers have higher knowledge, attitude and adoption of the packages like HYV seeds, balanced fertiliser application and plant protection practices. In case of improved agricultural implements and machineries the adoption level is low in spite of the higher knowledge of farmers about the practice. Among the categories of farmers levels of knowledge, attitude and adoption is higher in case of big farmers as compared to others. It is further revealed that knowledge and attitude are positively and significantly associated with the adoption of HYV seeds among farmers and balanced fertiliser application among the farmers of small farmer category.

Muthukrishnan and Purushothamaman (1992) conducted a field experiment during the rainy (kharif) season 1989 to find out the effect of irrigation, weed and fertiliser management on weed growth and yield of irrigated transplanted rice (Oryza sativa L.). The results indicate that the most economic irrigation schedule for low land rice could be irrigation to 5 cm depth, 1 day after disappearance of ponded water in terms of higher saving of water without any adverse effect on yield. Pre-emergence application of Butachlor @ 1.25 Kg a.i./ha at 3 days after transplanting, 1 hand-weeding at day 25 gave effective weed control. Bio-fertilisation with either Azospirrillum inoculation was equally effective for getting higher yields.

Pande R. C. et al. (1987) conducted an experiment in rainy season of 1981 at the JNKUV, College of Agriculture, Rewa. The treatments consisted of four rice varieties (Cauvery, Madhuri, JR 16-15-1-1 and Kranti) as main plots and four number of seedlings/hill (one, two, three and four seedlings) as sub plots were tested in a split plot design with three replications. The values of soil pH, organic carbon, available N, P_2O_5 and K_2O were 7.1, 0.72%, 161.47 Kg, 13.20 Kg and 470 Kg/ha, respectively. A dose of 120 Kg N, 60 Kg P_2O_5 and 40 Kg K_2/ha was applied to crop.

Among the varieties, Kranti being at par with Cauvery produced significantly higher grain yield than Madhuri and JR 16-15-1-1. Higher grain yield of Kranti may possibly be due to its genetic potential and suitability of the edaphic and climatic conditions of this area.

Number of seedlings/hill also affected grain yield, two three and four seedlings/hill being at par produced markedly higher grain yield over one seedling/hill.

Pandey R. et al. (1991) conducted a field experiment during the rainy seasons of 1983 and 1984 to study the effect of fertility levels, varieties and transplanting time on yield and uptake of nutrients by rice of the 4 varieties 'KR10-47' excelled the other varieties. The effect of delayed transplanting (15 days) was adverse on yield and uptake of nutrients.

Paliniappan S. P. et al. (1989) reported that a field experiment was conducted in wet lands at the Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore during Kharif 1987 in two locations. The experiment was laid out in a randomized block design with five treatments. The soil was clay loam having pH 7.8. The available N, P and K 188, 20, 448 and 225, 21, 380 kg/ha respectively at the two locations. Nitrogen at 100 kg/ha was applied in splits as per the treatments. The green leaf manure was incorporated 15 days prior to transplanting at 12.5 t/ha. A basal dose of 50 kg P_2O_5 and 50 kg K_2O was applied at transplanting.

In conclusion, green leaf manure at the rate of 12.5 t/ha applied 15 days prior to transplanting along with 100 kg N/ha in 3 equal splits viz., active tillering, panicle initiation and heading stages was superior to other treatments of N application.

Rajput A. L. et al. (1991) conducted a field experiment at Kumarganj, Faizabad, during the rainy season 1986 to study the effect of organic materials on transplanted 'Saket 4' rice. The crop was transplanted at a spacing of 15 cm x 10 cm on 29th October 1986.

Application of either of the organic materials with and without N significantly increased grain and straw yields from the control. Application of farm yard manure was superior to that of wheat straw. Application of N in conjunction with either of the 2 organic materials proved better than its application alone. Application of farmyard manure or wheat straw affected economy of 50 kg N/ha for grain production. The other plant parameters also followed the trend similar to that of grain and straw yields of the rice crop.

Rajput A. L. et al. (1992) carried out a field study during 1986-87 and 1987-88 to find out the effect of different levels of nitrogen and organic manure on yield of rice (Oryza sativa L.) and residual effect on wheat (Triticum aestivum L. emend.

Fiori and Poal) crop. Application of farmyard manure or wheat straw @ 10 tonnes/ha saved 50 kg N/ha and gave maximum yield of rice. The carry-over effect of farmyard manure on wheat also had the trend similar to rice. The benefit : cost ratio was maximum with farmyard manure @ 10 tonnes/ha + 100 kg N/ha treatment in wheat and farmyard manure alone in case of rice. But the treatments, 100 kg N, farmyard manure, farmyard manure + 50 kg N and farmyard manure + 100 kg N/ha had almost similar benefit : cost ratio.

Rao et al. (1990) reported that the Rice cv IET8579 transplanted at 10 x 10, 15 x 20 or 15 x 15, 20 x 15 cm row spacing recorded highest grain yield (2.9 t/ha) at 20 x 10 cm spacing and decreased with closer spacing due to few filled spikelets/panicle and lower panicle wt. Yield also decreased at wide spacing despite slightly higher panicle wt. Sarkar et al. (1990) conducted trials with 4 rice cultivators grown in 2 seasons, applying 0, 30, 60 or 90 kg N/ha gave av. paddy yields of 1.83, 2.14, 2.10 and 2.22 t/ha in the rainy season of 1982 and 2.18, 2.41, 2.70 and 3.33 t in the dry (winter0 season of 1982-83, respectively. Cv IET 6248 in the rainy season and cv IET 7029 in the dry season gave the highest yields of 3.41 and 3.02 t/ha respectively, compared with respective yields of 1.50-1.88 and 2.19-2.81 t for 3 other cultivators.

Reddy Rama Subba et al. (1989) conducted an experiment during Rabi seasons of 1982-83 and 1983-84 at Agricultural Research Institute, Rajendra Nagar, Hyderabad. The results showed that number of panicles, number of filled grains, panicle and test weight increased from 40 to 120 kg N/ha as compared to control, grain yield of rice was also increased significantly with increasing doses of N up to 120 kg N/ha. Urea super granules (USG) recorded higher number of panicles/m^2 and filled grains/panicle over other forms of urea. Deep placement of USG recorded significantly higher grain yield over other three forms of urea.

Reddy and Reddy (1992) conducted an experiment during the wet season of 1987 and 1988 to study the effect of time of transplanting of seedlings on growth and yield of rice (Oryza sativa L.). Grain yield was significantly higher with transplanting of rice on 29 August then on earlier plantings. Higher plant density (10 lakh hills/ha) recorded more grain yield than plant density of 4.4 lakh hills/ha. Thirty-day-old seedlings were superior to 45- and 60-day old seedlings.

Sagar and Ali (1993) reported that Rice Cv Basmati 370 grown in pots at Daska (traditional rice growing area) and Multan (not a traditional rice area), in soils from each area. Pots were also transferred between the 2 areas at panicle initiation or panicle emergence. Grain size and composition were unaffected by treatment, but cooking quality and aroma were highest in rice grain grown in Daska soil and environment throughout growth.

Sagwal et al. (1994) conducted experiment in the Karnal district, Haryana, on a sandy loam soil (typic ustochrept) with no fertiliser, 60 kg N, 30 Kg P_2O_5, 30 kg K_2O, 25 kg Zinc sulphate/ha as N, NP, NPK or NPKZn were applied. Two 5-week-old rice cv Basmati 370 seedlings were transplanted in the second week of July 1990. P, K and Zn were applied at puddling and N in 2 equal portions in 3rd and 6th weeks after transplanting. Rice grain yields ranged from 1.6 t/ha with no fertilisers to 2.59 t with NPKZn. Financial returns were greatest with NPKZn.

Saikia M. et al. (1989) reported that a two year field experiment was conducted on transplanted summer rice showed that continuous submergence produced significantly higher grain yield in both the years. The grain yield of rice responded to nitrogen significantly up to 80 and 40 kg/ha respectively in 1985 and 1986. N uptake by grain and straw were significantly higher under continuous submergence and also increased with increasing levels of nitrogen. The residual available nitrogen was highest under continuous submergence but the increasing levels of nitrogen failed to build up the residual available nitrogen reserves in the field.

Sharma S. D. et al. (1989) reported that a field experiment was conducted during kharif 1982 at Haryana Agricultural University, Hissar to study the relative efficiency of prilled urea and lac-coated urea (LCU) in transplanted rice. Nine treatment combinations were tested in a randomised block design with three replications. Before last harrowing a basal dose of 60 kg P_2O_5/ha and 25 kg/ha zinc sulphate were applied. LCU supplied by the Bihar State Co-operative Lac Marketing Federation Ltd., Dangratoli, Ranchi contained 33% nitrogen. The soil was sandy loam with pH 8.1, low in available nitrogen, medium in available phosphorus and high in potassium content, two rice seedlings per hill were transplanted at a distance of 15 cm x 15 cm on 12 July 1982.

Application of 60 kg N/ha as urea were applied in 3 equal splits gave significantly higher grain and straw over single or two split applications. The application of 60 kg N/ha through LCU was superior over urea only when it was applied in two splits either at transplanting plus maximum tillering or transplanting plus panicle initiation stages. The effect of treatments on straw yield and other yield attributing characters was identical to that of grain yield.

Sharma G. L. et al. (1990) reported that the wet soil ammonium-N expressed on dry weight basis was in maximum concentration in USG + Azolla treatments than PU + Azolla. PU + fresh wheat straw maintained higher wet soil ammonium-N at 60 DAT onwards than USG + fresh wheat straw treatments. At recommended 120 kg N/ha, USG + Azolla (half N incorporated and half inoculated) maintained higher level of wet soil ammonium – N over PU alone as best split. USG + Azolla at recommended dose of applied N gave higher yield over PU and was significant during 1985. Performance of PU + fresh wheat straw was better during both the years over USG + fresh wheat straw at the same rate of applied N. In another experiment, sesbania + PU at 80 kg/ha was significantly superior over 80 kg/ha through PU best split but was similar to sesbania + Azolla at same level of applied N.

Singh B. K. et al. (1991) conducted a field trial in randomized block with 4 replications during the wet season 1984 at Pusa. The soil was calcareous silty loam (pH 7.9), medium in organic carbon (0.73%), low in available N (275 kg/ha), phosphorus (16 kg P_2O_5/ha) and potassium (130 kg K_2O/ha).

Nitrogen uptake in grain increased significantly with incremental dose of N owing to higher grain yield and N concentration. Increase in straw yield with N addition was responsible for higher N uptake in straw. Sulphur-coated urea and urea supergranules resulted in higher N uptakes in grain and straw owing to higher production of these dry matter component.

Thus the crop responded significantly upto 87 kg/ha. Sulphur coated urea and urea super granules being at par, proved significantly superior to other N sources including split applied prilled urea.

Singh G. et al. (1991) conducted a field experiment at Ghagraghat during the rainy seasons of 1985, to study the effect of sources and levels of N on the yield, yield attributes and uptake of rice. Yield, yield attributes and N uptake were affected significantly due to sources and levels of N. Application of 87 kg N/ha being at par with 58 kg N/ha produced significantly higher grain and straw yields than 29 kg N/ha and the control in both years. The increase in yield at this level was mainly owing to superior yield attributes like (Panicle/m^2, panicle weight, panicle length and 1000 grain weight).

Response to grain yield was highest (22.7 kg grain/kg N) at 29 Kg N/ha level. However, uptake of N through grain was the highest 31.8 kg/ha) at 87 kg N/ha level.

Singandhupe R. B. et al. (1990) conducted a field experiment in three kharif seasons during 1986-88 in semi-reclaimed sodic soil at Karnal (Haryana) to study the influence of varying moisture regimes on nitrogen use efficiency in rice. The results revealed that unfertilised control produced 3.6 t/ha rice grain yield and 4.25 t/ha straw. At the highest N level (150 kg/ha), the grain yield was 65.5% more than control. The nitrogen use efficiency (Agronomic efficiency) in grain was 13.8 kg/ha applied N at 50 kg N/ha which increased to 18 kg/ha applied N at 100 kg

N/ha. Thereafter, with increase in N dose (150 kg/ha), the agronomic efficiency was reduced to 15.7 kg/ha applied N.

Soni P. N. et al. (1989) reported that the fertilizer use efficiency of the various new slow release nitrogenous fertilisers applied to rice-rice and rice-wheat crop sequences was studied. The results indicated that slow release fertilizer applied to rice was able to yield higher as compared to ordinary urea in both sequences. Also new fertiliser materials, by and large, happened to be more stable under varying environments as compared to prilled urea. Urea super granules, in particular, have emerged as the most promising new material at many centres.

Subhash et al. (1997) conducted a field experiment in 1993-94 at New Delhi, with rice (Oryza sativa) cv Pusa Basmati, N, P, and K uptake were significantly higher under transplanted (85.5-112.8 kg N, 10.8-17.0 kg P and 150.5-172.3 kg K/ha) than direct-sown rice (35.1-35.8 kg N, 4.4-5.9 kg P and 58.5-64.3 Kg K/ha). Uptake of these nutrients was markedly higher at 120 kg N than at 60 kg N/ha. Nutrient uptake was highest in hand-weeded (30, 40 and 60 days after sowing or transplanting) plots (88-104 kg N, 11-16 kg P and 146-172 kg K/ha), and lowest in unweeded plots (42-54 kg N, 5-8 kg P and 79-84 kg K/ha). Nutrient uptake in rice treated with butachlor, anilofos or chlorimuronethyl was similar and significantly higher than in unweeded plots. The N, P and K depletion by weeds were 6 times lower in transplanted rice than in direct-sown rice. N, P and K depletion by weeds was higher in plots given 120 than 60 kg N/ha. The highest depletion of N, P and K was in unweeded plots (42.7 kg N, 4.5 kg P and 63.1 kg K/ha) and the lowest in hand weeded plots (5.3 kg N, 0.6 kg P and 7.7 kg K/ha). Herbicide treatments significantly lowered N, P and K depletion.

Tanaka et al. (1959b) and Patnaik and Abichandani (1970) on the basis of the work on the traditional indica varieties of different durations grown under field conditions and in culture solutions, and Patnaik and Nanda (1969) on high-yielding varieties, grown under field conditions, reported that the pattern of absorption of the nutrients was intimately related to the processes taking place during different growth periods. The stage of maximum tiller formation (the period of peak vegetative growth) was found to be independent of the duration of the variety and was obtained 5 to 6 weeks after transplanting. In the short-duration indicas and in the high-yielding varieties, panicle initiation and the onset of reproductive growth period overlapped or closely followed the stage of maximum tiller formation, whereas in the medium- and long-duration indicas, there was a time lag between the stage of maximum tiller formation and the panicle initiation which was the vegetative lag period. The rate of dry-matter production appeared to increase during the reproductive period from ear initiation to flowering. Based on the process of absorption, the various nutrients studied could be grouped into 3 broad categories :

(i) Nitrogen, phosphorus and sulphur were absorbed from the beginning of the growth period up to flowering and were needed for protein build-up, a process going on during this period. In the short duration indicas and in the high yielding varieties, the absorption was continuous, whereas in the medium and long-duration indicas, there were two distinct stages of vigorous absorption during the active vegetative and reproductive growth periods, separated by an absorption lag during the vegetative lag period.

(ii) Potassium was absorbed from transplanting up to about the dough stage of the panicle to regulate carbon assimilation and protein synthesis. In the short-duration indicas and in the high-yielding varieties, the absorption was continuous, whereas in the medium- and long-duration varieties, there was an absorption lag, as in the case of N, P and S.

(iii) Calcium and magnesium were absorbed slowly during initial growth stages, but increased a little before the maximum tillering stage and continued almost up to maturity. The role of calcium was possibly to help to build up increased amounts of the cell-wall substances during the elongation stage and that of magnesium for increased photosynthesis which resulted in the increased rate of dry-matter production during the reproductive growth period.

Nutrients absorbed vigorously during the distinct growth periods, therefore, played dominant roles in the plant processes occurring during these periods, thus bringing about a complete integration between the plant processes and uptake of nutrients. Information on the stage of vigorous absorption by varieties of different durations might help to formulate effective and rational fertiliser schedules, in case the soil-test and the crop-response data suggested the need for the application of some of these nutrients.

Basak (1962) reported the continuous uptake of N and P. The uptake was, however, interrupted when the crop lodged. Sadanandan et al. (1969) reported that the uptake of N increased with the increasing application of N. The N content of the plant decreased, but the uptake increased with the growth, with the maximum utilization occurring during tillerinig and flowering. The application of P beyond 34 kg/ha of P_2O_5 id not improve its utilization. The uptake pattern closely followed that of N but with a lower amount. The content and uptake of K increased with the increased rate of application and the maximum uptake occurred at flowering. Ramanathan and Krishnamoorthy (1973) studied the uptake of nutrients in relation to the growth of 'IR.8', 'IR.20' and 'IR.22' in different soils, and found that the uptake of N, P, K was greater in red soils than in the alluvial and black soils, and that of Ca was highest in black soils, followed by its uptake in red and alluvial soils. The different soil types did not affect the uptake of magnesium. Varietal differences in respect of uptake were significant. But the pattern of uptake was found to be more or less similar.

The relative efficiency of ammonium and nitrate nitrogen for rice : Nitrogen is supplied to the plant either from soil or as fertiliser in the ammonium or nitrate form. The relative merits of ammonium and nitrate nitrogen for the rice plant per se have been investigated by a number of workers under controlled experiments in sand and culture solutions. Dastur and alkani (1933) found that the absorption of ammonium, nitrogen decreased and that of nitrate increased as the plant aged. Dastur and Kalyani (1934) assumed that this preferential uptake of nitrogen during different growth stages occurred owing to the differences in electrical charge on the protoplasm at the respective growth stages. Asana 91945), on the other hand, observed poor growth of rice in ammonium cultures and attributed this poor growth owing to a change in the pH of the medium. Tanaka et al. (1959c) controlled the pH of the culture solution containing ammonium of nitrate every 2 or 3 days and determined the efficiency of ammonium and nitrate nitrogen absorbed by the rice plant during different growth stages. It was found that at moderate levels of nitrogen supply (20 ppm of N), both the forms were equally efficient in respect of grain yield and nitrogen uptake. At higher rates, nitrate was found to be superior to ammonium nitrogen. The results gave indications of preferential absorption of ammonium nitrogen during the period of growth and of nitrate nitrogen during the reproductive period and attributed this preference to the fact that rice roots possessed strong oxidizing power during the vegetative growth period and reducing power later on. The situation was, however, different in the fertilizer-soil system and the fertilizer-soil-plant system.

The yield and nutrient uptake as influenced by nutrient interaction : Shinde and Datta (1964) and Datta and Shinde (1965) on the basis of radio tracer studies concluded that the application of N and P benefitted the yield of dry matter more under flooded conditions than under upland soil conditions. The application of N increased the uptake of P. The application of silicon did not appear to have any effect on the uptake of N and P. Singh (1967) observed increased uptake of N and P with the increasing rates of application of nitrogen. The application of ammonia sulphate resulted in a higher concentration of P than when sodium nitrate, ammonium-nitrate or calcium-ammonium nitrate were applied. Similar observations have also been recorded by Patnaik et al. (1974b) who have, however, reported an increasing efficiency in respect of grain yield and uptake of N and P in relation to growth with a nitrate-phosphate fertiliser produced by the Neyveli Lignite Corporation. Mehrotra et al. (1968) from studies on the uptake of N and P at increasing rates of application of the respective nutrients observed that : i) only one period of nitrogen and phosphorus efficiency occurred at tillering stages, (ii) maximum nitrogen and phosphorus uptake was obtained in a combination of 66 kg of N and 44 kg of P_2O_5 and resulted in the highest recovery of 64.8 percent of nitrogen, whereas the best recovery of phosphate was obtained in a combination of 66 kg of N and 22 kg of P_2O_5. Datta and Venkateswarlu (1968) reported no significant difference in the availability and utilisation of P fertiliser as superphosphate applied on the surface or 5 cm deep. Ammonium nitrate increased P availability when the fertilizers were mixed with superphosphate.

Rao and Rao (1965, 1966) have reported interactions of the uptake of P, molybdenum and calcium with the application of these 3 nutrients.

Thakur K. S. et al. (1987) conducted a field experiment at the HPKVV, Palampur in kharif seasons of 1983 and 1984 on a clay loam soil. Incorporation of Lontana, Eupatorium and wheat straw each at 5 t/ha on dry weight basis resulted in 38.2, 19.5 and 6.5% increase in grain yield of transplanted rice respectively over control. The response of rice to N was up to 100 kg/ha. Optimum level of N without organic waste was 114.6 kg/ha, whereas with Eupatorium and wheat straw it was 94.8 and 139.8 kg/ha respectively.

Tripathi et al. (1993) reported that the Mahi Sugandha (RRB94), identified in the F6 generation of the cross BK79 X Basmati 370, has a yield potential superior to that of Basmati 370 and Kali Kamod, out yielding them by 51 and 59% at Banswara and Sriganganagar. In All India Co-ordinated Trials during kharif 1990 Mahi Sugandha produced an average yield of 4.8 t/ha (58% greater than that of

Basmati 370). Resistance to insect pests and diseases is very good, compared to Basmati 370, Kali Kamil and local Basmati varieties. Plants have a semi dwarf, photoinsensitive habit, synchronized tillering and late leaf senescence and mature in 130-135 days (8-10 days earlier than Basmati 370). Panicles are fully exerted with long, slender, strongly scented grains. The grain displays many desirable cooking features.

Verma L. P. et al. (1991) laid out a field trial with rice in randomized block design with 4 replications at Faizabad during the rainy season 1986. The soil was silty loam with pH 8.1 and available P 6.8 kg/ha. Mussourie rock phosphate (MRP) containing 20% P alone and 1:1, 1:2 and 1:3 ratios with pyrite and pressmud was compared with single superphosphate. Pyrite and pressmud were mixed as P-solubilizing agents and applied to the field 1 week before transplanting of rice 'Saket 4' rice. P was applied at 60 kg P_2O_5/ha through each source at puddling. A recommended dose of 120 kg N and 60 kg K_2O/ha was also applied to all treatments. The crop was planted on 12 July and harvested on 29 October in 1986. The yield of rice was the highest when crop was fertilised with single super phosphate. However, the yields obtained under rock phosphate + pyrite (1:3) and rock phosphate + pressmud (1:3) were on a par with single superphosphate. Rock phosphate alone did not increase the yield significantly. Addition of pyrite and pressmud with rock phosphate significantly increased the yield with increasing quantity of pyrite and pressmud in the mixtures. Press mud was superior to pyrite at same ratios.

Yellamanda T. et al. (1992) conducted a field investigation to study the influence of different soil-moisture regimes and nitrogen levels on root growth of rice (Oryza sativa L.). The proportion of roots in total biomass of plant at tillering was 28% and gradually decreased to 15% at flowering. Root volume and root-dry weight were higher under continuous submergence (5 cm standing water) or at irrigation to 5 cm submergence after reaching the soil-saturation point than under drier upland moisture regimes. Soil strength was 0.2 kg/cm^2 with submergence and 20.0 kg/cm^2 with moisture level ranging from field capacity to 50% depletion of available soil moisture. Root length and soil strength were negatively correlated ($r = -0.95$). Third- to fourth-order root branching was under lowland condition and only the first-order branching under upland condition. Continuous submergence gave 12% non geotropic roots, whereas these were absent under upland moisture conditions. Roots were thick, wavy and short under upland condition. N and P uptake was clearly correlated with root length and root volume. In most cases higher level of applied N increased the root volume and root-dry weight. N and P uptake increased with increasing moisture levels due to more root growth. Grain yields were higher with higher moisture and N levels. Thus poor growth of rice under upland condition was due to reduced root growth which resulted in reduced nutrient uptake and grain yield.

2.2 EVAPOTRANSPIRATION (ET) AND CROP COEFFICIENT (K_c)

Allavena (1995) reported the normal rice growing season in the NW PO valley, 11 Apr-20 Sept., was divided into 20 day periods, and the crop coefficient for each period was determined. The crop coefficient was calculated as the ratio between the actual value of rice evapotranspiration and the reference value. The values obtained were compared with those reported in the literature. The coefficients and meteorological data from Vigellio were used to calculate frequency distributions for rice evapotranspiration. Comparison with those for maize in the same area showed that values for rice were considerably higher than those for maize for the whole growing season, but there was little difference between the 2 crops for the peak growing period. These results are discussed with reference to using costly reservoir water for irrigation.

Adachi et al. (1995) collected data from field experiments with paddy rice at Matsue, Japan, estimated evapotranspiration rate (EC) was calculated using the

Penman, Van Bavel and Penman-Monteith methods. The fitness of regression was highest between actual evapotranspiration (ET) and EC calculated by the penman-Monteith method. The fitness was further improved when canopy resistance was corrected by the ratio of irradiated to total leaf area calculated empirically from LAI. Transpiration rate (T) could be estimated reliably from the product of ET and T/ET, which was calculated from the empirical equation as a function of LAI.

Baker et al. (1997) projected the future climate change to include a strong likelihood of continued increases in the atmospheric carbon dioxide concentration ([CO_2] and possible shifts in precipitation patterns. Due mainly to uncertainties in the timing and amounts of monsoonal rainfall, draught is common in rainfed rice production systems. the objectives of this study were to quantify the effects and possible interactions of ([CO_2]) and draught stress on rice photosynthesis, evapotranspiration and water use efficiency. Rice cv. IR-72 was grown to maturity in eight naturally sunlit, plant growth chambers in atmospheric carbon dioxide concentrations [CO_2] of 350 and 700 μmol CO_2/mol air. In both [CO_2], water management treatments included continuously flooded controls, flood water removed and draught stress imposed at panicle initiation, antithesis, and both panicle initiation and antithesis. Potential acclimatization of rice photosynthesis to long term [CO_2] growth treatments of 350 and 700 μmol mol^{-1} was tested by comparing canopy photosynthesis rates across short-term [CO_2] ranging from 160 to 1000 μmol mol^{-1}. These tests showed essentially no acclimatization response with photosynthetic rate being a function of current short-term [CO_2] rather than long-term [CO_2] growth treatment. In both long term [CO_2] treatments, photosynthetic rate saturated with respect to [CO_2] near 510 μmol/mol. Carbon dioxide enrichment significantly increased both canopy net photosynthetic rate (21-27%) and water-use efficiency while reducing evapotranspiration by about 10%. This water saving under [CO_2] enrichment allowed photosynthesis to continue for about one to two days longer during draught in the enriched compared with the ambient $[CO_2]$ control treatments.

Bhardwaj A. K. et al. (1992) conducted a field and lysimeter study during the rainy seasons of 1985 and 1986 in submerged rice (Oryza sativa L.) culture in Mollisols of Nainital foot-hills, to study the effect of 3 forms of urea (prilled urea, urea supergranules of 1 g size and neemcake-coated urea) and 3 levels of N (56, 84 and 112 kg N/ha) on NH_4^+ and NH_3^- N contents of soil and N uptake by rice crop. In lysimeter ^{15}N-labelled urea forms were used to study the uptake of N from applied fertiliser. The NH_4^-N content in soil was the highest at tillering stage of the crop and it declined subsequently upto crop maturity. Its content increased with an increase in N level. Initially at tillering stage, NH_4^+-N was similar under different urea forms indicating uniform hydrolysis of urea, but at later stages higher NH_4^+-N was maintained in plots treated with urea supergranules, indicating reduced nitrification losses of NH_4^+-N. At tillering stage NO_3^--N in soil was less in plots treated with urea supergranules and neemcake-coated urea, indicating slow rate of nitrification as compared to prilled urea and reverse was true at panicle-initiation stage when NO_3^-N was a little higher in plots treated with urea supergranules and neemcake-coated urea. This shows higher availability of soil nitrogen (NH_4 and NO_3) in plots treated with urea supergranules and neemcake-coated urea, compared with prilled urea. This was also reflected in higher n uptake from plots treated with urea supergranules. The uptake of fertiliser ^{15}N from urea supergranules, neemcake-coated urea and prilled urea was 52.6, 33.8 and 27.7 kg out of 84 kg N/ha applied.

Humphreys et al. (1994) reviewed field measurements of evapotranspiration from rice (ET_{rice}) in the Murrembridge Valley of Southern New South Wales. The results are compared with US Class A open pan evaporation (E_{pan}) at CSIRO Griffith, and with reference evapotranspiration (ET_o) calculated using locally calibrated Penman equation. Both methods (ΣET_{rice}, ΣE_{pan} or $\Sigma Et_{rice} = \Sigma ET_o$) gave good estimates of total evapotranspiration from flooded rice over the ponded season of about 5 months, from October to February. Variation between seasons in total ET_o, rainfall and ET_o minus rainfall is large. Over 32 years, total seasonal ET_o varied by a factor of 1.5, while rainfall varied > ten fold. The irrigation water requirement for rice Σ (ET_o – rainfall) varied from 685 mm in 1992-93 to 1350 mm in 1990-91. This large variation highlights the need to adjust the rice water use limit (16 ML/ha or 1600 mm) on a seasonal basis, to detect and eliminate high water use paddocks where percolation to the groundwater or surface runoff is excessive (> 2 ML/ha). On average, an irrigation requirement of 10.5 ML/ha is needed to replace net evaporative loss Σ (ET_o – rainfall) for rice flooded for 5 months, October-February. Monthly totals of ET_o are compared for several locations within the rice growing areas of southern New South Wales, and differences between locations are found to be small and not sufficient. This reflects the strong dependence of evaporation on radiant energy, which is unlikely to vary spatially to a significant extent across the region. ET_o calculated from meteorological data collected as CSIRO Griffith therefore provides a definitive basis for estimating evapotranspiration from rice in southern new South Wales. Furthermore, CSIRO Griffith has a computerised meteorological database going back to the 1930s. Current meteorological data and historical records are readily available by contacting the Metdata Manager. Therefore, the case is made for using CSIRO Griffith ET_o as the reference for estimating evapotranspiration from rice in southern New South Wales. This study provided farmer, Land and Water Management Plan groups, and policy makers with a tool that can be used, on a yearly basis, to evaluate rice paddock water use efficiency. It should be adopted to confine rice growing to the least permeable soils.

Joseph and Havanagi (1988) studied Evapotranspiration (ET), pan evaporation (E) and ET/E were at different stages of crop growth in rice, during different seasons under shallow water table conditions. Seasonal ET in rice ranged from 45.23-57.12 cm under tank irrigation with shallow submergence of 1-5 cm standing water in the field. Water use and ET were greater in the first half of crop growth. The ET/E ratio for the crop season ranged from 0.76-1.06.

Mishra and Sharma (1997) conducted an experiment on integrated nutrient management was initiated during 1980, involving 3 levels, i.e., 0, 50 and 100% recommended NPK (120, 50 and 40 kg/ha) through fertilisers, 10 t/ha FYM, 13 kg blue green algae applied singly and in conjunction under rice-wheat and rice-winter maize cropping systems. In the 10^{th} year of cropping, evapotranspiration and percolation rates of the rice field increased with increasing level of fertilisers and continuous use of FYM either separately or in combination. However, addition of blue-green algae reduced the evapotranspiration rate. With respect to growth stages, the rate of evapotranspiration was maximum in rice-wheat and in rice-winter maize cropping systems at milking stage and thereafter it decreased. The percolation rate was found to increase with lapse of time from planting of rice.

Radersma et al. (1996) reported the literature data on crop parameters and environmental conditions that determine transpiration for four crops (oil palm, cocoa, maize and rice) and evaporation are analysed since land use changes from perennial to annual crops, and vice versa, may affect water balances, in particular through changing evapotranspiration rates, with great implications for modelling. Direct comparison of evapotranspiration rates published in the literature is difficult since differences in soils and climate make data incomparable. Transpiration at leaf scale and soil evaporation, as well as evaporation of intercepted rainfall, have been computed using these data and were scaled up to canopy scale to level out variation among crops owing to crop characteristics. The objective was to quantify evapotranspiration of the crops under identical environmental conditions at two temporal scales : daily and annually. Differences in annual evapotranspiration between perennial and annual crops occurred since perennial crops transpire during the dry season which, although at low rates, was still considerably higher than evaporation rates from bare and dry soils. The degree of soil cover with vegetation in space and time is of major importance in the evaluation of differences in annual evapotranspiration caused by changes in land use.

Sahoo et al. (1996) reported the reference crop evapotranspiration (ET at the 20% probability level for the existing climatic conditions) and crop coefficient values (K_c) were measured for rice, groundnuts, mustard [Brassica juncea], sesame, green gram [Vigna radiata], black gram [V. mungo], potatoes, tomatoes, cauliflowers, cabbages, radishes, onions, cucumbers, pumpkins, brinjals [aubergines] and beans (green) [Phaseolus vulgaris] grown in the command area of Kacharamal minor (Orissa), and their crop water requirements were determined. monthly ET was highest (175.91 mm) for Aug. and aman rice in June and lowest (26.42 mm) for green gram and groundnuts in December. Seasonal ET values were highest (598.32 mm) for aman rice and lowest (140.37 mm) for radish.

Zhou et al. (1993) constructed a model of evapotranspiration of paddy rice using leaf area and meteorological data. The model gave a close estimate of evapotranspiration, had a smaller error than Penman-Monteith model and did not require the wind speed observations used in the Penman-Monteith model. Sensitivity analysis of parameters showed the model to be practical and reliable. During the growth period, evapotranspiration peaked at jointing and panicle emergence to flowering stages.

2.3 CROP WATER USE

Hira et al. (1996) reported that the Indian Punjab (1.5% of India) has the largest canal irrigation system of India, 0.85 million shallow tubewells, and experiences phases of rising of groundwater tables, water logging, salinity, and falling water tables, putting the future of the Punjab farmer, irrigated agriculture, and the Central Punjab agriculture in danger. Reasons for these problems were analysed and remedial measures for altering evapotranspiration of rice, and recharging groundwater by canals, suggested.

Kurray (1998) conducted the field trial on Pusa Basmati 1 taking different levels of irrigation and fertiliser doses and tested the evapotranspiration, growth development, yield and yield attributes ET_c. He reported that increasing the level of irrigation increased the grain yield. Improving the fertiliser dose increased the production. Lysimeter with higher doses of fertiliser recorded increased evapotranspiration and crop coefficient at different growth stages.

Mathew Jose et al. (1991) conducted a field experiment during the summer and rainy seasons (kharif) of 1988 to find out the effect of timing of initial flooding and nitrogen on dry seeded bunded rice. The best irrigation schedule for dry seeded bunded rice was the flooding at 35 days after showing followed by post flood schedule of irrigation 1 day after the disappearance of water. Nitrogen application in 3 splits – 50:25:25 and 25:50:25% of 100 Kg N/ha at 20 days after showing, active tillering and panicle-initiation stages respectively recorded higher grain and straw yield.

Reddy M. N. et al. (1987) carried out a field investigation at the Agricultural Research Station, Maruteru (A.P.) during 1984-86. Continuous flooding (3-5 cm depth) was found to be significantly superior in increasing grain yield and in reducing weed growth over saturation regime. Marked decline in yield was not noticed by irrigating the crop even four days after disappearance of water. However, flooding the field five days after complete recession of water caused a reduction of 38.9% in grain yield. The water use efficiency was highest under flooding one day after disappearance of water and lowest in continuous flooding. Weed growth was reduced under prolonged flooding. Continuous submergence regime though suppressed grass and sedge population, stimulated broad leaved weeds.

Prasad U.K. et al. (1992) conducted a 2-year experiment with direct seeded rice (Oryza sativa L.) at Pusa with 4 levels of irrigation (3, 5, 7 days drying after disappearance of 7 cm ponded irrigation water and a rainfed control) along with 4

N levels (0, 40, 80 and 120 kg/ha). Rice field can be dried even upto 7 days after disappearance of irrigation water with a grain yield of 19.13-21.29 q/ha and set return of Rs. 2,648-3,014/ha against similar yields at 3 or 5 days drying. However, rainfed control showed a significant decrease in grain yield compared with the other drying periods. Response to N was recorded up to 80 kg N/ha, with a rice yield of 22.19-23.70 q/ha compared with 24.10-25.28 q/ha at 120 kg N/ha, both being at par with each other. Water-production function and growth character were also significantly decreased due to rainfed control and lower levels of N in most of the cases.

Rathore et al. (1996) reported that shortage of water in eastern madhya Pradesh, India is caused by uneven distribution of rains, significant gaps between rain events and field water losses rather than from low seasonal or annual rainfall totals. The results of water balance studies in a 1.05 ha field, with a 0.09 ha farm pond (which stored excess water from the wet season) showed that 28-37% of seasonal rainfall was available as surface runoff from a microcatchment 90.66 ha growing soybean, groundnut and pigeonpea [Cajanus cajan] for collection in the pond. This was sufficient to prevent draught stress in rice in a 0.30 ha area and for the establishment of chickpea (Cicer arietinum) and mustard (Brassica nigra) (in 0.90 ha) in the post-rainy season. Soybean, groundnut and pigeonpea, grown in the microcatchment during the rainy season, utilised respectively 371-726, 364-733 and 535-920 mm water in evapotranspiration (E_t) and deep percolation (P). Rice grown below the pond required 23-317 mm water in different seasons to save the crop from in-season draught stress which occurred during the vegetative and reproductive stages. The water requirement (E_t + P) of rice was 816-1342 mm in different seasons. Residual soil moisture after rainy season soybean, groundnut and rice was sufficient (172-203 mm) to support post-rainy season crops of chickpea and mustard. Losses of moisture from the soil surface layer after harvest of rainy season crops were rapid (7-23 mm), which necessitated a light irrigation

(21-45 mm) for the establishment of chickpea in the post rainy season. The water balance results of soybean-mustard, groundnut-mustard and groundnut-chickpea were nearly identical to soybean-chickpea cropping. Similarly, the water balance of rice-mustard was identical to rice-chickpea in Vertisols.

Singh R. D. et al. (1994) conducted an experiment during 1986-87 and 1987-88 at Pusa to evaluate the irrigation requirements of different rice based crop sequence. There was a positive gain in nitrogen and potassium in all the crop sequences at different levels of winter and summer irrigations but phosphorus balance was negative. Maximum nitrogen balance was recorded under rice-gram-green gram (128 kg N/ha) cropping sequence, whereas maximum potassium balance was under rice-maize-black gram (184 kg K/ha). Phosphorus balance sheet showed a loss in all the crop sequences. Maximum loss of phosphorus was recorded under rice-potato-green gram sequence.

Singh et al. (1992) conducted an experiment during 1986-87 and 1987-88 at Pusa to evaluate irrigation requirements of different rice based crop sequence. A significant in yield equivalence and net return due to different crop sequence was observed. Maximum yield equivalence (145.66 and 159.46 q/ha) was recorded in rice Rs. 15,534 and Rs. 18,193/ha during 1st and 2nd years respectively. This value was recorded when irrigation was scheduled with 3 days disappearance of ponded water in rice, 1.2 IW:CPE ratio in potato and 2 irrigations at 20 and 40 days after sowing in green gram with a total quantity of 131.80 and 188.91 cm/ha of water in all 3 crops of the sequence. Maximum quantity of water (145.80 and 188.55 cm/ha) was required by rice-maize) Zea mays)-blackgram (phaseoulus mungo L.) but the income was less than former sequence, though it was higher than remaining 3 sequences. Minimum yield equivalence (66.93 and 77.88 q/ha) and net profit (Rs. 7.971 and Rs. 10,198/ha) were recorded in rice-chickpea green gram sequence. Water use efficiency was also higher in rice-potato-green gram) 110.51 and 113.24 kg ha-cm) than others.

Verma (1999) conducted the field experiment during kharif 1999 at Roorkee on Pusa Basmati 1 taking different level of fertiliser, determine the evapotranspiration, crop coefficient tested the growth development, yield and yield attributes. He found that the application of copper improved the growth and development in crop, lysimeter with higher dose of fertiliser recorded increased evapotranspiration and crop coefficient at different growth stage.

Wahab K. et al. (1992) carried out an experiment during the winter (Rabi) seasons of 1986 and 1987 at Killikulam. The soil was gravelly clay, having a medium fertility status. Azolla was applied as dual crop at 100 g/m2 at 7 days after transplanting and allowed to grow. It was incorporated at 30 days after transplanting. Blue green algae (BGA) was applied at 7 days after transplanting @ 12.5 kg/ha. Continuous submergence (5 cm) resulted in the highest grain yield during both the seasons, followed by irrigation given immediately after the disappearance of ponded water. The straw yield also showed similar results. Nayak et al. (1981) and Prasad and Sharma (1984) also reported similar results. Water consumption was the highest under continuous submergence during both the years, followed by irrigation given immediately after the disappearance of ponded water. There was no significant difference between 75% recommended dose of N + biofertilizers (Azolla or BGA or a combination of both) and 100% recommended dose of N. This indicates saving of 25% of fertiliser N. The results indicate that continuous submergence can be beneficial under conditions of liberal supply of water. Irrigating rice crop (5 cm depth) immediately after the disappearance of ponded water can be practiced under conditions of limited water supply to get maximum benefit. Applications of Azolla or BGA to rice crop saves 25% fertilizer nitrogen.

2.4 Fertilizer Management

While advocating use of higher fertilizer which is essential for full yield expression of the high-yielding, dwarf varieties, research emphasis has always been for determining the economic optimum dose, need based application of various fertilizer nutrients, enhancement of nutrient-use efficiency and conjunctive use of organic and inorganic sources.

Increased Fertilizer N-Use Efficiency

Modified urea materials have been tried in flooded rice. Granulated compost and urea supergranules (USG) have been found to yield around 0.8 tonne/ha more than prilled urea. Coated urea materials have also similar yield advantage. Results of the IRRI-sponsored INSURF trials, for instance, indicate application of 50 kg N/ha through best splits to give 4.3 tonnes/ha compared with 4.7 and 4.9 tonnes/ha in respect of sulphur-coated urea and urea supergranules.

Nitrogen Management in Rainfed Ecologies

With the present-day price of fertilizers and rice, a rate of 30 to 40 kg N/ha with a ceiling of 60 kg N/ha in rainfed uplands has been found optimum to realize grain yields in the range of 2.5-3.5 tonnes/ha with a benefit : cost ratio of 4:5. Withholding basal dose application of 50-60% of N 3 weeks after planting, incorporation into soil, 20-25% when the crop is 40-45 days old and rest at boot-leaf stage reveal grain responses ranging from 26 to 54 kg/kg N (depending on the rainfall patterns), with an average of 37 kg grain kg N.

In alluvial deltaic soils of average fertility, application of 30-40 kg N/ha has been found to be optimum with ceiling at 60 kg N/ha for rainfed low-lands (intermediate and semi-deep water regimes). If the above moderate nitrogen application is coupled with good management, it is possible to achieve an yield of 4 tonnes/ha. Sub-surface application at sowing has proved better than split application. For the transplanted crop, application of N in nursery at 100 kg/ha enables the crop later to tolerate submergence. Where split application of N as urea has not been found effective, deep placement in a single dose at planting either as urea supergranules or as granulated compost (55 N) has been found quite effective. Since urea supergranule is still not adopted widely because of application problem, granulated compost and coated urea material are becoming popular.

Integrated Nutrient Management

Excessive and exclusive dependence on inorganic sources for N nutrient over the years have introduced new problems threatening soil productivity on a sustainable basis. Breaking from the age-old practice of using organic manures either alone or along with inorganic sources has resulted in the depletion of soil organic carbon content to much lower than the critial level and thus induced deficiency of micronutrients like Zn, S etc. Incorporation of 6000-8000 kg green matter to the soil has been found to be equivalent to the application of 40 kg N/ha through inorganic fertiliser. Combination of organic manures such as farmyard manure (FYM) of green-manure crop with inorganic N sources substitutes the latter 40-50% besides substantially reducing the cost on nutrient input. Significantly, continued practice of integrated nutrient management has helped sustain the productivity level of rice soils in different parts of the country without lowering the level of N-use efficiency.

Fertilizer Economy through Appropriate Rice-based Cropping Systems

Application of P and K fertilizers in rice-rice and rice-wheat rotations either in rainy (kharif) or winter season (rabi) or in both the seasons does not influence the grain yield of kharif rice significantly indicating that it is economical to apply P and K fertilizers to rabi crop (wheat or rice) and zinc to kharif rice in such rotations.

Nitrogen

Nitrogen Fertility Status of major Rice-Growing Soils : Soil samples collected from top 20 cm layer of 19 rice-growing farms across the country were analysed, revealing more than 60% of the soils to be low in their N-supplying capacity.

Nitrogen transformation and balance in flooded rice soils : The stable isotopic (N) studies with a lowland rice showed that rice derives 69% of its total N need from soils and the rest from applied fertilizer or manure. About 40-60% of the N applied through chemical fertilizer is lost through various pathways – 23% of the applied N by ammonia volatilization, 15% by denitrification and 2% by leaching. The N mineralization from organic residues has been found to be influenced by seasonal conditions and residue characteristics. Application of urea or green-manure N enhances the soil N uptake by rice. Application of organic manures of wider C : N ratio immobilizes mineral N present in soil or applied through fertilizers.

Loss of Applied Fertilizer N in Lowland Rice Fields : Loss of urea N applied in 3 splits to kharif rice has been estimated in field experiments conducted at different locations. The loss by ammonia volatalization ranges from 1 to 4%, by leaching 8 to 14% and by denitrification, immobilization and other unknown mechanisms together 43 to 61%. The losses are more in light textured and alkaline soils. These losses could be considerably reduced by using coated or modified urea in place of prilled urea as N source.

Advantage of Coated or Modified Urea Materials as N Source for Lowland Rice : Multilocation field experiments conducted over several years to evaluate various N fertilizers for lowland rice reveal application of neemcake-coated urea, gypsum-coated urea, mussorie rockphophate-coated urea or urea supergranules in single basal dose to be significantly superior to prilled urea applied in recommended splits. Under farmers practice of field to field irrigation, basal as well as split application of neemcake-coated urea reduces N losses and increase n uptake by rice.

Nitrogen Release Pattern and Efficiency of Organic Manures in Low Land Rice : The N release pattern of FYM, rice straw, sesbania and Gliricidia incorporated in submerged rice soil and their efficiency as N sources have been compared with that of urea in a series of field experiments. While urea has been found superior to all the organic manures during rabi seasons, green manures are as effective as urea for kharif rice.

Efficient N Management Practices for Wet-seeded Rice : Total N requirement of wet-seeded rice (established in the main field by sowing of sprouted seeds) has been found to be similar to that of the transplanted crop. Wet-seeded rice, however, requires very little or no supply of fertilizer N during the first 3-4 weeks. Much of the fertilizer N supplied through basal dose is not utilised by the crop and instead lost from the root zone.

Efficient Use of (Native) Soil N in Lowland Rice : Rice derives almost two-thirds of its total N from native soil N pool even when recommended level of fertilizer N is applied. Mineral N availability in rice soil and its use by different rice varieties have been studied at Hyderabad. In the absence of fertilizer N use, 0-45 cm soil profile supplies to rice crop about 60 kg mineral N/ha. About 45% of this N resides below the top 15 cm layer of the profile. Efficiency of soil N use varies with cropping season, and also with varieties. Late-maturing varieties like Pranava and Salivahana, for instance are more efficient user of soil N than early maturing ones like Aditya and Prasanna. If medium-duration varieties yield more than 3 tonnes grain/ha without using any fertilizer N, early-maturing one yield only 1 tonne grain/ha. In other words early ones like Aditya and Prasanna require 120 kg fertilizer N/ha to produce same yields as Pranava.

The effect of land submergence on the growth and yield of rice

Studies have been undertaken by many workers to determine the effect of land submergence on the growth and yield of rice (Bhatia and Dastane, 1971; Asana and Sarin, 1968; Singh et al., 1967; Bal, 1935; Chakladhar, 1946; Choudhary and Singh, 1963; Vamadevan and Dastane, 1968; Choudhary and Pande, 1966, 1968; Ghildyal and Jana, 1967; Rajale and Prasad, 1970; Pande and Singh, 1969; Pande and Mitra, 1971; Lenka et al, 1971; Sen and Dutta, 1967; Vemadevan and Manna, 1971; Satyanarayana and Ghildyal, 1970; Datta and Shinde, 1965; Mahapatra, 1968; Nelliat and Dastane, 1970; Mane, 1969; Rao, 1971; Jha, 1972). The majority of the above workers state that the submergence is beneficial to the rice crop. Soil saturation appears to be sufficient for good yields under low atmospheric demands, whereas flooding seems to be essential under high atmospheric evaporative demands (Ghildyal and Jana, 1967; Jana and Ghildyal, 1969).

The depth of submergence

The advantages of land submergence led the workers to initiate work to know the optimum depth of submergence for obtaining the maximum yield.

Ganguli (1950) working in Assam reported that the water level of 7.62 cm throughout the growth period of rice was the best, whereas Pillai (1958) inferred that the maintenance of 5.08 cm of standing water, with frequent changes, with fresh water resulted in high rice production.

In the black soil of Siruguppa, Mysore (Anonymous, 1970), submergence under 5 cm deep water resulted in the highest grain and straw yields obtained under the following three treatments :

(a) 5 cm submergence, (b) saturation to hair-cracking, and (c) flowing water

A thin layer of water is sufficient to maximize the yield of rice; no additional advantage occurs from very deep submergence, which entails only wastage of water.

Bhatia and Dastane (1971) found that a depth range up to 0-4 cm seems to be the optimum for high-yielding dwarf rice.

The above workers further added that for dwarf rice varieties, deeper submergence may be harmful, as shown above. Pande and Mitra (1970) found that the grain yield of rice was better under submergence than under meter saturation during summer and spring and also that the crop under shallow submergence (5 ± 3 cm) gave as good a yield as deep submergence (10 ± 3 cm).

Ghildyal and Jana (1967), on the basis of pot experiments, observed in general that the highest yield was obtained during a cool and dry season, with 0-3 cm of water, Pande and Singh (1972) from Kharagpur found that shallow submergence was better than deep submergence.

The results of the experiments conducted recently under the All-India Co-ordinated Scheme for Research on Water Management and Salinity 9Yadav, 1972) have shown that the field submergence under water 5 to 10 cm deep does not produce any significant difference in the yield and hence, shallow submergence up to 5 cm is economical.

From an experiment conducted at Bhubaneswar on a sandy loam soil with a pH of 4.9. Sahu and Rout (1969) reported that the lowland rice (T1242) gave the maximum yield when the soil was kept submerged under 15 cm of water. The yield was reduced by 26.4% under field capacity and 29.2 at 75 percent available moisture as compared with the yield under deep continuous submergence, through the efficiency per unit of water used was higher from the first two treatments.

Nephade and Ghildyal (1971) observed in a laterite sandy clay loam soil with a pH of 5.1 at Kharagpur that the yield of rice was higher under shallow flooding (3 cm0 than under deep flooding (15 cm). Chandra Mohan (1970) from Tamil Nadu reported that among the various depths of submergence, the 5 cm depth of water proved, in general, to be the optimum depth of submergence for getting the best yield.

According to Ghose et al. (1956), a small quantity of water used at shorter intervals was more beneficial to the rice crop than larger quantities at longer intervals.

The results of studies made at Kharagpur on a laterite soil (pH 5.4, hydraulic conductivity, 0.51 cm/hr, of low fertility 0.04%N, 0.0055% available P and 0.1% available K) under the Co-ordinated Project for Research on Water management and Salinity show that during the monsoon season, shallow submergence and deep submergence were as good as saturation for 'IR.8' rice because of the effect of rains, low evaporative demands, but during summer, shallow submergence scored over deep submergence or saturation.

The work done at Chakuli (sandy loam soil), Orissa at Siruguppa Iheavy black soil with 50% clay), Mysore and at Roorkee (alluvial soil), Uttar Pradesh, under the Co-ordinated Scheme (Yadav, 1970) showed that submergence up to 5 and 10 cm did not show any significant difference in yield, and therefore, submergence upto 5 cm only was economical.

The results discussed above show that for tall rice varieties, a slightly higher depth of submergence may be tolerated, whereas for new dwarf high-yielding rice varieties, a depth of 5 cm is enough to get a good yield.

Effect of partial submergence

Since the continuous submergence of the field involves a huge quantity of assured water, many workers started experiment to find out the critical period of land submergence for economizing on water.

According to Singh et al. (1935), Ghosh and Bhattacharya (1958), Sen and Dutta (1967), Vamadevan and Dastane (1968), Chaudhary and Pande (1968), tiller initiation primordium initiation and flowering are the most critical stages. A shortage of water during these stages could reduce grain yield appreciably. Therefore, submergence at these stages should be practiced. Further, Ray and

Pande (1969) emphasized the point that the flowering stage was the most critical period.

Experiments were conducted, using the variety 'IR.8' in the daula season (January-May 1972) on a medium-textured soil at Chakuli (Orissa) and in February–June 1972 and july-October 1972 on a lateritic soil at Kharagpur (West bengal) to study whether submergence (5 ± 2 cm) was required throughout the growth period or only at certain growth stages. The data revealed that the highest grain yield at Chakuli was obtained when the soil moisture was maintained at saturation till tillering, followed by submergence under 5 cm of water till harvesting. Continuous submergence did not how any additional advantage, while continuous saturation till flowering brought about a reduction in the yield.

MATERIALS AND METHODS

This chapter deals with the materials and methods adopted in the conduct of the experiment during Kharif 2000 on demonstration farm of WRDTC located in the campus of the University of Roorkee, Roorkee, India.

3.1 SITE

The site of the experiment is located at latitude of 29°52' N and longitude of 77°54' E and the elevation is 262 m.

3.2 EXPERIMENTAL LAYOUT

The experiment was laid out with 3 irrigation levels, 3 fertiliser treatments and 3 replication. Details are shown in Fig. 1.

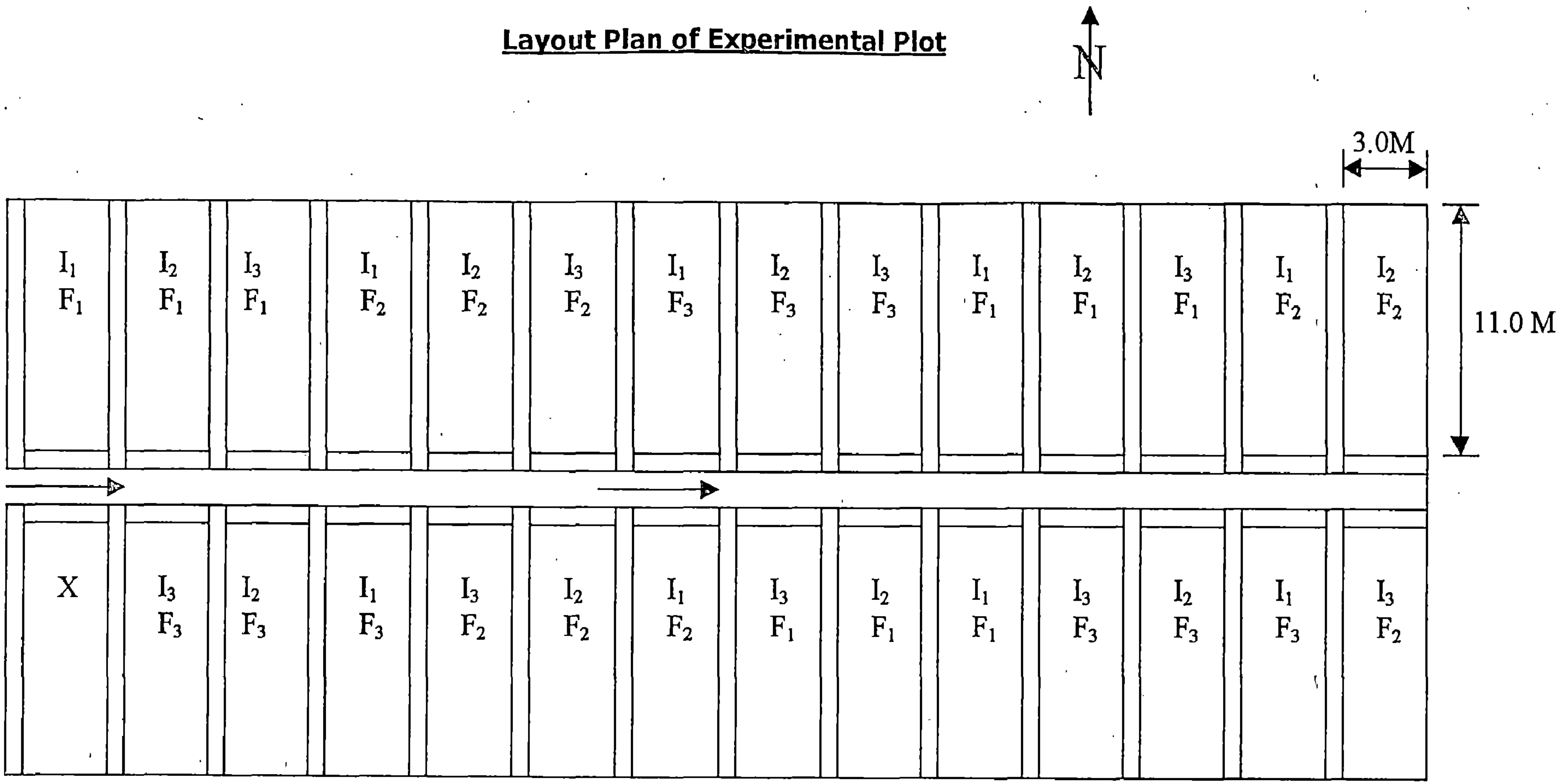
3.3 FIELD PREPARATION

Field preparation done by puddling for nursery and then transplanting the crop.

3.3.1 Nursery

Nursery was prepared giving three ploughing with tractor drawn cultivator. Irrigation water was first ponded on 11th June 2000 and puddling was done. 4 Kg DAP and 4 kg MOP was applied in the nursery area of 50 sq. m on 15th June 2000. The seed used in nursery was 5 kg of Pusa Basmati-1. The total depth of water used in the nursery was 1512 mm and total rainfall received during nursery was 434.6 mm. The nursery to transplanted area ratio was 1:20. Hence the depth of irrigation water used was 75.6 mm. Details are given in Annexure – 1.

Layout Plan of Experimental Plot



PLOT SIZE

Net size = 11.0 x 3.0 m
Total No. = 27
Net area = 891 m^2
Gross Area = 55 x 30 = 1650 m^2

IRRIGATION LEVELS = 3
I_1 = 40 mm/irr
I_2 = 80 mm/irr
I_3 = 120 mm/irr

FERTILISER LEVELS = 3
F_1 = 50 kg N/ha
F_2 = 100 kg N/ha
F_3 = 150 kg N/ha

- **REPLICATION = 3**

3.3.2 Transplanting

The seedling grew in the nursery from 16.6.2000 to 20.7.2000 for 35 days. The two seedlings were planted per hill maintaining a random spacing of about 15 cm x 20 cm. The field was prepared for transplanting by puddling the field on 21.7-2000 with 120 mm watering.

3.4 FERTILISER APPLICATION

The fertiliser was used in nursery and field as described below :

(1) Nursery was fertilised with 4 kg DAP and 4 kg MOP in basal dressing at the time of puddling.

(2) Field : The experimental field had the fertility of green manure given before preparation of field.

Fertiliser application :

F_1 = 50 kg/ha N

F_2 = 100 kg/ha N

F_3 = 150 kg/ha N

1/3 nitrogen and full dose of P & K was applied at the time of puddling. The nitrogen was applied; 1/3 at tilling and 1/3 at flowering. A uniform dose of 60 kgs P_2O_5, 60 kg K_2O and 25 kgs/ha $ZnSO_4$ was applied in the plot.

3.5 IRRIGATION

The irrigation was scheduled to be applied to the plot as per the treatments described below :

I_1 = @ 40 mm/irrigation

I_2 = @ 80 mm/irrigation

I_3 = @ 120 mm/irrigation

Weeds were removed manually as and when required.

3.6 SOIL ANALYSIS

The soil of the field was analysed for its soil textural class, pH and electrical conductivity. The root zone depth of soil was sampled to study the profile character of the soil. The soil was analysed as sandy loam in texture and pH and E_c being normal.

3.7 WEATHER

Weather parameters were recorded daily on agrometerological lab of the WRDTC demonstration farm from the date of nursery (16.6.2000) till the harvest. The weather data was used for calculation of evapotranspiration of reference crop (E_{TO}) by modified Penman method mentioned in FAO 24 Weather parameters data and E_{TO} calculation are given in Annexure II.

3.8 LYSIMETRIC EXPERIMENT

Cylindrical plastic drums of 54 cm ϕ and 85 cm length were used as a lysimeter and embedded in the field. The lysimeter filled with soil resembling their profile condition existing in the plot. The lysimeter were placed in I_1F_1, I_1F_2 and I_1F_3. Lysimeter were saturated and flooded to 15 mm depth of water. In each lysimeter 6 hills were transplanted with 2 seedlings each. Water level was maintained with the help of pointer fixed in the lysimeter.

The evapotranspiration of the crop was recorded daily in each lysimeter. On the clear day addition of water was recorded as evapotranspiration of the crop rice (E_{TC}), where on the rainy day, rainfall minus removal of water from the Lysimeter was recorded as crop evapotranspiration.

3.9 Computation of Reference Crop Evapotranspiration (E_{TO}) by Modified Panman Method

As already mentioned in the Chapter III of this study that for the areas where measured data on temperature, humidity, wind and sunshine duration or radiations are available, the Modified Panman method is accepted to give the satisfactory result. This method would offer minimum possible error of $\pm 10\%$ in summer and upto 20% under low evaporative conditions.

Due to this reason, the Modified Panman method is adopted in this study.

The relationship recommended in the Modified Panman method is given by

$$E_{TO} = c\,[W.R_n + (1-W)\,.\,f(u)\,.\,(e_a - e_d)\,]$$

where

E_{TO} = Reference crop evapotranspiration in mm/day

W = Temperature-related weighing factor

f(u) = Wind related function

$(e_a - e_d)$ = Difference between the saturation vapour pressure at mean air temperature and the mean actual vapour pressure of the air, both in m bar.

c = Adjustment factor to compensate for the effect of day and night weather conditions.

3.9.1 Description of Variables

(a) Vapour Pressure $(e_a - e_d)$

Air humidity affects E_{TO}. Humidity is expressed as saturation vapour pressure deficit $(e_a - e_d)$, i.e., the difference between the mean saturation water vapour pressure (e_a) and the mean actual water vapour pressure (e_d).

Air humidity data are reported as relative humidity (RHmax and RHmin in percentage) and its time of measurement is important. In our case, the relative humidity measured at 9.30 is considered as 'RHmax' while the same measured at 2.30 hrs is considered as 'RHmin'.

(b) Wind Function f(u)

The effect of wind on E_{TO} has been studied for different climates resulting in a wind function [f(u)] given by an expression as

$$f(u) = 0.27\,(1 + U/100)$$

where U is 24 hr wind run in km/day at 2m height.

Where wind data is not collected at 2 m height then appropriate corrections to be applied to the expression given for f(u) as above. But in our case the wind data is measured at 2 m height so no correction factor is needed to apply.

(c) Weighting Factor (1-W)

(1-W) is a weighting factor for the effect of wind and humidity on E_{TO}. Values and (1-W) as related to mean temperature and altitude are available in the ready reckoner table given in FAO-24.

(d) Weighting Factor (W)

W is the weighting factor for the effect of radiation on E_{TO}. Values of W as related to mean temperature and altitudes are available in the ready reckoner table given in FAO-24.

(e) Net Radiation (Rn)

Net radiation (Rn) is the difference between all incoming and outgoing radiation. It can be measured, but such data are seldom available. Rn can be calculated from solar radiation or sunshine hours (or degree of cloud cover0, temperature and humidity data.

Following relationships are recommended and may be used in the determination of net radiation (Rn).

$$R_n = R_{ns} - R_{nl}$$

$$R_{ns} = 0.75\,R_s$$

$$R_s = (0.25 + 0.5\,n/N)\,Ra$$

and $R_{nl} = f(T) \times f(e_d) \times f(n/N)$

where,

R_{ns} is net shortwave radiation

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R_s is solar radiation

R_a is extra terrestrial radiation in mm/day and dependent on latitude and time of the year only.

n/N is the ratio of actual (n) to maximum possible (N) sunshine hours

R_{nl} is net longwave radiation and can be determined from available temperature (T), vapour pressure (e_d) and ratio n/N.

f(T), f(e_d) and f(n/N) are the functions of temperature, vapour pressure and ratio n/N and can be determined from the tables available.

(f) Adjustment Factor (c)

The Penman equation given assumes the most common conditions where radiation is medium to high, maximum relative humidity is medium to high and moderate daytime wind about double the night time wind. However, these conditions are not always met.

Therefore correction to Panman equation is required. This correction is made by applying adjustment factor (c) to the Panman equation.

A table is available showing values of c for different conditions of RH_{max}, R_s, U_{day} and U_{day}/U_{night}.

3.9.2 Procedure of Computation and Sample Calculation

The procedure laid down in "Guidelines for predicting crop water requirements – FAO-24, publication 1992" for the modified Panman method to compute evapotranspiration (E_{TO}) is followed in this study. The tables given in the aforesaid guidelines are used in the calculations.

A sample calculation is illustrated below for the 20th July 2000.

The climatic data of July 2000 is shown at page no. iv of Annexure No. II and this data is used to calculate E_{TO}.

Steps of Calculations

(1) Maximum air temperature in °C = 32.0 (from climatic data)

(2) Minimum air temperature in °C = 25.0 (from climatic data)

(3) Mean air temperature in °C = (32.0 + 25.0)/2 = 28.5 (calculated)

(4) Maximum relative humidity (RHmax%) = 85 (from Table No. 6a calculated)

(5) Minimum relative humidity (RHmin%) = 73 (from Table No. 6a calculated)

(6) Mean relative humidity (RHmean%) = (85 + 73)/2 = 79 (calculated)

(7) Average wind speed in km/day (u) = 71 (climatic data)

(8) Wind speed (day) in m/sec = 0.23 (calculated)

(9) Sunshine hours (n) = 4 (from climatic data)

(10) Maximum possible sunshine hours (N) = 13.9 (from Table no. 11)

(11) Saturation vapour pressure (e_a) in mbar corresponding to mean temperature of 28.5°C = 38.95 (from Table No. 5)

(12) Actual vapour pressure (e_d) = (e_a x RHmean)/100
= (38.95 x 79)/100 = 30.77 (calculated)

(13) Vapour pressure deficit (e_a-e_d) = 38.95 – 30.77 = 8.18 (calculated)

(14) Wind function f(u) = 0.27 (1 + u/100) = 0.46 (calculated)

(15) Extra terrestrial radiation (R_a) corresponding to latitude 29°52′ N and month July in northern hemisphere = 16.8 (From Table No. 10)

(16) Ratio n/N corresponding to sunshine hour 4 = 0.29 (calculated)

(17) Short wave radiation R_s = (0.25 + 0.5 n/N) R_a = 6.61 (calculated)

(18) R_{ns} = 0.75R_s = 0.75 x 6.61 = 4.96 (calculated)

(19) Function of temperature f(T) corresponding to mean temperature 28.5°C = 16.40 (from Table No. 13)

(20) Function of vapour pressure f (e_d) corresponding to e_d = 30.77 = 0.10 (from Table No. 14)

(21) Function of sunshine duration f(n/N) corresponding to n/N = 0.29 = 0.36 (from table no. 15)

(22) Net longwave radiation $R_{nl} = f(T) \times f(e_d) \times f(n/N)$ = 0.59 (calculated)

(23) Net radiation $R_n = R_{ns} - R_{nl}$ = 4.37 (calculated)

(24) Adjustment factor 'C' corresponding to RHmax = 85%, R_s = 6.61,
Uday = 0.23 and Uday/Unight = 4 = 1.04 (from Table No. 16)

(25) Weighing factor W corresponding to mean temperature 28.5°C
and altitude 260 m = 0.78 (from Table No. 9)

(26) 1 – W = 1 – 0.78 = 0.22 (calculated)

(27) $E_{TO} = C [W \times R_n + (1-W) \times f(u) \times (e_a-e_d)]$ in mm/day = 4.41 (calculated)

3.10 GROWTH AND DEVELOPMENT STUDY

3.10.1 Plant Height

Plant height was recorded at 20 days interval with the help of metre scale. The height of plant was measured as average height of plant.

3.10.2 Tiller Number

The tiller number per hill recorded at 20 days interval from the two hills in each plot and average tiller number was recorded.

3.10.3 Leaf Area Index

Leaf Area Index (LAI) was calculated at 20 days interval. The length of leaf, breadth of leaf measured and shape factor was developed. The number of leaves per hill were counted to calculate LAI as mentioned below.

$$LAI = \frac{(\text{Hill no.}/M^2 \times \text{leaf no./hill} \times \text{Av. leaf length} \times \text{Av. leaf width} \times \text{shape factor}}{10^4}$$

3.10.4 Rooting Depth

Soil sample was collected between two hills of plant upto depth of 1.2 m. Soil samples were collected in the block of 15 cm each and presence of root in the different layers was seen with naked eyes and recorded as the rooting depth.

3.11 YIELD AND YIELD ATTRIBUTES

3.11.1 This was recorded from 1 m^2 area by counting the numbers of matured earhead before the harvest.

3.11.2 Filled grain per earhead

This was recorded by taking 10 earhead sample from each treatment and counting the number of filled grains per earhead.

3.11.3 Unfilled grain per earhead

This was counted from 10 earhead collected from different treatments for unfilled grains per earhead.

3.11.4 Test Weight

1000 grains were collected from each treatment from sample and its weight was recorded.

3.11.5 The husk was removed from the seed and the weight of husk and kernels were separately recorded to compute the hulling percent.

3.11.6 Yield

Yield was recorded harvesting the plants of 1 m^2 area from each treatment. The grains were dried in the sun. Weight was recorded for the estimation of yield per hectare.

3.12 QUALITY

3.12.1 Length of Kernel

After the hulling of grains, 6 kernels were collected from each treatment and the kernels were put on the graph sheet and average length of 6 kernels was recorded.

3.12.2 Breadth of Kernel

The 6 kernels were collected from each treatment and the kernels were put on the graph sheet and average breadth of kernel was recorded.

3.13 WATER USE EFFICIENCY

Water use efficiency was measured as Irrigation Water Use Efficiency (IWUE = grain yield (kgs)/irrigation applied (m^3) and Total Water Use Efficiency (TWUE = grain yield (kgs)/total water applied (m^3).

3.14 ANALYSIS OF VARIANCE

Data collected on growth and development of paddy plant at every 20 days interval and yield attribute and quality at harvest were analysed statically with factorial design using Indostat Agronomy Pack Software. The analysis of Variance Table used was as follows :

C. Factor		**C.V.**			
Source of variance	**d.f.**	**Sum of squares**	**Mean sum of squares**	**F. value**	**F. Prob.**
Block	2				
F	2				
I	2				
F x I	4				
Error	17				
Total	27				

3.15 GRAPHICS AND CURVE FITTING

Graphics regression, correlation and curve fitting of the data was done using Microsoft Excel and Curve Expert.

OBSERVATIONS

Observations recorded during the experiment are discussed in this chapter.

4.1 WEATHER AND HYDRAULIC CONDITION

Weather and hydraulic conditions recorded were rainfall (mm), E_{TO} (mm), evaporation (mm), average ground water level (m), sunshine (hrs), average temperature (°C) and humidity (%) are presented in Table 4.1. The total rainfall was 1180.60 mm, E_{TO} was 736.20 mm, average ground water level varied between 0.76 m to 3.00 m, average sunshine varied between 4.32 hrs to 10.20 hrs and average humidity varied between 53.50% to 81.45%.

Table 4.1 : Weather and hydrologic condition during experimental period (01/06/2000 – 25/10/2000)

Period (date)	Rainfall mm)	E_{TO} (mm)	Evap. (mm)	Av. GWL (m)	Sunshine (hrs)	Humidity (%)
1.6-10.6	224.80	57.97	30.4	1.72	8.40	72.65
11.6-20.6	10.00	63.90	33.6	2.56	8.60	71.45
21.6-30.6	123.80	58.34	27.3	3.00	8.25	71.35
1.7-10.7	66.60	60.89	27.1	1.79	8.60	73.80
11.7-20.7	234.20	47.53	18.0	0.73	5.00	78.50
21.7-31.7	112.20	48.07	24.4	0.90	4.32	81.36
1.8-10.8	39.00	61.26	28.6	0.76	10.20	76.35
11.8-20.8	128.60	46.31	25.4	1.02	6.10	81.45
21.8-31.8	273.40	46.39	22.8	1.26	4.91	77.36
1.9-10.9	68.40	45.01	27.7	0.88	7.25	74.20
11.9-20.9	0.00	50.19	26.9	1.52	8.30	70.55
21.9-30.9	10.6	49.43	27.4	1.97	9.35	64.95
1.10-10.10	0.0	47.23	24.7	2.35	9.85	63.45
11.10-20.10	0.0	39.10	24.0	2.68	9.75	53.50
21.10-25.10	0.0	19.17	8.80	2.94	8.65	60.30
Total	1291.60	736.29	377.10	-	-	-

4.2 TOTAL WATER USE

The total water use recorded in different treatments of irrigation is given in Table 4.2. There were three treatments I_1, I_2 and I_3 which recorded water use of 1231.40 mm, 1431.40 mm and 1631.40 mm respectively. The period in which the water use recorded maximum was in the last decadal of August 2000.

Table 4.2 : Total water use (Irrigation and rainfall) in rice

Period (date)	I_1 (F_1-F_3) (mm)	I_2 (F_1-F_3) (mm)	I_3 (F_1-F_3) (mm)	Total (F_1-F_3) (mm)	Average (mm)
11.6-20.6	85.6	85.6	85.6	256.8	85.6
21.6-30.6	12.8	12.8	12.80	38.4	12.8
1.7-10.7	66.6	66.6	66.60	199.8	66.6
11.7-20.7	234.20	234.2	234.20	702.6	234.2
21.7-31.7	112.20	112.2	112.20	336.6	112.2
1.8-10.8	79.0	119.0	159.0	357.0	119.0
11.8-20.8	128.6	128.6	128.6	385.8	128.6
21.8-31.8	273.4	273.4	273.4	820.2	273.4
1.9-10.9	68.4	68.4	68.4	205.2	68.4
11.9-20.9	40.0	80.0	120.0	240.0	80.0
21.9-30.9	50.6	90.6	130.6	271.8	90.6
1.10-10.10	0.0	0.0	0.0	0.0	0.0
11.10-20.10	80.0	160.0	240.0	480.0	160.0
21.10-25.10	0.0	0.0	0.0	0.0	0.0
Total	1231.40	1431.4	1631.4	4294.2	1431.4

4.3 EVAPOTRANSPIRATION

Lysimetric experiment conducted with three treatments and evapotranspiration during different periods of growth is presented in Table 4.3.

The average, the total evapotranspiration was 621.21 mm. The daily average varied with the growth stage. Last decadal of September recorded maximum average actual evapotranspiration, i.e., 9.40 mm/day.

Table 4.3 : Crop evapotranspiration (mm) in rice grown under different fertility treatments in Lysimeter.

Period (date)	I_1F_1	I_1F_2	I_1F_3	Daily Average (mm)	Total (mm)
28.7-31.7	9.98	8.73	9.17	2.32	9.29
1.8-10.8	46.62	45.81	480.03	4.68	46.82
11.8-20.8	50.88	45.60	56.81	5.11	51.09
21.8-31.8	54.70	48.07	57.18	4.85	53.31
1.9-10.9	74.33	67.42	93.37	7.83	78.37
11.9-20.9	85.16	78.23	109.40	9.09	90.93
21.9-30.9	86.96	83.19	112.01	9.40	94.05
1.10-10.10	80.42	78.38	103.15	8.73	87.31
11.10-20.10	79.84	78.30	96.96	8.50	85.03
21.10-25.10	23.67	23.33	28.04	5.00	25.01
Total	592.56	557.06	714.12	-	621.21
Average	6.58	6.19	7.93	-	6.90

4.4 CROP COEFFICIENT

The crop coefficient developed from three different lysimeters are given in Table 4.4. The overall average crop coefficient throughout growing period recorded was 1.46. The Lysimeter that received nitrogen application (150 kg/ha) recorded 1.68 and the Lysimeter received nitrogen application (100 kg/ha) recorded 1.32.

Table 4.4 : Crop coefficient (K_c) of rice grown under different fertility treatments in Lysimeter

Period (date)	Lysi. 1	Lysi. 2	Lysi. 3	Average
28.7-31.7	0.77	0.67	0.71	0.72
1.8-10.8	0.76	0.75	0.78	0.76
11.8-20.8	1.10	0.98	1.23	1.10
21.8-31.8	1.18	1.04	1.23	1.15
1.9-10.9	1.65	1.50	2.07	1.74
11.9-20.9	1.70	1.56	2.18	1.81
21.9-30.9	1.76	1.68	2.27	1.90
1.10-10.10	1.70	1.83	2.41	1.98
11.10-20.10	2.04	2.00	2.48	2.17
21.10-25.10	1.23	1.21	1.46	1.30
Total	13.89	13.22	16.82	14.63
Average	1.39	1.32	1.68	1.46

4.5 LEAF AREA INDEX IN LYSIMETER

Leaf area index was measured at 20 days interval and is recorded in Table 4.5. The maximum leaf area index was recorded at 60 days after transplanting. Treatment also considerably varied in the LAI. The maximum was recorded in treatment I_1F_3 (5.90) and minimum was recorded in treatment I_1F_2 (4.88) at 60 days after transplanting.

Table 4.5 : Leaf area index of rice grown in Lysimeter

Period (date)	I_1F_1	I_2F_2	I_3F_3
20 dat	1.58	1.81	2.31
40 dat	4.35	4.07	5.20
60 dat	4.92	4.88	5.90
80 dat	2.05	1.91	2.49

4.6 YIELD AND YIELD ATTRIBUTES

Yield and yield attributes of the rice grown in lysimeter on an area of 2290 cm^2 are recorded in Table 4.6. The average biomass production was 357 g.

Table 4.6 Yield and yield attributes of rice in Lysimeter.

Observation	I_1F_1	I_1F_2	I_1F_3	Average
Grain wt. (g)	122	95	58	92
Straw wt (g)	260	315	220	265
Total wt (g)	382	410	278	357
G : S	0.47	0.30	0.26	0.34

4.7 PLANT HEIGHT

The plant height recorded at 20 days interval from the date of transplanting under different treatment is presented in Table 4.7.

Table 4.7 : Plant height (cm) recorded in rice grown under different fertility and irrigation treatments

Treatments	20 dat	40 dat	60 dat	80 dat	100 dat
$I_1F_1R_1$	42	60	68	80	80
$I_2F_1R_1$	39	55	67	83	82
$I_3F_1R_1$	33	52	71	85	83
$I_1F_2R_1$	43	60	76	87	87
$I_2F_2R_1$	40	51	75	87	87
$I_3F_2R_1$	34	52	79	88	87
$I_1F_3R_1$	42	60	73	86	86
$I_2F_3R_1$	42	55	75	87	85
$I_3F_3R_1$	38	62	74	87	85
$I_1F_1R_2$	45	55	75	87	87
$I_2F_1R_2$	48	57	73	91	90
$I_3F_1R_2$	40	55	78	87	87
$I_1F_2R_2$	37	60	77	86	85
$I_2F_2R_2$	37	60	73	85	84
$I_3F_2R_2$	38	53	80	87	85
$I_1F_3R_2$	45	57	80	89	88
$I_2F_3R_2$	45	58	75	94	92
$I_3F_3R_2$	40	65	81	89	89
$I_1F_1R_3$	41	65	81	89	88
$I_2F_1R_3$	38	60	75	83	82
$I_3F_1R_3$	33	56	75	86	85
$I_1F_2R_3$	40	62	79	87	85
$I_2F_2R_3$	37	56	69	90	88
$I_3F_2R_3$	40	53	77	89	88
$I_1F_3R_3$	40	60	79	87	87
$I_2F_3R_3$	40	62	76	90	88
$I_3F_3R_3$	41	67	81	90	88
Test of Sig					
F	N.S.	Sig.	N.S.	N.S.	N.S.
I	Sig.	N.S.	N.S.	N.S.	N.S.
F x I	N.S.	Sig.	N.S.	N.S.	N.S.

4.8 TILLER NUMBERS PER HILL

Tillers recorded at 20 days interval after transplanting the data is presented in Table 4.8.

Table 4.8 : Tillers/hill recorded in rice under different fertility and irrigation treatments

Treatments	20 dat	40 dat	60 dat	80 dat	100 dat
$I_1F_1R_1$	9.5	7	7.5	7.5	7.0
$I_2F_1R_1$	10.0	7	6.5	6.5	7.0
$I_3F_1R_1$	8.0	7.5	6.5	8.5	8.0
$I_1F_2R_1$	12.0	10.5	8.5	9.0	8.5
$I_2F_2R_1$	9.5	8.0	10.0	9.5	9.0
$I_3F_2R_1$	7.5	8.5	8.0	9.0	9.0
$I_1F_3R_1$	8.5	6.5	7.0	8.0	8.0
$I_2F_3R_1$	4.0	10.0	9.0	7.0	7.0
$I_3F_3R_1$	9.5	13.5	8.0	8.5	8.0
$I_1F_1R_2$	9.0	10.0	7.0	11.0	7.5
$I_2F_1R_2$	11.5	7.5	7.0	8.5	8.0
$I_3F_1R_2$	10.0	9.0	9.0	8.5	8.0
$I_1F_2R_2$	9.5	8.0	7.0	7.5	7.0
$I_2F_2R_2$	9.0	8.0	7.5	9.5	9.0
$I_3F_2R_2$	8.0	7.5	10.0	6.5	7.0
$I_1F_3R_2$	11.0	9.5	8.0	8.5	8.0
$I_2F_3R_2$	10.5	8.5	7.0	7.5	7.0
$I_3F_3R_2$	9.5	9.0	9.5	9.0	8.5
$I_1F_1R_3$	9.0	8.0	9.0	7.0	7.0
$I_2F_1R_3$	9.5	8.5	8.5	9.0	8.5
$I_3F_1R_3$	8.5	7.0	7.5	8.5	8.0
$I_1F_2R_3$	9.0	9.5	7.5	7.5	7.5
$I_2F_2R_3$	8.5	6.0	8.5	7.5	7.0
$I_3F_2R_3$	11.0	8.5	8.0	8.5	8.0
$I_1F_3R_3$	8.5	10.0	10.5	11.0	10.0
$I_2F_3R_3$	9.0	9.0	7.5	7.5	8.0
$I_3F_3R_3$	11.5	9.0	11.5	8.5	8.0
Test of Sig					
F	N.S.	N.S.	N.S.	N.S.	N.S.
I	N.S.	N.S.	N.S.	N.S.	N.S.
F x I	N.S.	N.S.	N.S.	N.S.	N.S.

4.9 LEAF AREA INDEX

Leaf area index recorded at 20 days interval from the date of transplanting under different fertility and irrigation management and presented in Table 4.9.

Table 4.9 : Leaf area index

Treatments	20 dat	40 dat	60 dat	80 dat	100 dat
$I_1F_1R_1$	1.38	3.08	2.46	1.17	1.04
$I_2F_1R_1$	1.80	2.32	2.00	1.70	1.38
$I_3F_1R_1$	1.11	2.20	2.18	1.96	1.25
$I_1F_2R_1$	0.74	3.05	3.92	1.28	1.35
$I_2F_2R_1$	1.29	2.37	4.99	2.02	1.30
$I_3F_2R_1$	1.44	2.67	2.95	2.72	1.81
$I_1F_3R_1$	0.73	2.30	3.27	1.96	1.45
$I_2F_3R_1$	1.01	2.41	3.34	1.43	1.00
$I_3F_3R_1$	1.36	5.24	4.86	3.24	1.75
$I_1F_1R_2$	1.80	2.41	3.94	1.74	0.89
$I_2F_1R_2$	1.78	3.63	3.20	2.29	1.44
$I_3F_1R_2$	1.75	3.91	3.69	2.62	1.27
$I_1F_2R_2$	1.08	2.58	2.50	2.08	1.60
$I_2F_2R_2$	1.03	2.58	2.53	2.85	1.31
$I_3F_2R_2$	0.68	1.65	4.47	1.54	1.17
$I_1F_3R_2$	1.94	3.77	3.85	2.19	1.76
$I_2F_3R_2$	1.74	2.63	2.03	1.76	1.44
$I_3F_3R_2$	1.58	2.75	5.30	3.16	1.71
$I_1F_1R_3$	1.26	2.65	4.32	2.06	1.13
$I_2F_1R_3$	1.57	2.23	3.65	2.12	1.43
$I_3F_1R_3$	1.39	1.69	3.83	3.45	1.29
$I_1F_2R_3$	1.61	3.35	3.70	2.49	1.15
$I_2F_2R_3$	0.91	2.17	3.57	1.76	1.10
$I_3F_2R_3$	1.20	2.65	3.47	2.59	1.36
$I_1F_3R_3$	1.46	3.96	5.90	3.13	2.10
$I_2F_3R_3$	1.49	3.36	4.41	1.73	1.48
$I_3F_3R_3$	1.93	2.72	5.09	2.07	1.49
Test of Sig					
F	Sig.	N.S.	N.S.	N.S.	Sig.
I	N.S.	N.S.	N.S.	Sig.	N.S.
F x I	N.S.	N.S.	N.S.	N.S.	Sig.

4.10 ROOTING DEPTH

Rooting system recorded at 20 days interval after the transplantation and data is presented in Table 4.10.

Table 4.10 : Rooting depth (cm) recorded in rice

Treatments	20 dat	40 dat	60 dat	80 dat
$I_1F_1R_1$	30	55	88	90
$I_2F_1R_1$	28	44	90	85
$I_3F_1R_1$	25	48	85	88
$I_1F_2R_1$	30	55	98	87
$I_2F_2R_1$	27	55	100	89
$I_3F_2R_1$	27	60	80	93
$I_1F_3R_1$	29	55	95	85
$I_2F_3R_1$	28	65	92	92
$I_3F_3R_1$	28	60	90	95
$I_1F_1R_2$	30	75	89	93
$I_2F_1R_2$	32	60	92	100
$I_3F_1R_2$	28	58	90	95
$I_1F_2R_2$	27	55	88	95
$I_2F_2R_2$	25	55	82	98
$I_3F_2R_2$	27	55	82	100
$I_1F_3R_2$	30	60	81	99
$I_2F_3R_2$	30	75	83	100
$I_3F_3R_2$	28	60	82	99
$I_1F_1R_3$	40	60	84	85
$I_2F_1R_3$	27	55	85	86
$I_3F_1R_3$	28	55	85	88
$I_1F_2R_3$	30	58	86	95
$I_2F_2R_3$	26	65	84	98
$I_3F_2R_3$	29	62	83	99
$I_1F_3R_3$	30	58	89	100
$I_2F_3R_3$	28	60	88	102
$I_3F_3R_3$	27	57	85	105
Test of Sig				
F	N.S.	N.S.	N.S.	Sig.
I	Sig.	N.S.	N.S.	N.S.
F x I	N.S.	N.S.	N.S.	N.S.

4.11 DRY MATTER

The dry matter recorded at 20 days interval after transplantation and present in Table 4.11.

Table 4.11 : Dry matter (gm/hill) recorded in rice

Treatments	20 dat	40 dat	60 dat	80 dat	100 dat
$I_1F_1R_1$	2.52	4.92	19.60	18.95	20.0
$I_2F_1R_1$	1.79	6.44	18.71	20.50	20.55
$I_3F_1R_1$	1.34	4.16	12.30	16.00	17.10
$I_1F_2R_1$	2.24	7.95	18.49	25.60	26.0
$I_2F_2R_1$	2.44	7.65	15.90	24.60	27.10
$I_3F_2R_1$	1.51	6.68	11.75	20.50	22.50
$I_1F_3R_1$	1.84	7.37	11.52	19.25	21.25
$I_2F_3R_1$	2.16	7.26	15.75	27.50	29.50
$I_3F_3R_1$	2.23	5.10	15.44	26.60	28.75
$I_1F_1R_2$	2.51	8.79	18.59	23.10	24.00
$I_2F_1R_2$	1.70	6.82	16.89	21.75	22.10
$I_3F_1R_2$	1.65	4.77	15.36	20.90	21.10
$I_1F_2R_2$	1.30	7.47	15.82	23.50	25.40
$I_2F_2R_2$	1.05	7.30	14.30	20.00	21.50
$I_3F_2R_2$	1.05	6.52	14.15	29.75	30.50
$I_1F_3R_2$	2.07	9.22	20.41	22.90	24.70
$I_2F_3R_2$	1.62	6.98	21.11	28.90	30.40
$I_3F_3R_2$	1.85	6.61	22.61	20.75	23.10
$I_1F_1R_3$	1.38	8.54	15.54	23.00	23.00
$I_2F_1R_3$	1.17	6.84	18.84	22.75	22.80
$I_3F_1R_3$	1.18	6.38	15.70	22.75	23.50
$I_1F_2R_3$	1.10	11.25	14.84	21.25	22.70
$I_2F_2R_3$	1.60	5.46	14.79	20.50	22.50
$I_3F_2R_3$	1.09	7.89	17.01	19.50	21.80
$I_1F_3R_3$	1.56	5.25	18.01	25.60	27.40
$I_2F_3R_3$	1.11	6.89	13.13	23.90	26.80
$I_3F_3R_3$	1.30	7.11	14.72	25.00	26.30
Test of Sig					
F	N.S.	N.S.	N.S.	N.S.	Sig.
I	N.S.	N.S.	N.S.	N.S.	N.S.
F x I	N.S.	N.S.	N.S.	N.S.	N.S.

4.12 YIELD AND YIELD ATTRIBUTES

The data recorded on grain yield, straw yield, filled grain, unfilled grain per earhead, test weight of grain, grain length, grain width, test weight of kernel, kernel length, kernel width, etc. are presented in Table 4.12.

Table 4.11 : Dry matter (gm/hill) recorded in rice

Treatments	G.Y. (q/ha)	S.Y. (q/ha)	Fg (Nos)	Ufg (Nos.)	Spike (Nos.)	Test wt (g) (g/th)	gl (mm)	gW (mm)	Ktw (g/th)	Kl (mm)	Kw (mm)	Shelling (%)	% fg	Kl:b	g:st	Earhead/sqm
$I_1F_1R_1$	23.2	61.5	61	59	120	21.82	11.0	2.08	16.36	8.17	1.67	74.97	0.51	4.89	0.37	298
$I_2F_1R_1$	27.0	60.0	68	64	132	21.59	10.67	2.0	16.25	8.00	1.83	75.26	0.52	4.37	0.45	264
$I_3F_1R_1$	34.4	82.5	86	63	149	20.78	10.5	2.08	15.56	8.33	1.67	74.87	0.58	4.98	0.42	322
$I_1F_2R_1$	26.8	99.75	54	61	115	21.92	10.67	2.0	16.38	8.17	1.83	74.72	0.47	4.46	0.27	335
$I_2F_2R_1$	19.2	63.75	55	86	141	20.54	10.83	2.08	15.53	8.00	1.83	75.60	0.39	4.37	0.30	272
$I_3F_2R_1$	22.0	90.0	71	55	126	23.41	10.67	2.08	17.90	8.16	1.83	76.46	0.56	4.45	0.24	326
$I_1F_3R_1$	29.0	110.25	44	64	110	23.41	10.83	1.83	17.92	8.33	1.67	76.54	0.40	4.98	0.26	330
$I_2F_3R_1$	24.8	96.0	56	49	105	21.22	10.33	2.0	16.33	8.50	1.67	76.95	0.53	5.08	0.26	323
$I_3F_3R_1$	20.4	111.0	36	68	124	20.42	10.50	2.0	15.43	8.67	1.83	75.56	0.45	4.73	0.18	378
$I_1F_1R_2$	20.0	60.75	54	56	110	19.91	10.67	1.83	15.29	8.50	1.67	76.79	0.49	5.08	0.33	216
$I_2F_1R_2$	18.3	77.25	44	61	105	15.13	10.83	2.0	11.80	8.33	1.83	77.99	0.50	4.55	0.24	292
$I_3F_1R_2$	23.0	80.25	53	72	125	20.85	10.6	2.0	16.23	8.00	1.8	77.84	0.42	4.44	0.29	282
$I_1F_2R_2$	25.6	75.00	68	56	124	19.08	10.67	2.0	14.42	8.00	1.83	75.57	0.55	4.37	0.34	241
$I_2F_2R_2$	27.6	75.00	106	45	151	22.53	10.50	2.0	16.96	8.67	1.67	75.27	0.70	5.19	0.37	258
$I_3F_2R_2$	25.7	66.00	81	45	126	22.52	11.0	2.0	16.93	8.17	1.67	75.17	0.64	4.89	0.39	278
$I_1F_3R_2$	23.5	92.25	62	56	118	18.45	10.33	1.83	14.29	8.83	1.67	77.45	0.52	5.28	0.25	358
$I_2F_3R_2$	25.7	103.5	78	60	138	19.34	10.4	2.0	15.04	8.00	1.8	77.76	0.56	4.44	0.25	334
$F_3F_3R_2$	35.7	117.0	78	54	132	20.40	10.8	1.83	15.32	9.70	1.67	75.09	0.42	5.80	0.30	358
$I_1F_1R_3$	33.9	82.50	103	45	148	20.82	10.4	1.95	16.17	8.50	1.75	77.66	0.69	4.85	0.41	308
$I_2F_1R_3$	27.3	87.75	64	57	121	21.37	10.5	1.83	16.28	8.00	1.67	76.18	0.53	4.79	0.31	293
$I_3F_1R_3$	29.3	71.25	60	66	126	19.68	10.83	1.83	15.27	8.17	1.83	77.59	0.48	4.46	0.41	259
$I_1F_2R_3$	23.3	81.75	40	56	96	20.94	11.00	1.83	15.94	8.33	1.67	76.12	0.42	4.98	0.28	311
$I_2F_2R_3$	36.4	81.75	100	55	115	20.27	10.33	2.16	15.65	9.83	1.83	77.20	0.87	5.37	0.44	309
$I_3F_2R_3$	35.2	78.00	37	91	128	20.32	10.67	2.16	15.16	9.67	1.83	74.60	0.29	5.28	0.45	320
$I_1F_3R_3$	35.7	86.25	62	76	138	18.45	10.2	2.0	14.05	8.40	1.6	76.15	0.45	5.25	0.41	334
$I_2F_3R_3$	30.0	81.00	90	66	156	20.62	11.0	2.0	16.22	8.50	1.67	78.66	0.58	5.08	0.37	348
$I_3F_3R_3$	32.4	83.25	76	62	138	19.13	10.0	2.0	15.16	8.33	1.83	79.24	0.55	4.55	0.39	357
Test of Sig																
F	N.S.	Sig.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	Sig.
I	N.S.	N.S.	N.S:	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
F x I	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

4.13 WATER USE EFFICIENCY

Data recorded on water use efficiency are presented in Table 4.14.

Table 4.13 : Water use efficiency

Treatments	Yield (gm/ha)	Water use Efficiency (Kgs/m^3)	
		Irrigation	Total (irrigation + rainfall)
$I_1F_1R_1$	23.2	0.84	0.15
$I_2F_1R_1$	27.0	0.56	0.15
$I_3F_1R_1$	34.4	0.51	0.17
$I_1F_1R_2$	20.0	0.73	0.13
$I_2F_1R_2$	18.3	0.38	0.10
$I_3F_1R_2$	23.0	0.34	0.12
$I_1F_1R_3$	33.9	1.23	0.22
$I_2F_1R_3$	27.3	0.57	0.15
$I_3F_1R_3$	29.3	0.43	0.15
Average	26.26	0.62	0.13
$I_1F_2R_1$	26.8	0.97	0.17
$I_2F_2R_1$	19.2	0.40	0.11
$I_3F_2R_1$	22.0	0.32	0.11
$I_1F_2R_2$	25.6	0.93	0.16
$I_2F_2R_2$	27.6	0.58	0.16
$I_3F_2R_2$	25.7	0.38	0.13
$I_1F_2R_3$	23.3	0.84	0.15
$I_2F_2R_3$	36.4	0.76	0.21
$I_3F_2R_3$	35.2	0.52	0.18
Average	26.86	0.63	0.15
$I_1F_3R_1$	29.0	1.05	0.18
$I_2F_3R_1$	24.8	0.52	0.14
$I_3F_3R_1$	20.4	0.30	0.10
$I_1F_3R_2$	23.5	0.85	0.15
$I_2F_3R_2$	25.7	0.54	0.14
$I_3F_3R_2$	35.7	0.53	0.18
$I_1F_3R_3$	35.7	1.29	0.23
$I_2F_3R_3$	30.0	0.63	0.17
$I_3F_3R_3$	32.4	0.48	0.16
Average	28.57	0.68	0.17
Test of Sign			
F	-	N.S.	Sig
I	-	N.S.	N
F x I	-	N.S.	N

RESULTS AND DISCUSSIONS

This chapter deals with the results obtained and discussions made on various observations recorded during the experiment.

5.1 WEATHER AND HYDROLOGIC CONDITION

The weather and hydrologic condition that prevailed during the experiment period (nursery preparation to harvesting) was 1291.60 mm rainfall, 736.29 mm E_{TO} , 377.10 mm evaporation. The ground water table ranged between 0.73 M to 3.00 M. The sunshine was between 4.32 hours to 10.20 hours and humidity between 53.50% to 81.45%. This indicates that the rainfall was much higher than E_{TO} so there was shortage of water in the crop. It indicated that the season was no suitable for rice crop. The pattern of occurrence of various elements of weather and hydrologic condition is shown in Fig. 5.1, and Table 4.1. Results are in conformity to the reports of Kurray (1998) and Verma (1999).

5.2 TOTAL WATER USE

The pattern of total water use presented in Fig. 5.2 and Table 4.2 indicates that July 2000 and August 2000 received sufficient rainfall and no irrigation was needed. Whereas September and October period needed irrigation. The total water use (irrigation and rainfall) was 1231.40 mm, 1431.40 mm and 1631.40 mm in I_1, I_2 and I_3 respectively. This indicates that the sufficient water available for rice crop. Similar results were also reported by Bali and Uppal (1995), Kurray (1998), Verma (1999), Reddy, M. N. (1987), Singh et al. (1992).

5.3 EVAPOTRANSPIRATION

The evapotranspiration of rice grown in Lysimeter under different

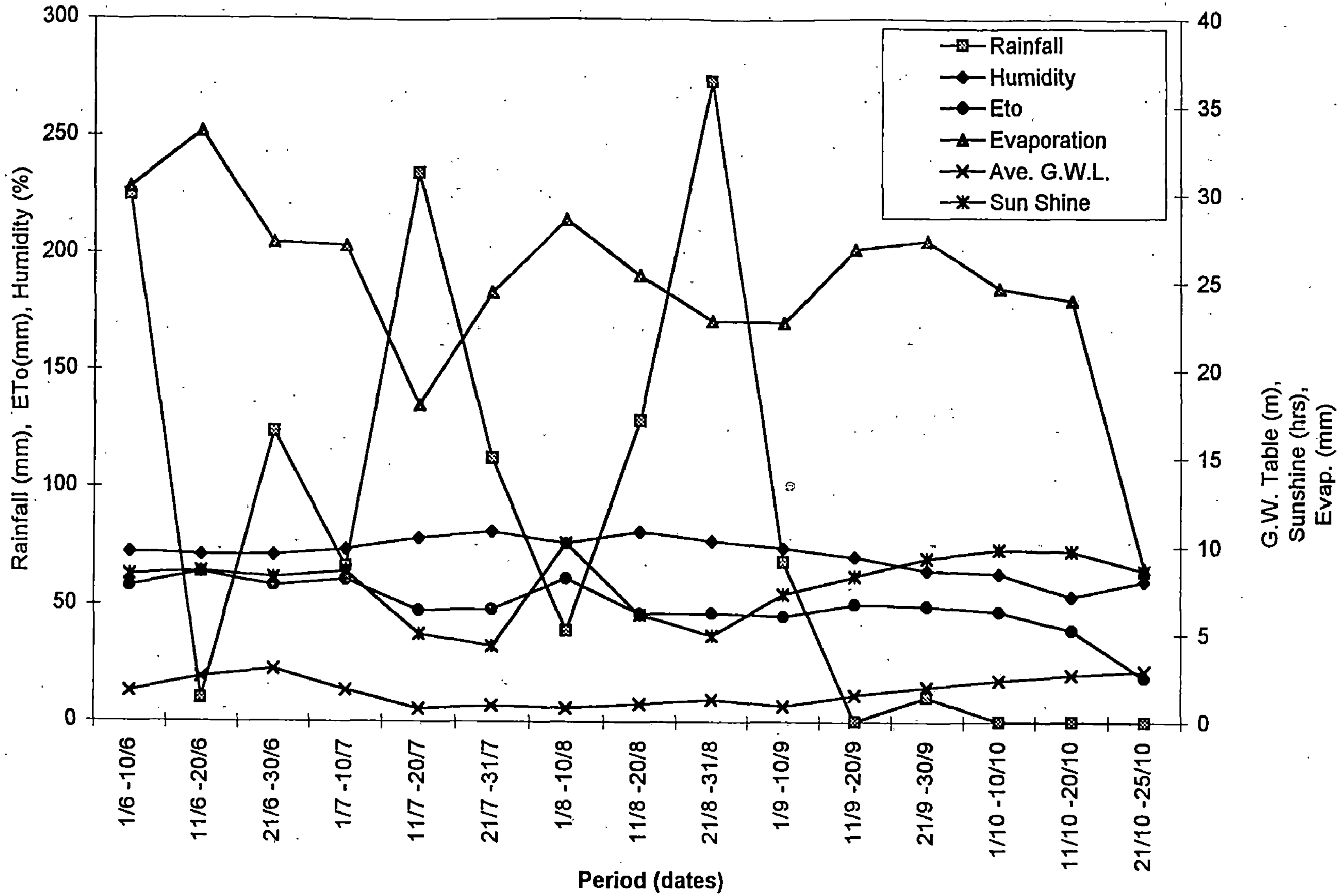

Fig. 5.1: Weather and Hydrologic Condition of the Demonstration Farm during experimental period (Kharif 2000)

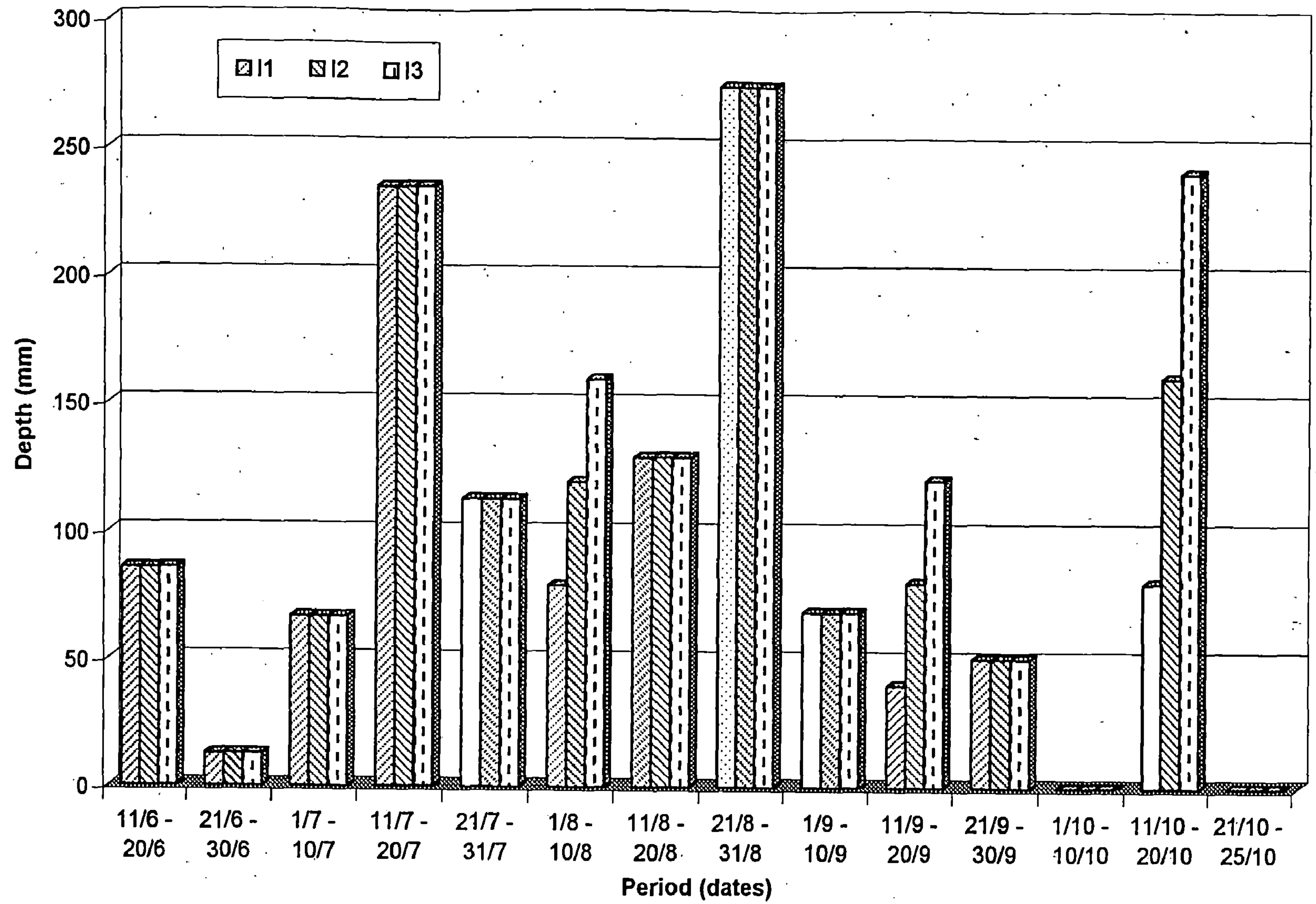

Fig. 5.2: Total Water Use in Rice under different Irrigation treatment during Kharif 2000.

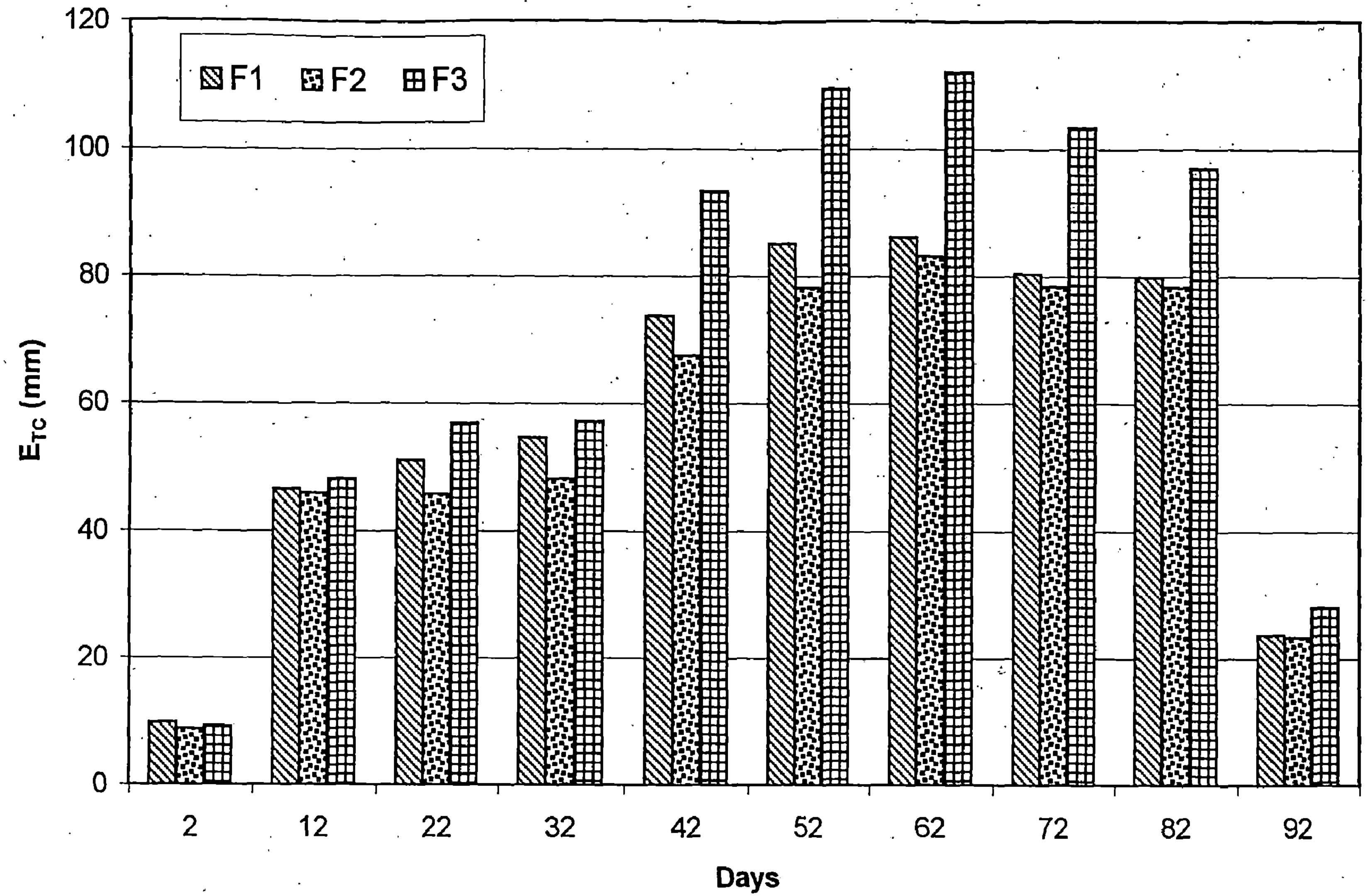

Fig. 5.3 : Crop Evapotranspiration (mm) in rice grown under different fertility treatment in Lysimeter

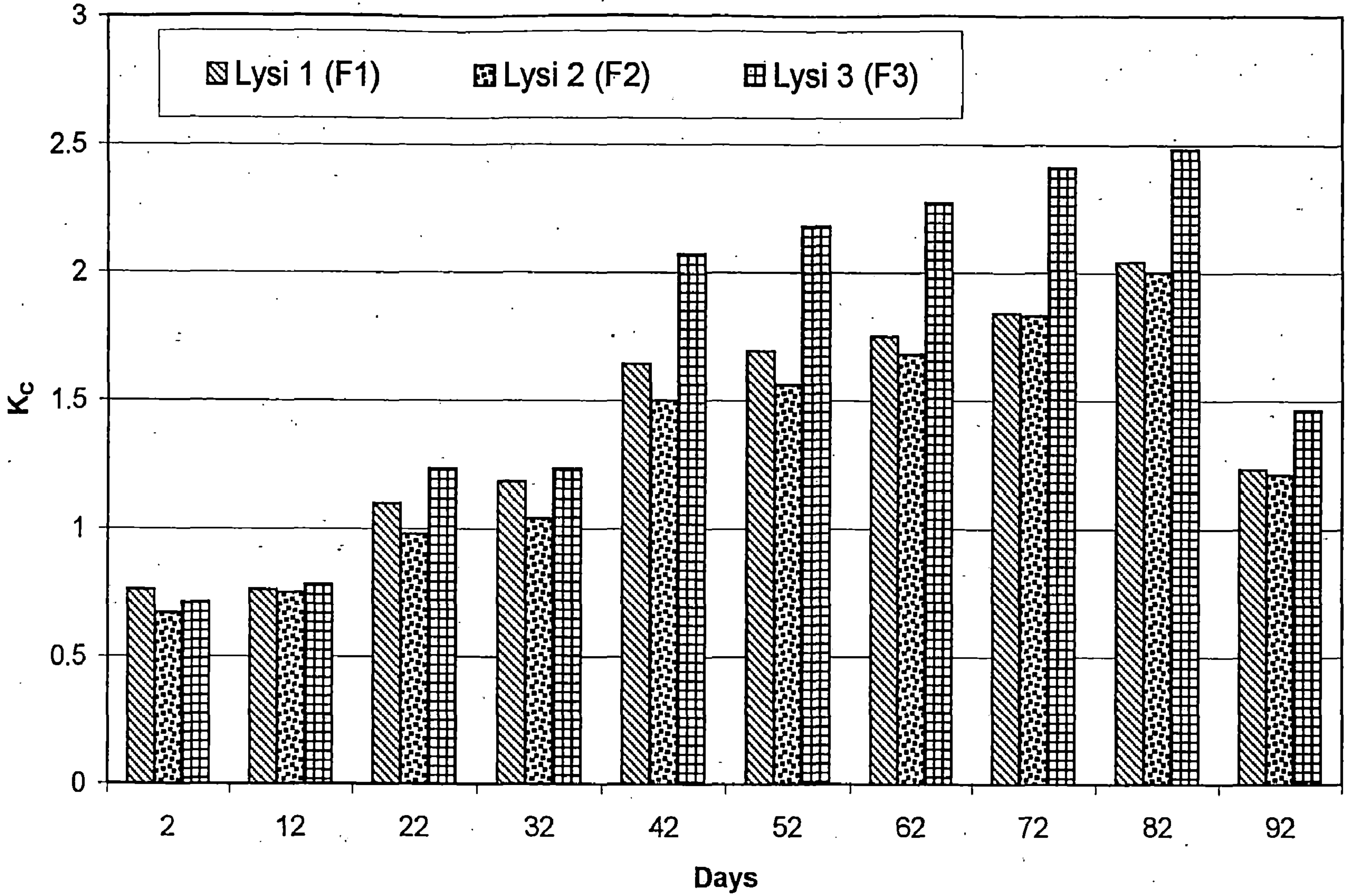

Fig. 5.4 : Crop Coefficient (K_c) of rice grown under different fertility treatment in Lysimeter

treatments presented in Fig. 5.3 and Table 4.3 indicated that nitrogen influenced the consumptive use favourably because of its increased plant growth. The evapotranspiration increased linearly from the date of transplanting to maturity irrespective of the treatments it received. There was not much difference in the evapotranspiration demand upto first decadal of August 2000 but afterwards all the treatments started showing change in the evapotranspirative demand. The maximum evapotranspiration was 714.12 mm in the Lysimeter No. 3 and minimum was 557.06 mm in Lysimeter No. 2. Results are in conformity to the reports of baker et al. (1997), Allavena (1995), Adachi et al. (1995), Humphreys et al. (1994), Joseph and Havanagi (1988), Mishra and Sharma (1997), Rodersma et al. (1996), Sahoo et al. (1996), Zhou et al. (1993), Bhardwaj et al. (1992), Kurray (1998) and Verma (1999).

5.4 CROP COEFFICIENT (K_c)

The crop coefficient recorded under different treatment and plants grown in Lysimeter are presented in Fig. 5.4 and Table 4.4. The 10 days average calculated throughout the growing period and there was a linear increase in the value of crop coefficient. It was recorded as 0.72 in the beginning and it rose to 2.17 at the time of maturity and at the time of harvest, it reduced to 1.30. Different treatment recorded different crop coefficients the maximum was 2.48 in the treatment receiving nitrogen 150 kg/ha. The variation in coefficient values could be attributed to the growth of plants and the longevity of their leaves. Results are in conformity to the reports of Baker et al. (1997), Allavena (1995), Adachi et al. (1995), Humphreys et al. (1994), Joseph and Havanagi (1988), Mishra and Sharma (1997), Rodersma et al. (1986), Sahoo et al. (1996), Zhou et al. (1993), Bhardwaj et al. (1992), Kurray (1998) and Verma (1999).

5.5 PLANT HEIGHT

The plant height recorded at 20 days interval after transplanting under

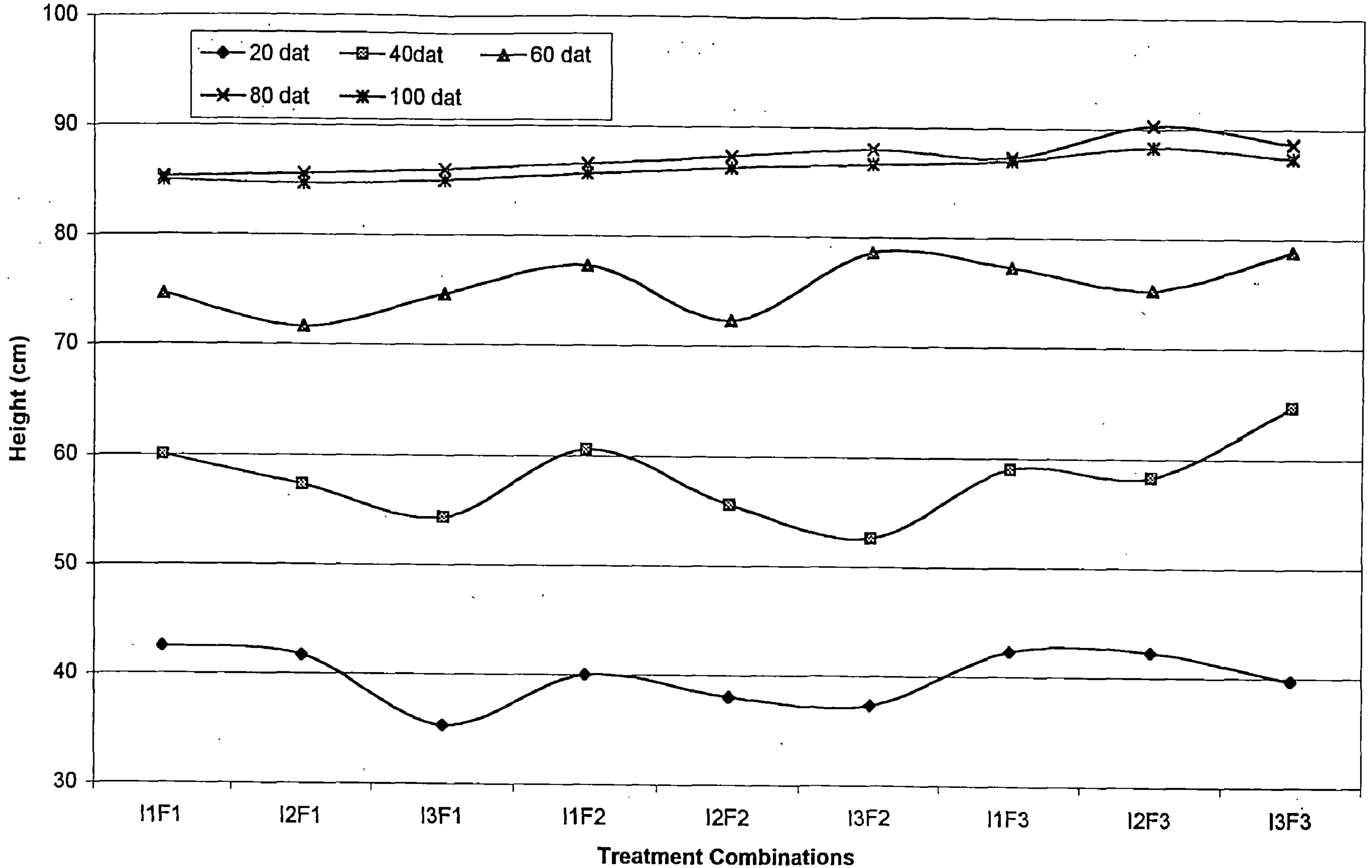

Fig. 5.5: Plant Height of Rice as influenced by Nitrogen and Irrigation Depth during Kharif 2000.

different treatments is presented in Fig. 5.5 and Table 4.7. The effect of irrigation application was significant at 20th day whereas the nitrogen application left a significant effect at 40th day observation. The plant height through fertilisation has been reported by Bhagat et al. (1991), Bhattacharya et al. (1992), Kalita and Gogoi (1994), Kurray (1998), Reddy and Reddy (1992), Verma (1999), Subhash et al. (1997).

5.6 TILLERS/HILL

The data presented in Fig. 5.6 and Table 4.8 indicate that the application of irrigation and nitrogen has no effect. The maximum number of tillers/hill were recorded at the end of 20 days. The report confirmed with Reddy and Reddy (1992), Bisht et al. (1991), Bhattacharya et al. (1992), Chandra (1997), Hazarika et al. (1996), Kalita and Gogoi (1994), Kulmi (1992), Kurray (1998) and verma (1999).

5.7 LEAF AREA INDEX

Leaf area index data presented in Fig. 5.7 and Table 4.9 showed inconsistently response of irrigation application and nitrogen application. It was increased up to 60 days and declined marginally later because of senescence and leaf fall. Leaf area index has been also reported by Hussain et al. (1989), Kurray (1998), Kulmi (1992) and Verma (1999).

5.8 ROOTING DEPTH

Data presented in Fig. 5.8 and Table 4.10 shows inconsistent response of irrigation and nitrogen application on root depth. Improved rooting depth with appropriate nutrient application has been also reported by Hazarika et al. (1996), Hussain et al., Kulmi (1992), Kurray (1998) and Verma (1999).

5.9 DRY MATTER/HILL

Dry matter production recorded at different stages of growth and presented

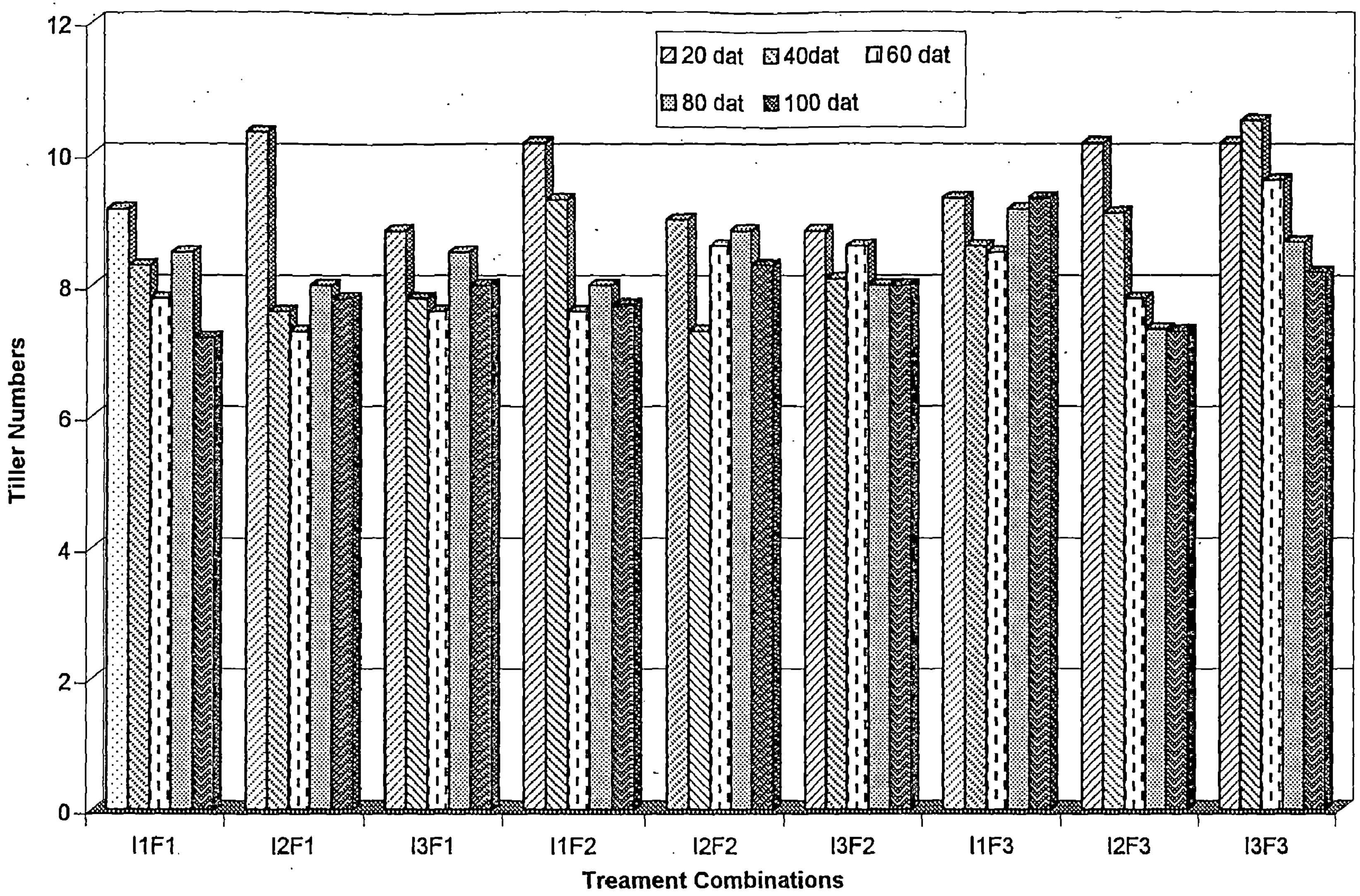

Fig. 5.6: Tiller Numbers of Rice as influenced by Nitrogen and Irrigation Depth during Kharif 2000.

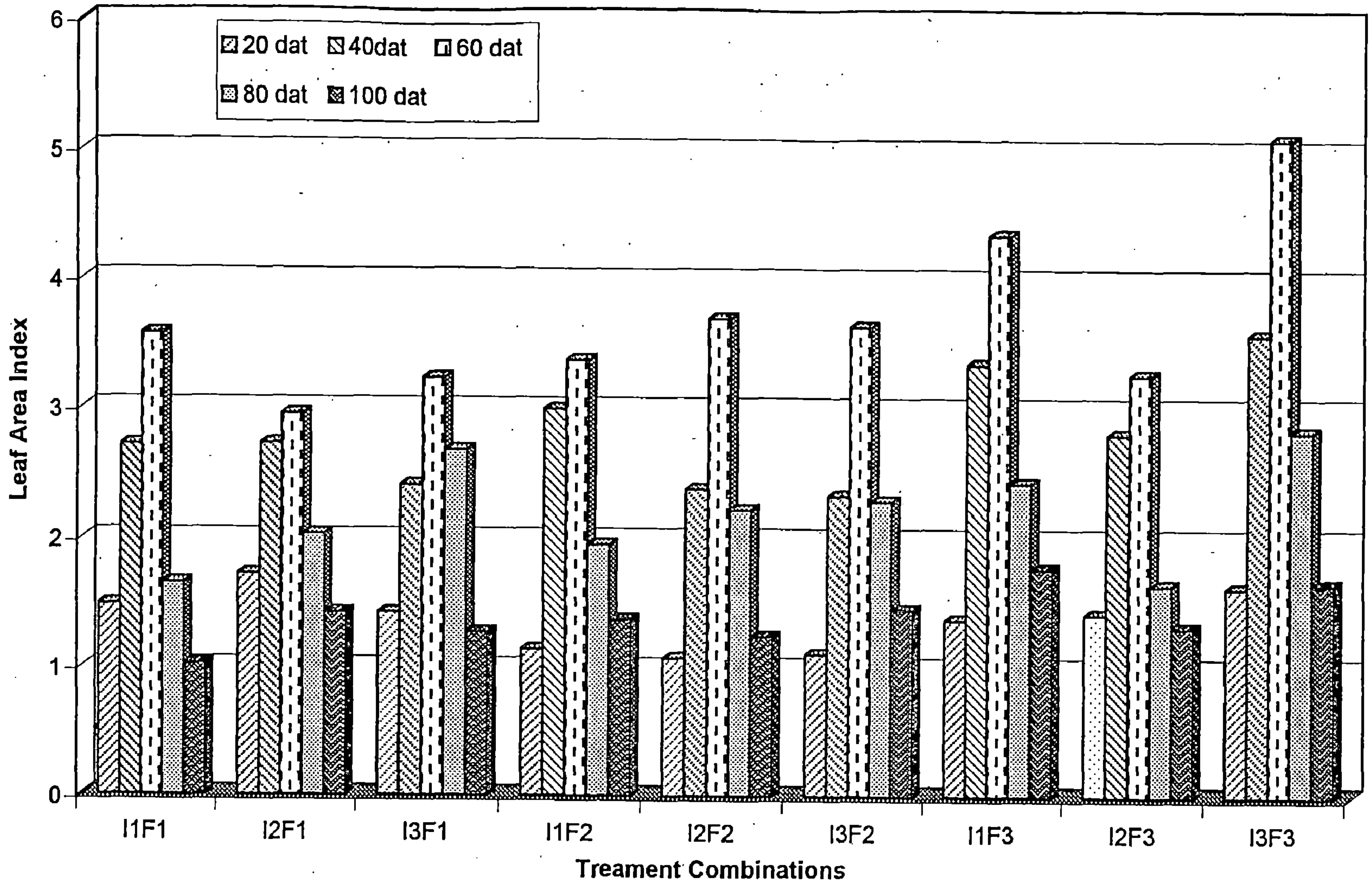

Fig. 5.7.: Leaf Area Index of Rice as influenced by Nitrogen and Irrigation Depth during Kharif 2000.

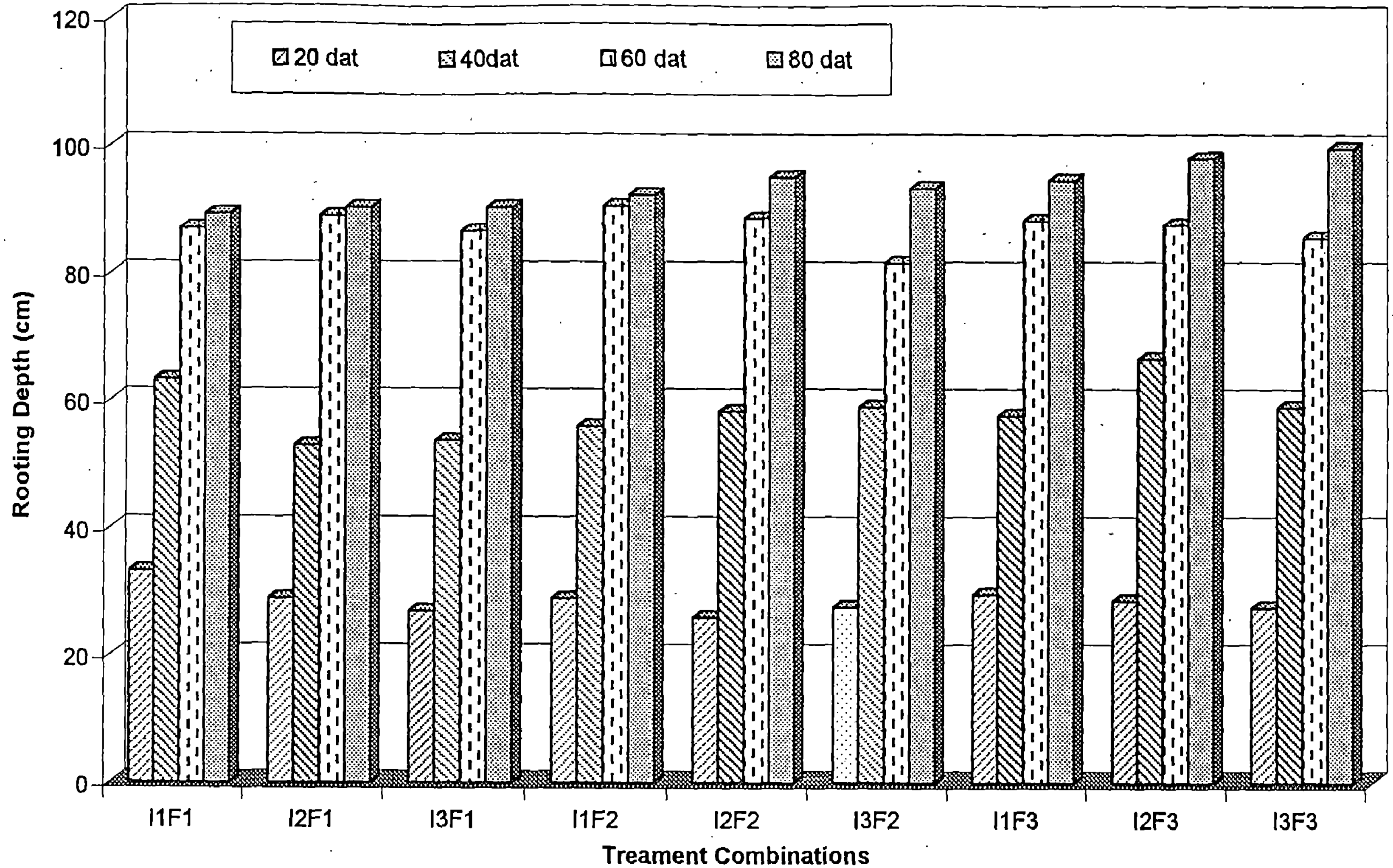

Fig. 5.8: Rooting Depth of Rice as influenced by Nitrogen and Irrigation Depth during Kharif 2000.

in Fig. 5.9 and Table No. 4.11 indicated that there was no effect of irrigation application and only at the time of harvesting nitrogen showed its significant influence. the result reported by Raju et al. (1992), A. A. Ahmed et al. (1992), Kulmi (1992), Biswas and Banerjee, Kurray (1998) and Verma (1999).

5.10 YIELD AND YIELD ATTRIBUTES

Data presented in Fig. 5.10, 5.11 and Table 4.12 indicated a significant influence of fertilizer on straw only and the grain yield. Filled grain per earhead, infilled grain per earhead, spikes per earhead, test weight of grain, grain length, grain width, test weight of kernel, kernel length, kernel width, etc. were not significant. Because the crop was damaged by sudden attack of disease at grain formation stage.

5.11 WATER USE EFFICIENCY

The average water use efficiency were recorded 0.62 kg/m^3, 0.63 kg/m^3, and 0.68 kg/m^3 with F_1, F_2 and F_3, respectively without rainfall and 0.13 kg/m^3, 0.15 kg/m^3 and 0.17 kg/m^3 with rainfall. It shows that the fertilizer application of nitrogen with 150 kg/ha gives higher efficiency. Results are in conformity with the reports of Adachi et al. (19950, Verma (1999).

5.12 CORRELATIONS STUDIES

Correlation matrix prepared from the yield and yield attributes is presented in Table 5.1. The grain yield had a significant correlation with the kernel length, kernel length width ratio and grain straw ratio, percentage of filled grain correlate with the filled grain per earhead, kernel length width ratio correlate with the kernel length, test weight of kernel correlate with the test weight of grain and the spike correlate with the filled grain per earhead. Same correlation also has been reported by Kurray (1998), Verma (1999).

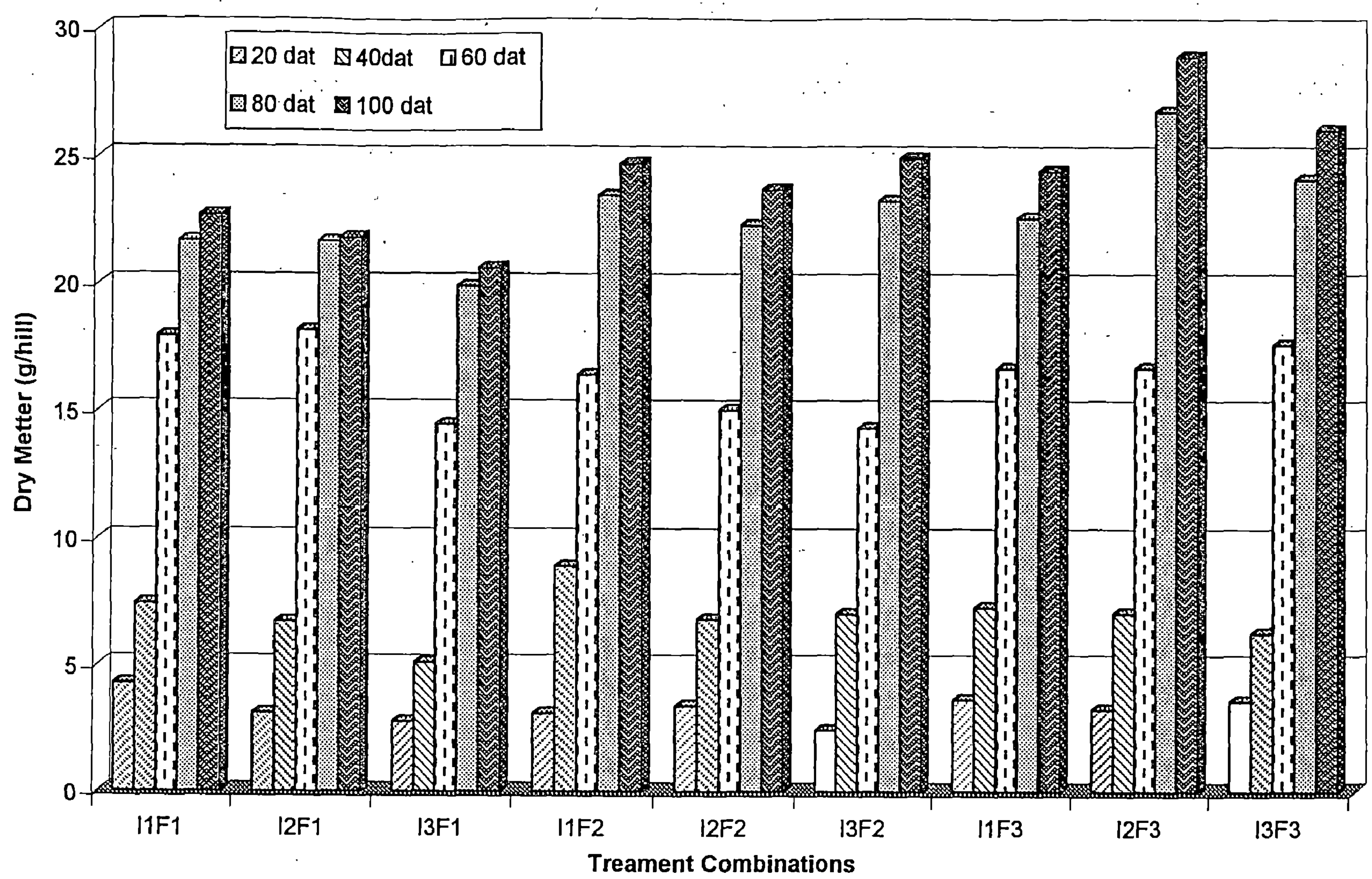

Fig. 5.9: Dry Metter of Rice as influenced by Nitrogen and Irrigation Depth during Kharif 2000.

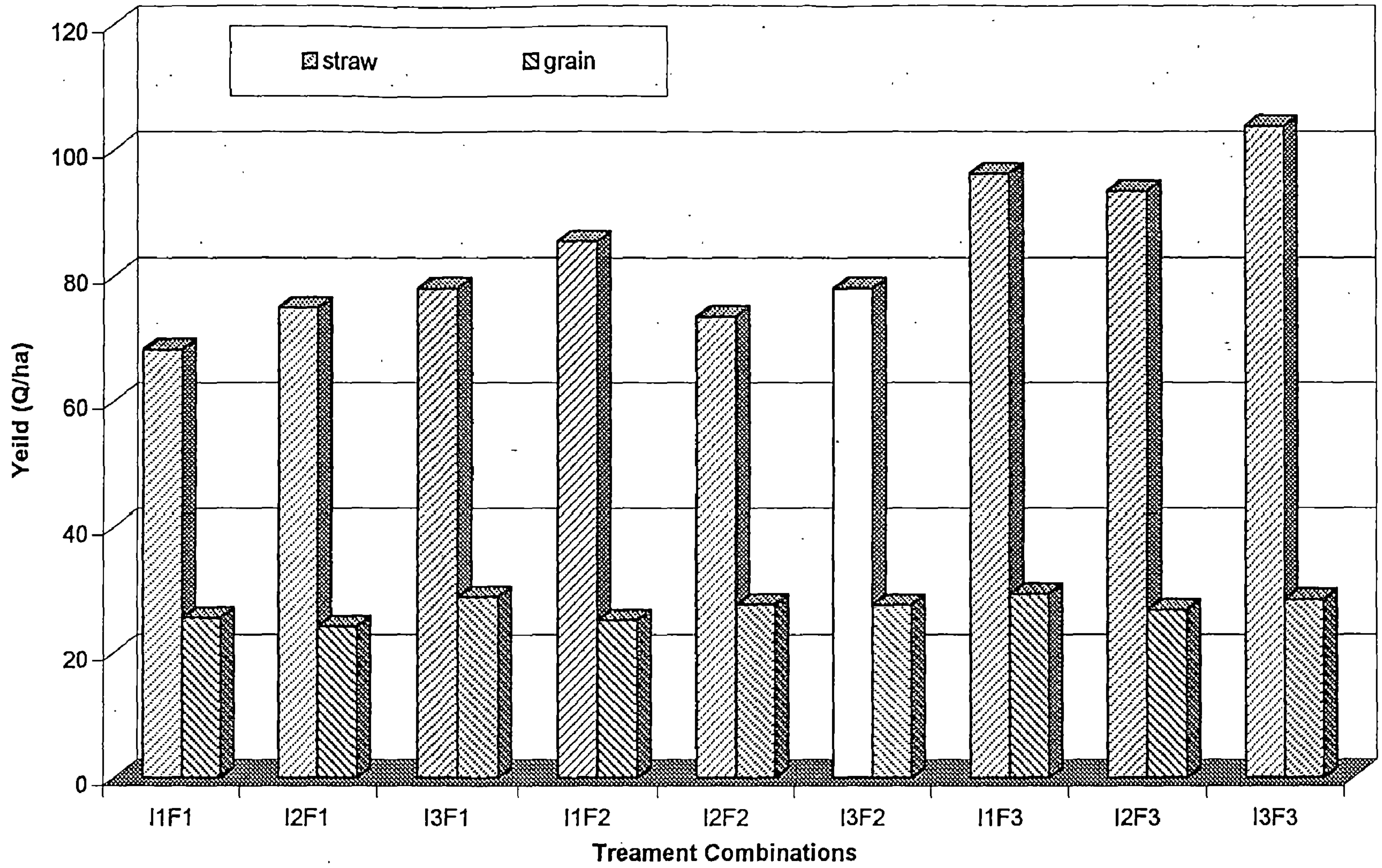

Fig. 5.10: Grain and Straw Yeild of Rice as influenced by Nitrogen and Irrigation Depth during Kharif 2000.

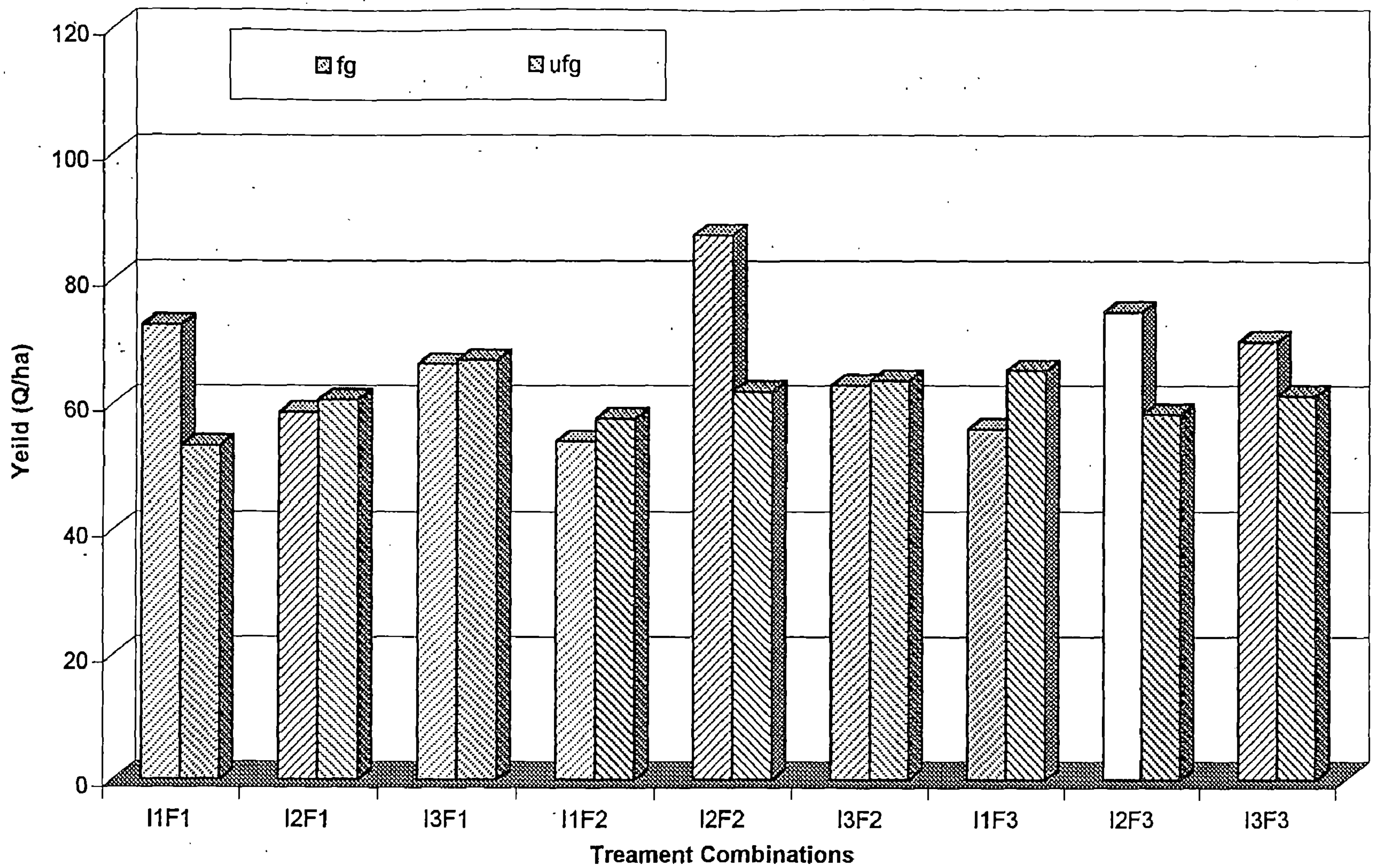

Fig. 5.11: Filled Grain and Unfilled Grain per earhead of Rice as influenced by Nitrogen and Irrigation Depth during Kharif 2000.

Table 5.1 : Correlation matrix of yield and yield attributes of rice

	Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13	Col. 14	Col. 15
Col. 1	1.0000	-0.0506	-0.0925	-0.1082	0.0364	-0.2857	-0.2709	0.0559	0.2958	-0.0919	0.0682	0.2882	-0.5831	-0.1571	0.1934
Col. 2		1.0000	-0.5242	0.6691	0.1780	-0.2871	0.2112	0.2203	0.1749	-0.1179	0.1369	0.2057	0.4169	0.8426	0.4557
Col. 3			1.0000	0.1369	-0.2156	0.0572	0.3181	-0.2493	0.0390	0.3219	-0.1030	-0.1620	0.1044	-0.6646	0.0444
Col. 4				1.0000	0.0886	-0.1964	0.3030	0.1042	-0.0286	-0.0217	0.0331	-0.0016	0.4436	0.2425	0.4271
Col. 5					1.0000	0.2523	0.0449	0.9806	-0.1034	-0.1889	-0.4247	0.0246	0.0486	0.0883	0.0604
Col. 6						1.0000	-0.1327	0.1988	-0.1560	-0.0768	-0.3209	-0.0761	-0.0828	-0.2938	-0.3480
Col. 7							1.0000	0.0047	0.1500	0.4198	-0.1971	-0.1461	0.3179	0.2409	0.1407
Col. 8								1.0000	-0.1319	-0.1767	-0.2396	-0.0060	0.0293	0.1434	0.0607
Col. 9									1.0000	-0.0520	-0.1106	0.7972	0.2174	0.1200	0.5354
Col. 10										1.0000	0.1275	-0.6434	-0.0447	-0.0245	-0.1661
Col. 11											1.0000	-0.1646	-0.1133	0.2362	-0.0386
Col. 12												1.0000	0.1896	0.0983	0.5117
Col. 13													1.0000	0.3148	0.6706
Col. 14														1.0000	0.2377
Col. 15															1.0000

Col. 1 : Straw yield
Col. 2 : Grain yield
Col. 3 : Filled grain per earhead
Col. 4 : Unfilled grain per earhead
Col. 5 : Spikes/earhead
Col. 6 : Test weight of grain
Col. 7 : Grain length
Col. 8 : Grain width
Col. 9 : Test weight of kernel
Col. 10 : Kernel length
Col. 11 : Kernel width
Col. 12 : Shelling percentage
Col. 13 : Kernel length : width
Col. 14 : Grain : straw
Col. 15 : Percentage filled grain

Chapter 6

SUMMARY AND CONCLUSIONS

Te study on water and nutrient management in rice was conducted during the Kharif 2000 at WRDTC Demonstration Farm, University of Roorkee, Roorkee (Uttaranchal), India. The treatment consisted three levels of nitrogen and three levels of irrigation applications.

The nitrogen application were used

F_1 = 50 kg/ha N

F_2 = 100 kg/ha N

F_3 = 150 kg/ha N

The irrigation application were used

I_1 = 40 mm/irrigation

I_2 = 80 mm/irrigation

I_3 = 120 mm/irrigation

1/3 nitrogen and full dose of P and K was applied at the time of puddling. The nitrogen was applied, 1/3 at tillering and 1/3 at flowering. A uniform dose of 60 kg P_2O_5, 60 kg/ha K_2O and 25 kg/ha $ZnSO_4$ was applied in the plot. Data were collected and results obtained are summarised as following.

(1) Total water use (irrigation + rainfall) (11.6.2000 to 25.10.2000) in different irrigation treatments was 1231.40 mm, 1431.40 mm and 1631.40 mm in I_1, I_2 and I_3 respectively. Rice crop received sufficient rainfall upto first decadal of September and after that for the rest of the period there was no rain, therefore needed irrigation.

(2) Evapotranspiration of a reference crop (E_{TO}) was calculated as 230.27 mm during nursery and 613.25 during the period of crop. The

rainfall during nursery was 434.60 whereas during the cropping period was 632.20 mm. There was sufficient rainfall during nursery so no irrigation was needed.

(3) The Lysimetric observation revealed remarkable difference in the pattern of crop evapotranspiration (E_{Tc}) grown in the different treatments. The crop evapotranspiration were 592.56 mm, 557.06 mm and 714.12 mm in the Lysi1, Lysi2 and Lysi3, respectively.

(4) The crop coefficient (K_c) was recorded as 1.46 on an average and 1.39, 1.32 and 1.68 in the Lysi1, Lysi2 and Lysi3, respectively.

(5) The leaf area index was recorded in the plants grown in Lysimeter. The average leaf area index was 1.82 at 20 dat, 4.44 at 40 dat, 5.17 at 60 dat and 2.12 at 80 dat. The maximum leaf area index was recorded in the Lysimeter in which 150 kg/ha nitrogen was applied.

(6) The average plant height was 39.92 cm at 20 dat, 58.07 cm at 40 dat, 75.62 cm at 60 dat, 87.25 cm at 80 dat and 86.22 m at harvesting. The fertiliser application showed the response at the age of 40 dat and the irrigation showed the response at the age of 20 dat. The interaction of a fertiliser and irrigation showed the response at the age of 40 dat after that no response of fertiliser and irrigation.

(7) The average tiller/hill was recorded 9.5 at 20 dat, 8.5 at 40 dat, 8.2 at 60 dat, 8.3 at 80 dat, 7.98 at the time of harvesting. We saw that there is no appreciable change in the tiller number, from 20 dat to harvesting.

(8) The average dry matter/hill was 1.64 gm/hill at 20 dat, 6.94 gm/hill at 40 dat, 16.34 gm/hill at 60 dat, 22.85 gm/hill at 80 dat and 24.16

gm/hill at the time of harvest. Fertiliser showed the response at the time of harvest.

(9) The average leaf area index recorded was 1.37 at the age of 20 dat, 2.83 at the age of 40 dat, 3.68 at the age of 60 dat, 2.19 at the age of 80 dat and 1.38 at the time of harvest. The fertiliser application significant at the age of 20 dat and at the time of harvest and the irrigation application significant at the age of 80 dat.

(10) The average rooting depth was recorded 28.66 cm at the age of 20 dat, 58.51 cm at the age of 40 dat, 87.25 cm at the age of 60 dat and 94.11 cm at the age of 80 dat. The fertiliser application significant at the age of 80 dat and the irrigation application was significant at the age of 20 dat.

(11) The average grain yield, straw yield, earhead/m^2, filled grain/earhead unfilled grain/earhead, grain weight/1000 nos, kernel weight/1000 nos, spikes per earhead, grain length, grain width, kernel length, kernel width were recorded as 27.23 q/ha, 83.52 q/ha, 307.5/m^2, 66.2, 61.9, 20.55 gm, 15.69 gm, 128.1, 10.62 mm, 1.98 mm, 8.45 mm and 1.71 mm, respectively. Fertiliser application significant only for straw yield.

(12) The average water use efficiency recorded for irrigation was 0.64 kg/m^3 and for (irrigation + rainfall) was 0.15 kg/m^3. Fertiliser application significant for irrigation + rainfall.

Based on the above observation, the findings can be summarised as below :

(1) Application of nitrogen showed an insignificant change in the growth and development of crop.

(2) Application of irrigation also did not affected the growth and development of crop because it rained constantly during the growing period.

(3) Damage of the crop due to disease at grain formation stage was maximum in plot receiving maximum dose of nitrogen.

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Total water use in nursery of rice during kharif 2000

Date	Irrigation (mm)	Rain fall (mm)	Run off (mm)	TWUN (mm)	CTWUN (mm)	Eto (mm)	Ratio TWUN/Eto
11/6/00	412	0	0	412	412.0	6.34	64.98
12/6/00	360	0	0	360	772.0	6.28	57.32
13/6/00	380	0	0	380	1152.0	6.96	54.60
14/6/00	0	0	0	0	1152.0	4.78	0.00
15/6/00	360	5	0	365	1517.0	3.38	107.99
16/6/00	0	0	0	0	1517.0	4.79	0.00
17/6/00	0	0	0	0	1517.0	7.37	0.00
18/6/00	0	0	0	0	1517.0	7.58	0.00
19/6/00	0	0	0	0	1517.0	8.59	0.00
20/6/00	0	5	0	5	1522.0	7.23	0.69
21/6/00	0	4	0	4	1526.0	6.82	0.59
22/6/00	0	0	0	0	1526.0	7.12	0.00
23/6/00	0	5	0	5	1531.0	7.53	0.66
24/6/00	0	0	0	0	1531.0	6.98	0.00
25/6/00	0	11	0	11	1542.0	6.93	1.59
26/6/00	0	3.8	0	3.8	1545.8	3.90	0.97
27/6/00	0	0	0	0	1545.8	4.78	0.00
28/6/00	0	100	0	100	1645.8	5.36	18.66
29/6/00	0	0	0	0	1645.8	3.23	0.00
30/6/00	0	0	0	0	1645.8	5.90	0.00
1/7/00	0	0	0	0	1645.8	6.68	0.00
2/7/00	0	10	0	10	1655.8	5.90	1.69
3/7/00	0	0	0	0	1655.8	7.27	0.00
4/7/00	0	0	0	0	1655.8	7.60	0.00
5/7/00	0	0	0	0	1655.8	6.72	0.00
6/7/00	0	0	0	0	1655.8	6.93	0.00
7/7/00	0	23.6	0	23.6	1679.4	5.71	4.13
8/7/00	0	0	0	0	1679.4	6.16	0.00
9/7/00	0	33	0	33	1712.4	3.71	8.89
10/7/00	0	0	0	0	1712.4	4.21	0.00
11/7/00	0	5.2	0	5.2	1717.6	5.05	1.03
12/7/00	0	0	0	0	1717.6	5.41	0.00
13/7/00	0	53.4	0	53.4	1771.0	7.10	7.52
14/7/00	0	0	0	0	1771.0	7.94	0.00
15/7/00	0	0	0	0	1771.0	5.75	0.00
16/7/00	0	47	0	47	1818.0	3.33	14.11
17/7/00	0	109	0	109	1927.0	2.96	36.82
18/7/00	0	13	0	13	1940.0	2.87	4.53
19/7/00	0	4	0	4	1944.0	2.71	1.48
20/7/00	0	2.6	0	2.6	1946.6	4.41	0.59
TOTAL	**1512**	**434.6**	**0**	**1946.6**	**-**	**230.27**	**8.45**

Total depth of irrigation(mm) = **1512**
Area transplanted(times) = **20**
Total rainfall (mm) = **434.60**
Depth of irrigation (mm) = **75.6**
Total nursery water use (mm) = **510.20**

Annexure -2

Weather and hydrologic condition during experimental period (01-06-2000 to 25-10-2000) at Demonstration Farm WRDTC

Date	Tmax. 0 C	Tmin. 0 C	Tmean 0 C	RHMax. %	RHMin. %	RHMean %	Wind km/day	Uday m/sec	Sunshine n (hrs)	N (hrs)	ea mbar	ed mbar	ea-ed mbar	F(u)	Ra mm/day
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1/6/00	33.5	24.5	29.00	58	55	56.5	33	0.60	12.00	14	40.10	22.66	17.44	0.36	17
2/6/00	33.0	25.0	29.00	79	57	68.0	40	0.74	12.50	14	40.10	27.27	12.83	0.38	17
3/6/00	32.0	24.5	28.25	67	62	64.5	59	1.15	12.00	14	38.37	24.75	13.62	0.43	17
4/6/00	32.0	24.0	28.00	84	73	78.5	44	0.70	4.00	14	37.80	29.67	8.13	0.39	17
5/6/00	35.0	20.5	27.75	58	57	57.5	68	0.79	12.00	14	37.27	21.43	15.84	0.45	17
6/6/00	27.0	25.0	26.00	82	75	78.5	68	1.39	12.00	14	33.60	26.38	7.22	0.45	17
7/6/00	25.0	21.5	23.25	92	84	88.0	0	0.00	0.00	14	28.52	25.10	3.42	0.27	17
8/6/00	26.0	22.5	24.25	85	84	84.5	36	0.67	0.00	14	30.27	25.58	4.69	0.37	17
9/6/00	28.0	22.0	25.00	85	71	78.0	28	0.65	10.50	14	31.70	24.73	6.97	0.35	17
10/6/00	31.5	23.5	27.50	73	72	72.5	19	0.28	9.00	14	36.75	26.64	10.11	0.32	17
11/6/00	31.0	24.0	27.50	85	73	79.0	31	0.55	10.00	14	36.75	29.03	7.72	0.35	17
12/6/00	32.0	24.5	28.25	85	68	76.5	16	0.28	12.00	14	38.37	29.35	9.02	0.31	17
13/6/00	36.0	23.0	29.50	58	57	57.5	24	0.46	12.00	14	41.25	23.72	17.53	0.33	17
14/6/00	36.5	27.0	31.75	70	68	69.0	43	0.74	4.00	14	46.92	32.37	14.55	0.39	17
15/6/00	31.0	26.0	28.50	76	73	74.5	74	1.38	0.00	14	38.95	29.02	9.93	0.47	17
16/6/00	30.0	24.0	27.00	78	72	75.0	68	1.20	5.00	14	35.70	26.78	8.93	0.45	17
17/6/00	34.0	24.5	29.25	72	69	70.5	90	1.85	10.00	14	40.67	28.67	12.00	0.51	17
18/6/00	35.0	25.5	30.25	78	69	73.5	74	1.38	11.00	14	43.02	31.62	11.40	0.47	17
19/6/00	35.5	26.0	30.75	72	64	68.0	130	2.54	11.00	14	44.27	30.10	14.17	0.62	17
20/6/00	36.0	25.0	30.50	78	64	71.0	32	0.69	11.00	14	43.65	30.99	12.66	0.36	17
21/6/00	35.5	26.0	30.75	58	57	57.5	36	0.69	10.00	14	44.27	25.46	18.81	0.37	17
22/6/00	28.0	25.0	26.50	86	66	76.0	46	0.92	12.00	14	34.65	26.33	8.32	0.39	17
23/6/00	34.0	26.0	30.00	85	69	77.0	38	0.69	12.25	14	42.40	32.65	9.75	0.37	17
24/6/00	34.5	24.0	29.25	71	63	67.0	20	0.30	12.00	14	40.67	27.25	13.42	0.32	17
25/6/00	33.0	23.5	28.25	78	68	73.0	19	0.40	12.25	14	38.37	28.01	10.36	0.32	17
26/6/00	32.0	23.5	27.75	78	73	75.5	33	0.50	3.00	14	37.27	28.14	9.13	0.36	17
27/6/00	30.5	22.5	26.50	85	73	79.0	32	0.09	6.00	14	34.65	27.37	7.28	0.36	17
28/6/00	34.0	24.0	29.00	82	57	69.5	36	0.69	6.00	14	40.10	27.87	12.23	0.37	17
29/6/00	27.5	23.0	25.25	92	85	88.5	48	0.55	2.00	14	32.17	28.47	3.70	0.40	17
30/6/00	35.0	23.5	29.25	73	58	65.5	46	0.90	7.00	14	40.67	26.64	14.03	0.39	17

Date	n/N	Rs mm/da	Rns mm/day	F(T)	F(ed)	F(n/N)	Rnl mm/day	Rn mm/day	C	W	1-W	**Eto mm/day**	G.W.L. M.	Rainfall mm.	Evap. mm.
1	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1/6/00	0.86	11.53	8.65	16.5	0.13	0.87	1.87	6.78	1.07	0.78	0.22	**7.13**	1.35	0.0	4.8
2/6/00	0.89	11.83	8.87	16.5	0.11	0.90	1.64	7.23	1.13	0.78	0.22	**7.58**	1.70	0.0	4.3
3/6/00	0.86	11.53	8.65	16.35	0.12	0.87	1.71	6.94	1.12	0.78	0.22	**7.50**	2.35	11.8	2.9
4/6/00	0.29	6.68	5.01	16.3	0.10	0.36	0.58	4.43	1.05	0.78	0.22	**4.36**	2.50	0.0	2.9
5/6/00	0.86	11.53	8.65	16.25	0.14	0.87	1.98	6.67	1.03	0.77	0.23	**6.99**	2.85	0.0	5.1
6/6/00	0.86	11.53	8.65	15.9	0.11	0.87	1.52	7.12	1.17	0.76	0.24	**7.25**	3.10	40.0	4.5
7/6/00	0.00	4.25	3.19	15.25	0.12	0.10	0.18	3.00	1.04	0.73	0.27	**2.54**	2.05	68.0	0.0
8/6/00	0.00	4.25	3.19	15.46	0.12	0.10	0.19	3.00	1.02	0.74	0.26	**2.72**	0.00	105.0	0.5
9/6/00	0.75	10.62	7.97	15.65	0.12	0.78	1.46	6.51	1.11	0.75	0.25	**6.09**	0.30	0.0	1.4
10/6/00	0.64	9.71	7.28	16.2	0.11	0.68	1.21	6.07	1.07	0.77	0.23	**5.80**	1.00	0.0	4.0
11/6/00	0.71	10.32	7.74	16.2	0.10	0.74	1.20	6.54	1.12	0.77	0.23	**6.34**	1.25	0.0	4.8
12/6/00	0.86	11.53	8.65	16.35	0.10	0.87	1.42	7.22	1.10	0.78	0.22	**6.88**	1.60	0.0	3.8
13/6/00	0.86	11.53	8.65	16.6	0.13	0.87	1.88	6.77	1.06	0.78	0.22	**6.96**	2.20	0.0	3.2
14/6/00	0.29	6.68	5.01	17.14	0.09	0.36	0.55	4.46	1.02	0.80	0.20	**4.78**	2.40	0.0	3.2
15/6/00	0.00	4.25	3.19	16.4	0.10	0.10	0.16	3.02	1.00	0.78	0.22	**3.38**	2.60	5.0	1.2
16/6/00	0.36	7.28	5.46	16.1	0.11	0.42	0.75	4.71	1.05	0.77	0.23	**4.79**	2.80	0.0	1.8
17/6/00	0.71	10.28	7.71	16.55	0.10	0.74	1.23	6.48	1.15	0.78	0.22	**7.37**	2.95	0.0	3.4
18/6/00	0.79	10.88	8.16	17.01	0.09	0.81	1.24	6.92	1.15	0.79	0.21	**7.58**	3.02	0.0	4.0
19/6/00	0.79	10.88	8.16	16.89	0.10	0.81	1.36	6.80	1.19	0.79	0.21	**8.59**	3.35	0.0	4.1
20/6/00	0.79	10.88	8.16	16.82	0.09	0.81	1.22	6.94	1.12	0.80	0.20	**7.23**	3.42	5.0	4.1
21/6/00	0.71	10.32	7.74	16.89	0.12	0.74	1.51	6.23	1.07	0.79	0.21	**6.82**	3.50	4.0	3.6
22/6/00	0.86	11.53	8.65	16	0.11	0.87	1.53	7.11	1.15	0.76	0.24	**7.12**	3.50	0.0	3.3
23/6/00	0.88	11.64	8.73	16.7	0.09	0.89	1.33	7.40	1.14	0.79	0.21	**7.53**	3.62	5.0	3.2
24/6/00	0.86	11.53	8.65	16.55	0.11	0.87	1.59	7.06	1.08	0.78	0.22	**6.98**	3.65	0.0	3.6
25/6/00	0.88	11.64	8.73	16.35	0.11	0.89	1.60	7.13	1.10	0.78	0.22	**6.93**	3.70	11.0	3.6
26/6/00	0.21	6.07	4.55	16.25	0.11	0.29	0.52	4.03	1.01	0.77	0.23	**3.90**	3.75	3.8	2.5
27/6/00	0.43	7.89	5.92	16	0.11	0.49	0.85	5.06	1.07	0.76	0.24	**4.78**	3.80	0.0	1.9
28/6/00	0.43	7.89	5.92	16.5	0.11	0.49	0.88	5.04	1.09	0.78	0.22	**5.36**	3.80	100.0	0.8
29/6/00	0.14	5.44	4.08	15.71	0.11	0.23	0.39	3.69	1.03	0.75	0.25	**3.23**	0.00	0.0	0.6
30/6/00	0.50	8.5	6.38	16.55	0.11	0.55	1.00	5.37	1.09	0.78	0.22	**5.90**	0.65	0.0	4.2

Weather and hydrologic condition during experimental period (01-06-2000 to 25-10-2000) at Demonstration Farm WRDTC

Date	Tmax. 0 C	Tmin. 0 C	Tmean 0 C	RHMax. %	RHMin. %	RHMean %	Wind km/day	u day m/s	Sunshine n (hrs)	N (hrs)	ea mbar	ed mbar	ea-ed mbar	F(u)	Ra mm/day
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1/7/00	33.0	27.0	30.0	79	63	71.0	34	0.62	10.0	13.9	42.40	30.10	12.30	0.36	16.8
2/7/00	33.5	24.5	29.0	80	62	71.0	28	0.53	8.0	13.9	40.10	28.47	11.63	0.35	16.8
3/7/00	34.5	27.0	30.8	73	69	71.0	32	0.51	12.0	13.9	44.27	31.43	12.84	0.36	16.8
4/7/00	36.0	28.0	32.0	80	64	72.0	30	0.55	12.0	13.9	47.60	34.27	13.33	0.35	16.8
5/7/00	37.0	28.0	32.5	68	64	66.0	17	0.32	10.0	13.9	48.95	32.31	16.64	0.32	16.8
6/7/00	29.5	26.0	27.8	70	69	69.5	79	0.32	12.0	13.9	37.27	25.90	11.37	0.48	16.8
7/7/00	30.0	24.5	27.3	79	75	77.0	112	1.99	7.0	13.9	36.22	27.89	8.33	0.57	16.8
8/7/00	32.0	25.0	28.5	85	72	78.5	35	0.65	9.0	13.9	38.95	30.58	8.37	0.36	16.8
9/7/00	30.0	25.5	27.8	85	68	76.5	43	0.78	2.0	13.9	37.27	28.51	8.76	0.39	16.8
10/7/00	31.0	26.0	28.5	92	79	85.5	28	0.51	4.0	13.9	38.95	33.30	5.65	0.35	16.8
11/7/00	33.0	25.5	29.3	79	79	79.0	33	0.60	6.0	13.9	40.67	32.13	8.54	0.36	16.8
12/7/00	35.0	27.0	31.0	79	74	76.5	8	0.14	7.0	13.9	44.90	34.35	10.55	0.29	16.8
13/7/00	35.0	24.0	29.5	75	63	69.0	35	0.65	12.0	13.9	41.25	28.46	12.79	0.36	16.8
14/7/00	35.0	27.5	31.3	81	79	80.0	69	1.27	12.0	13.9	45.57	36.46	9.11	0.46	16.8
15/7/00	31.0	25.0	28.0	75	68	71.5	61	0.74	8.0	13.9	37.80	27.03	10.77	0.43	16.8
16/7/00	29.5	25.0	27.3	85	73	79.0	70	0.88	1.0	13.9	36.22	28.61	7.61	0.46	16.8
17/7/00	29.5	24.5	27.0	85	79	82.0	50	0.92	0.0	13.9	35.70	29.27	6.43	0.41	16.8
18/7/00	28.0	24.5	26.3	85	79	82.0	40	0.74	0.0	13.9	34.12	27.98	6.14	0.38	16.8
19/7/00	28.0	24.5	26.3	89	85	87.0	17	0.32	0.0	13.9	34.12	29.68	4.44	0.32	16.8
20/7/00	32.0	25.0	28.5	85	73	79.0	71	0.23	4.0	13.9	38.95	30.77	8.18	0.46	16.8
21/7/00	31.5	25.5	28.5	80	73	76.5	173	2.03	6.0	13.9	38.95	29.80	9.15	0.74	16.8
22/7/00	28.5	24.5	26.5	92	89	90.5	44	0.74	11.0	13.9	34.65	31.36	3.29	0.39	16.8
23/7/00	35.0	27.0	31.0	75	64	69.5	69	1.06	10.0	13.9	44.95	31.24	13.71	0.46	16.8
24/7/00	25.0	31.0	28.0	80	73	76.5	54	1.00	8.0	13.9	37.80	28.92	8.88	0.42	16.8
25/7/00	26.5	24.5	25.5	85	82	83.5	30	0.50	2.0	13.9	32.65	27.26	5.39	0.35	16.8
26/7/00	27.5	24.5	26.0	89	74	81.5	20	0.37	3.5	13.9	33.60	27.38	6.22	0.32	16.8
27/7/00	28.0	23.5	25.8	85	75	80.0	21	0.37	2.0	13.9	33.12	26.50	6.62	0.33	16.8
28/7/00	30.5	24.5	27.5	80	79	79.5	21	0.37	2.0	13.9	36.75	29.22	7.53	0.33	16.8
29/7/00	31.0	25.5	28.3	90	83	86.5	44	0.74	0.0	13.9	32.65	28.24	4.41	0.39	16.8
30/7/00	32.0	24.5	28.3	85	80	82.5	31	0.50	3.0	13.9	29.21	24.10	5.11	0.35	16.8
31/7/00	29.0	24.0	26.5	92	85	88.5	19	0.32	0.0	13.9	34.65	30.67	3.98	0.32	16.8

Date	n/N	Rs mm/da	Rns mm/day	F(T)	F(ed)	F(n/N)	Rnl mm/day	Rn mm/day	C	W	1-W	**Eto mm/day**	G.W.L. M.	Rainfall mm.	Evap. mm.
1	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1/7/00	0.72	10.25	7.69	16.70	0.10	0.75	1.25	6.44	1.11	0.79	0.21	**6.68**	1.20	0.00	2.10
2/7/00	0.58	9.07	6.80	16.50	0.11	0.62	1.12	5.68	1.11	0.78	0.22	**5.90**	1.35	10.00	2.30
3/7/00	0.86	11.42	8.57	16.89	0.09	0.88	1.33	7.23	1.09	0.79	0.21	**7.27**	1.75	0.00	4.00
4/7/00	0.86	11.42	8.57	17.20	0.08	0.88	1.21	7.36	1.11	0.81	0.19	**7.60**	2.00	0.00	3.30
5/7/00	0.72	10.25	7.69	17.30	0.09	0.75	1.16	6.52	1.07	0.81	0.19	**6.72**	2.20	0.00	3.20
6/7/00	0.86	11.42	8.57	16.25	0.12	0.88	1.71	6.85	1.06	0.77	0.23	**6.93**	2.40	0.00	4.50
7/7/00	0.50	8.40	6.30	16.15	0.11	0.55	0.98	5.32	1.10	0.77	0.23	**5.71**	2.65	23.60	3.70
8/7/00	0.65	9.66	7.25	16.40	0.10	0.68	1.12	6.13	1.13	0.78	0.22	**6.16**	2.65	0.00	2.60
9/7/00	0.14	5.38	4.04	16.25	0.11	0.23	0.41	3.62	1.04	0.77	0.23	**3.71**	0.50	33.00	1.30
10/7/00	0.29	6.64	4.98	16.40	0.09	0.36	0.53	4.45	1.08	0.78	0.22	**4.21**	1.20	0.00	1.10
11/7/00	0.43	7.81	5.86	16.55	0.09	0.49	0.73	5.13	1.08	0.78	0.22	**5.05**	1.65	5.20	1.60
12/7/00	0.50	8.40	6.30	16.95	0.08	0.55	0.75	5.55	1.07	0.80	0.20	**5.41**	1.75	0.00	1.30
13/7/00	0.86	11.42	8.57	16.60	0.11	0.88	1.60	6.96	1.10	0.78	0.22	**7.10**	1.85	53.40	3.70
14/7/00	0.86	11.42	8.57	17.01	0.07	0.88	1.04	7.52	1.16	0.80	0.20	**7.94**	0.30	0.00	3.00
15/7/00	0.58	9.07	6.80	16.30	0.11	0.62	1.11	5.69	1.05	0.78	0.22	**5.75**	0.70	0.00	2.00
16/7/00	0.07	4.79	3.59	16.15	0.10	0.16	0.27	3.33	0.99	0.77	0.23	**3.33**	0.30	47.00	0.50
17/7/00	0.00	4.20	3.15	16.10	0.10	0.10	0.16	2.99	1.02	0.77	0.23	**2.96**	0.30	109.00	0.00
18/7/00	0.00	4.20	3.15	15.95	0.11	0.10	0.18	2.97	1.02	0.76	0.24	**2.87**	0.00	13.00	1.50
19/7/00	0.00	4.20	3.15	15.95	0.10	0.10	0.16	2.99	1.04	0.76	0.24	**2.71**	0.00	4.00	2.00
20/7/00	0.29	6.61	4.96	16.40	0.10	0.36	0.59	4.37	1.04	0.78	0.22	**4.41**	0.40	2.60	2.40
21/7/00	0.43	7.81	5.86	16.40	0.10	0.49	0.80	5.06	0.97	0.78	0.22	**5.27**	0.90	0.00	4.00
22/7/00	0.79	10.83	8.12	16.00	0.09	0.81	1.17	6.95	1.13	0.76	0.24	**6.32**	1.00	5.00	2.90
23/7/00	0.72	10.24	7.68	16.95	0.09	0.75	1.14	6.54	1.07	0.79	0.21	**6.93**	1.25	0.00	2.80
24/7/00	0.58	9.03	6.77	16.30	0.10	0.62	1.01	5.77	1.13	0.77	0.23	**5.98**	1.60	10.60	2.60
25/7/00	0.14	5.40	4.05	15.77	0.11	0.23	0.40	3.65	1.05	0.75	0.25	**3.37**	1.60	4.20	1.00
26/7/00	0.25	6.31	4.73	15.90	0.11	0.33	0.57	4.16	1.07	0.75	0.25	**3.88**	1.65	35.60	1.00
27/7/00	0.14	5.40	4.05	15.83	0.12	0.23	0.44	3.61	1.04	0.75	0.25	**3.38**	0.00	1.00	1.00
28/7/00	0.14	6.21	4.66	16.20	0.10	0.23	0.37	4.29	1.02	0.77	0.23	**3.94**	0.35	0.00	1.40
29/7/00	0.00	4.20	3.15	16.35	0.11	0.10	0.18	2.97	1.03	0.77	0.23	**2.76**	0.60	8.00	1.60
30/7/00	0.22	6.00	4.50	16.35	0.11	0.29	0.53	3.97	1.03	0.77	0.23	**3.58**	0.80	14.80	3.00
31/7/00	0.00	4.20	3.15	16.00	0.10	0.10	0.16	2.99	1.03	0.76	0.24	**2.66**	0.15	33.00	3.10

Weather and hydrologic condition during experimental period (01-06-2000 to 25-10-2000) at Demonstration Farm WRDTC

Date	Tmax. 0 C	Tmin. 0 C	Tmean 0 C.	RHMax. %	RHMin. %	RHMean %	Wind km/day	u day m/s	Sunshine n (hrs)	N (hrs)	ea mbar	ed mbar	ea-ed mbar	F(u)	Ra mm/day
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1/8/00	31.5	25.0	28.25	80	76	78.0	10	0.14	9.5	13.2	38.37	29.93	8.44	0.30	15.7
2/8/00	32.0	25.0	28.50	80	80	80.0	10	0.18	11.5	13.2	38.95	31.16	7.79	0.30	15.7
3/8/00	33.5	25.0	29.25	80	69	74.5	18	0.32	12.0	13.2	40.67	30.30	10.37	0.32	15.7
4/8/00	33.5	26.5	30.00	74	69	71.5	28	0.55	12.0	13.2	42.40	30.32	12.08	0.35	15.7
5/8/00	34.0	26.5	30.25	74	69	71.5	38	0.60	12.0	13.2	43.02	30.76	12.26	0.37	15.7
6/8/00	35.0	28.0	31.50	83	69	76.0	11	0.18	12.0	13.2	46.25	35.15	11.10	0.30	15.7
7/8/00	35.5	27.5	31.50	81	70	75.5	31	0.58	12.0	13.2	46.25	34.92	11.33	0.35	15.7
8/8/00	35.5	27.5	31.50	73	72	72.5	78	0.90	10.0	13.2	46.25	33.53	12.72	0.48	15.7
9/8/00	35.0	26.0	30.50	76	75	75.5	74	0.86	10.0	13.2	43.65	32.96	10.69	0.47	15.7
10/8/00	27.0	24.0	25.50	92	85	88.5	41	0.46	1.0	13.2	32.65	28.90	3.75	0.38	15.7
11/8/00	32.0	24.0	28.00	79	73	76.0	30	0.46	5.0	13.2	37.80	28.73	9.07	0.35	15.7
12/8/00	33.0	26.5	29.75	73	66	69.5	54	0.83	9.0	13.2	41.82	29.06	12.76	0.42	15.7
13/8/00	33.0	26.5	29.75	73	69	71.0	40	0.46	8.0	13.2	41.82	29.69	12.13	0.38	15.7
14/8/00	31.0	25.5	28.25	88	80	84.0	44	0.50	6.0	13.2	38.37	32.23	6.14	0.39	15.7
15/8/00	32.0	26.0	29.00	100	88	94.0	105	1.38	8.0	13.2	40.10	37.69	2.41	0.55	15.7
16/8/00	30.0	22.5	26.25	88	85	86.5	6	0.07	6.0	13.2	34.12	29.51	4.61	0.29	15.7
17/8/00	32.5	24.5	28.50	85	74	79.5	19	0.21	9.0	13.2	38.95	30.97	7.98	0.32	15.7
18/8/00	29.0	26.0	27.50	86	82	84.0	17	0.30	3.0	13.2	36.75	30.87	5.88	0.32	15.7
19/8/00	31.0	24.0	27.50	94	77	85.5	5	0.07	3.0	13.2	36.75	31.42	5.33	0.28	15.7
20/8/00	31.0	25.0	28.00	89	80	84.5	7	0.07	4.0	13.2	37.80	31.94	5.86	0.29	15.7
21/8/00	33.0	23.5	28.25	73	68	70.5	20	0.05	5.0	13.2	38.37	27.05	11.32	0.32	15.7
22/8/00	28.0	20.0	24.00	89	85	87.0	11	0.25	3.0	13.2	29.80	25.93	3.87	0.30	15.7
23/8/00	29.0	23.5	26.25	85	79	82.0	6	0.14	3.0	13.2	34.12	27.98	6.14	0.29	15.7
24/8/00	34.0	24.0	29.00	68	63	65.5	8	0.10	12.0	13.2	40.10	26.27	13.83	0.29	15.7
25/8/00	31.0	26.5	28.75	73	73	73.0	42	0.78	1.0	13.2	39.52	28.85	10.67	0.38	15.7
26/8/00	33.5	25.5	29.50	72	71	71.5	9	0.21	9.0	13.2	41.25	29.49	11.76	0.29	15.7
27/8/00	35.0	28.0	31.50	69	54	61.5	26	0.30	6.0	13.2	46.25	28.44	17.81	0.34	15.7
28/8/00	29.5	25.0	27.25	89	86	87.5	42	0.50	3.0	13.2	36.22	31.69	4.53	0.38	15.7
29/8/00	28.5	23.5	26.00	92	82	87.0	22	0.40	3.0	13.2	33.60	29.23	4.37	0.33	15.7
30/8/00	32.0	25.0	28.50	91	67	79.0	24	0.27	5.0	13.2	38.95	30.77	8.18	0.33	15.7
31/8/00	28.0	24.5	26.25	88	85	86.5	24	0.46	4.0	13.2	34.12	29.51	4.61	0.33	15.7

Date	n/N	Rs mm/da	Rns mm/day	F(T)	F(ed)	F(n/N)	Rnl mm/day	Rn mm/day	C	W	1-W	**Eto mm/day**	G.W.L. M.	Rainfall mm.	Evap. mm.
1	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1/8/00	0.72	9.58	7.19	16.35	0.10	0.75	1.22	5.96	1.08	0.77	0.23	**5.58**	0.0	0.4	3.0
2/8/00	0.87	10.76	8.07	16.40	0.09	0.88	1.30	6.77	1.08	0.77	0.23	**6.20**	0.3	0.0	1.9
3/8/00	0.91	11.06	8.30	16.55	0.10	0.92	1.52	6.78	1.09	0.78	0.22	**6.55**	0.6	0.0	2.9
4/8/00	0.91	11.06	8.30	16.70	0.10	0.92	1.53	6.76	1.10	0.78	0.22	**6.81**	0.7	0.0	4.4
5/8/00	0.91	11.06	8.30	16.35	0.10	0.92	1.50	6.79	1.08	0.79	0.21	**6.83**	1.0	0.0	3.4
6/8/00	0.91	11.06	8.30	17.10	0.08	0.92	1.26	7.04	1.08	0.80	0.20	**6.80**	1.1	0.0	2.6
7/8/00	0.91	11.06	8.30	17.10	0.08	0.92	1.26	7.04	1.09	0.80	0.20	**7.01**	1.1	0.0	3.8
8/8/00	0.76	9.86	7.40	17.10	0.08	0.78	1.07	6.33	1.04	0.80	0.20	**6.53**	1.3	0.0	3.1
9/8/00	0.76	9.89	7.42	16.80	0.09	0.78	1.18	6.24	1.04	0.80	0.20	**6.23**	1.5	35.4	2.7
10/8/00	0.08	4.51	3.38	15.80	0.10	0.17	0.27	3.12	1.01	0.75	0.25	**2.72**	0.0	3.2	0.8
11/8/00	0.38	6.89	5.17	16.30	0.10	0.44	0.72	4.45	1.02	0.77	0.23	**4.24**	0.3	0.0	2.0
12/8/00	0.68	9.26	6.95	16.70	0.10	0.71	1.19	5.75	1.07	0.79	0.21	**6.05**	0.6	0.0	3.0
13/8/00	0.61	8.68	6.51	16.65	0.10	0.65	1.07	5.44	1.05	0.78	0.22	**5.51**	0.7	0.0	3.0
14/8/00	0.45	7.49	5.62	16.35	0.09	0.51	0.75	4.87	1.06	0.78	0.22	**4.58**	0.8	17.0	3.3
15/8/00	0.61	8.63	6.47	16.50	0.07	0.65	0.75	5.73	1.08	0.78	0.22	**5.14**	1.0	29.0	3.9
16/8/00	0.45	7.49	5.62	15.95	0.10	0.51	0.81	4.81	1.08	0.76	0.24	**4.29**	1.0	15.6	3.7
17/8/00	0.68	9.28	6.96	16.50	0.09	0.71	1.06	5.90	1.09	0.78	0.22	**5.63**	1.3	0.0	1.9
18/8/00	0.23	5.71	4.28	16.10	0.09	0.30	0.44	3.84	1.05	0.77	0.23	**3.55**	1.4	53.0	1.0
19/8/00	0.23	5.71	4.28	16.10	0.09	0.30	0.44	3.84	1.06	0.77	0.23	**3.50**	1.5	0.0	1.6
20/8/00	0.30	6.3	4.73	16.30	0.09	0.37	0.55	4.18	1.06	0.77	0.23	**3.82**	1.6	14.0	2.0
21/8/00	0.38	6.9	5.18	16.35	0.11	0.44	0.79	4.38	1.02	0.78	0.22	**4.31**	1.7	8.0	2.9
22/8/00	0.23	5.71	4.28	15.40	0.12	0.30	0.56	3.72	1.06	0.73	0.27	**3.21**	1.7	85.0	1.0
23/8/00	0.23	5.71	4.28	15.95	0.11	0.30	0.53	3.75	1.05	0.76	0.24	**3.43**	1.8	2.6	0.5
24/8/00	0.91	11.06	8.30	16.50	0.11	0.92	1.67	6.63	1.06	0.78	0.22	**6.42**	1.9	0.0	2.6
25/8/00	0.08	4.51	3.38	16.45	0.10	0.17	0.28	3.11	1.01	0.78	0.22	**3.36**	1.9	0.0	2.7
26/8/00	0.68	9.27	6.95	16.60	0.10	0.71	1.18	5.77	1.07	0.78	0.22	**5.63**	1.9	0.0	3.4
27/8/00	0.45	7.49	5.62	17.10	0.10	0.51	0.87	4.75	1.00	0.80	0.20	**5.01**	2.0	22.0	3.4
28/8/00	0.23	5.7	4.28	16.15	0.09	0.30	0.44	3.83	1.06	0.77	0.23	**3.55**	0.0	76.2	1.5
29/8/00	0.23	5.7	4.28	15.90	0.10	0.30	0.48	3.79	1.06	0.75	0.25	**3.39**	0.2	3.6	1.2
30/8/00	0.38	6.9	5.18	16.90	0.09	0.44	0.67	4.50	1.06	0.78	0.22	**4.36**	0.3	48.0	2.1
31/8/00	0.30	6.3	4.73	15.95	0.10	0.37	0.59	4.13	1.06	0.76	0.24	**3.72**	0.5	28.0	1.5

Weather and hydrologic condition during experimental period (01-06-2000 to 25-10-2000) at Demonstration Farm WRDTC

Date	Tmax. 0 C	Tmin. 0 C	Tmean 0 C	RHMax. %	RHMin. %	RHMean %	Wind km/day	u day m/s	Sunshine n (hrs)	N (hrs)	ea mbar	ed mbar	ea-ed mbar	F(u)	Ra mm/day
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1/9/00	32.0	24.0	28.00	85	74	79.5	5	0.10	10.00	12.4	37.80	30.05	7.75	0.28	13.9
2/9/00	33.0	25.5	29.25	74	67	70.5	27	0.46	6.00	12.4	40.67	28.67	12.00	0.34	13.9
3/9/00	35.0	24.0	29.50	83	63	73.0	4	0.07	12.00	12.4	41.25	30.11	11.14	0.28	13.9
4/9/00	35.0	25.5	30.25	69	68	68.5	19	0.11	6.00	12.4	43.02	29.47	13.55	0.32	13.9
5/9/00	32.0	22.0	27.00	92	73	82.5	35	0.55	5.00	12.4	35.70	29.45	6.25	0.36	13.9
6/9/00	28.0	23.0	25.50	85	85	85.0	20	0.37	2.00	12.4	33.12	28.15	4.97	0.32	13.9
7/9/00	32.5	25.0	28.75	75	68	71.5	18	0.21	5.00	12.4	39.52	28.26	11.26	0.32	13.9
8/9/00	32.0	24.0	28.00	75	70	72.5	16	0.32	5.00	12.4	37.80	27.41	10.40	0.31	13.9
9/9/00	33.0	24.5	28.75	72	65	68.5	15	0.18	11.00	12.4	39.52	27.07	12.45	0.31	13.9
10/9/00	32.0	24.0	28.00	76	65	70.5	21	0.42	10.50	12.4	37.80	26.65	11.15	0.33	13.9
11/9/00	31.5	24.5	28.00	72	62	67.0	17	0.30	10.00	12.4	37.80	25.33	12.47	0.32	13.9
12/9/00	33.0	24.5	28.75	72	63	67.5	22	0.42	10.00	12.4	39.52	26.68	12.84	0.33	13.9
13/9/00	33.5	26.0	29.75	71	68	69.5	27	0.51	10.25	12.4	41.82	29.06	12.76	0.34	13.9
14/9/00	35.0	26.0	30.50	68	64	66.0	25	0.47	10.25	12.4	43.65	28.81	14.84	0.34	13.9
15/9/00	33.5	26.0	29.75	65	63	64.0	46	0.81	7.00	12.4	41.82	26.76	15.06	0.39	13.9
16/9/00	34.0	24.0	29.00	72	63	67.5	26	0.60	11.00	12.4	40.10	27.07	13.03	0.34	13.9
17/9/00	33.0	25.5	29.25	83	81	82.0	19	0.18	11.00	12.4	40.67	33.35	7.32	0.32	13.9
18/9/00	34.0	24.0	29.00	72	63	67.5	53	0.65	10.50	12.4	40.10	27.07	13.03	0.41	13.9
19/9/00	29.5	25.0	27.25	82	76	79.0	50	1.04	1.00	12.4	36.22	28.61	7.61	0.41	13.9
20/9/00	28.5	24.0	26.25	79	72	75.5	39	0.81	2.00	12.4	34.12	25.76	8.36	0.38	13.9
21/9/00	29.0	22.0	25.50	79	66	72.5	46	0.88	6.50	12.4	32.65	23.67	8.98	0.39	13.9
22/9/00	31.0	21.0	26.00	77	67	72.0	23	0.46	9.00	12.4	33.00	23.76	9.24	0.33	13.9
23/9/00	32.5	22.5	27.50	72	62	67.0	14	0.23	10.00	12.4	36.75	24.62	12.13	0.31	13.9
24/9/00	32.0	22.5	27.25	76	62	69.0	16	0.37	10.25	12.4	36.22	24.99	11.23	0.31	13.9
25/9/00	33.0	22.5	27.75	63	60	61.5	24	0.55	10.50	12.4	37.27	22.92	14.35	0.33	13.9
26/9/00	28.0	20.0	24.00	83	78	80.5	13	0.16	7.00	12.4	29.80	23.99	5.81	0.31	13.9
27/9/00	32.5	20.0	26.25	65	47	56.0	13	0.27	9.50	12.4	34.65	19.40	15.25	0.31	13.9
28/9/00	33.0	20.5	26.75	59	52	55.5	13	0.27	10.00	12.4	35.17	19.52	15.65	0.31	13.9
29/9/00	32.0	20.5	26.25	59	57	58.0	16	0.37	10.50	12.4	34.12	19.79	14.33	0.31	13.9
30/9/00	32.5	20.0	26.25	58	57	57.5	21	0.42	10.25	12.4	34.12	19.62	14.50	0.33	13.9

Date	n/N	Rs mm/da	Rns mm/day	F(T)	F(ed)	F(n/N)	Rnl mm/day	Rn mm/day	C	W	1-W	**Eto mm/day**	G.W.L. M.	Rainfall mm.	Evap. mm.
1	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1/9/00	0.81	9.08	6.81	16.30	0.10	0.83	1.35	5.46	1.09	0.77	0.23	**5.14**	0.50	0.0	2.8
2/9/00	0.48	6.70	5.03	16.55	0.10	0.54	0.89	4.14	1.06	0.78	0.22	**4.38**	0.60	1.0	3.6
3/9/00	0.97	10.19	7.64	16.60	0.10	0.97	1.61	6.03	1.09	0.78	0.22	**5.88**	0.70	0.0	3.7
4/9/00	0.48	6.83	5.12	16.75	0.10	0.54	0.90	4.23	1.02	0.79	0.21	**4.34**	0.76	31.4	2.8
5/9/00	0.40	6.25	4.69	16.10	0.10	0.46	0.75	3.94	1.05	0.76	0.24	**3.72**	0.80	37.0	2.7
6/9/00	0.16	4.59	3.44	15.83	0.11	0.25	0.43	3.02	1.03	0.75	0.25	**2.74**	0.95	0.0	1.1
7/9/00	0.40	6.27	4.70	16.45	0.11	0.46	0.84	3.86	1.03	0.78	0.22	**3.92**	1.05	0.0	2.4
8/9/00	0.40	6.27	4.70	16.30	0.11	0.46	0.83	3.87	1.02	0.78	0.22	**3.81**	1.05	0.0	1.7
9/9/00	0.89	9.64	7.23	16.45	0.11	0.90	1.63	5.60	1.06	0.78	0.22	**5.54**	1.15	0.0	4.0
10/9/00	0.85	9.38	7.04	16.30	0.11	0.86	1.55	5.49	1.09	0.78	0.22	**5.54**	1.20	0.0	2.9
11/9/00	0.81	9.08	6.81	16.30	0.12	0.83	1.62	5.19	1.07	0.78	0.22	**5.26**	1.25	0.0	2.0
12/9/00	0.81	9.10	6.83	16.45	0.11	0.83	1.49	5.33	1.08	0.78	0.22	**5.50**	1.30	0.0	2.5
13/9/00	0.83	9.24	6.93	16.65	0.10	0.84	1.41	5.52	1.09	0.78	0.22	**5.75**	1.35	0.0	3.5
14/9/00	0.83	9.24	6.93	16.95	0.10	0.84	1.43	5.50	1.08	0.79	0.21	**5.83**	1.40	0.0	3.3
15/9/00	0.56	7.39	5.54	16.65	0.11	0.61	1.11	4.43	1.02	0.78	0.22	**4.86**	1.45	0.0	3.1
16/9/00	0.89	9.59	7.19	16.50	0.11	0.90	1.63	5.56	1.08	0.78	0.22	**5.74**	1.60	0.0	3.1
17/9/00	0.89	9.59	7.19	16.55	0.08	0.90	1.19	6.00	1.10	0.78	0.22	**5.72**	1.60	0.0	3.2
18/9/00	0.85	9.38	7.04	16.50	0.11	0.86	1.56	5.47	1.04	0.78	0.22	**5.67**	1.70	0.0	3.3
19/9/00	0.08	4.03	3.02	16.15	0.10	0.17	0.28	2.74	1.00	0.77	0.23	**2.82**	1.70	0.0	0.7
20/9/00	0.16	4.58	3.44	15.95	0.12	0.25	0.47	2.97	1.01	0.76	0.24	**3.04**	1.80	0.0	2.2
21/9/00	0.52	7.09	5.32	15.77	0.13	0.57	1.17	4.15	1.07	0.75	0.25	**4.27**	1.80	8.6	2.6
22/9/00	0.73	8.55	6.41	15.90	0.12	0.75	1.44	4.98	1.09	0.76	0.24	**4.92**	1.80	0.0	2.8
23/9/00	0.81	9.10	6.83	16.20	0.12	0.83	1.61	5.22	1.07	0.77	0.23	**5.22**	1.90	0.0	3.3
24/9/00	0.83	9.22	6.92	16.15	0.12	0.84	1.64	5.28	1.08	0.77	0.23	**5.26**	1.90	0.0	2.1
25/9/00	0.85	9.38	7.04	16.25	0.13	0.86	1.82	5.21	1.06	0.77	0.23	**5.43**	1.95	2.0	3.0
26/9/00	0.56	7.36	5.52	15.40	0.12	0.61	1.12	4.40	1.05	0.74	0.26	**3.90**	2.00	0.0	2.0
27/9/00	0.77	8.82	6.62	16.00	0.15	0.79	1.89	4.72	1.04	0.76	0.24	**4.89**	2.05	0.0	2.2
28/9/00	0.81	9.10	6.83	16.05	0.15	0.83	1.99	4.84	1.04	0.76	0.24	**5.01**	2.05	0.0	2.6
29/9/00	0.85	9.38	7.04	15.95	0.14	0.86	1.93	5.11	1.06	0.76	0.24	**5.26**	2.10	0.0	3.5
30/9/00	0.83	9.24	6.93	15.95	0.14	0.84	1.88	5.05	1.06	0.76	0.24	**5.27**	2.15	0.0	3.3

Weather and hydrologic condition during experimental period (01-06-2000 to 25-10-2000) at Demonstration Farm WRDTC

Date	Tmax. 0 C	Tmin. 0 C	Tmean 0 C	RHMax. %	RHMin. %	RHMean %	Wind km/day	u day m/s	Sunshine n (hrs)	N (hrs)	ea mbar	ed mbar	ea-ed mbar	F(u)	Ra mm/day
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1/10/00	32.0	20.0	26.00	66	65	65.50	9	0.21	10.25	11.5	33.60	22.01	11.59	0.29	11.6
2/10/00	32.5	21.0	26.75	63	59	61.00	16	0.37	10.25	11.5	35.17	21.45	13.72	0.31	11.6
3/10/00	32.5	22.0	27.25	63	62	62.50	25	0.49	10.00	11.5	36.22	22.64	13.58	0.34	11.6
4/10/00	33.0	22.5	27.75	68	66	67.00	16	0.35	10.00	11.5	37.27	24.97	12.30	0.31	11.6
5/10/00	33.0	23.5	28.25	66	62	64.00	18	0.35	10.00	11.5	38.37	24.56	13.81	0.32	11.6
6/10/00	32.5	23.5	28.00	67	62	64.50	15	0.32	9.00	11.5	37.80	24.38	13.42	0.31	11.6
7/10/00	33.0	24.0	28.50	70	59	64.50	16	0.30	9.50	11.5	38.95	25.12	13.83	0.31	11.6
8/10/00	33.0	23.5	28.25	70	59	64.50	11	0.25	9.75	11.5	38.37	24.75	13.62	0.30	11.6
9/10/00	33.0	22.0	27.50	67	57	62.00	17	0.35	9.75	11.5	36.75	22.79	13.97	0.32	11.6
10/10/00	33.0	19.5	26.25	66	52	59.00	14	0.27	10.00	11.5	34.12	20.13	13.99	0.31	11.6
11/10/00	33.0	18.5	25.75	70	57	63.50	13	0.28	9.50	11.5	33.12	21.03	12.09	0.31	11.6
12/10/00	32.0	17.0	24.50	52	45	48.50	13	0.28	10.00	11.5	30.75	14.91	15.84	0.31	11.6
13/10/00	31.5	16.5	24.00	59	41	50.00	14	0.28	10.00	11.5	29.80	14.90	14.90	0.31	11.6
14/10/00	31.0	15.0	23.00	52	43	47.50	13	0.28	10.00	11.5	28.10	13.35	14.75	0.31	11.6
15/10/00	31.5	16.0	23.75	53	41	47.00	13	0.30	10.00	11.5	29.37	13.80	15.57	0.31	11.6
16/10/00	32.5	16.5	24.50	52	50	51.00	12	0.23	10.00	11.5	30.75	15.68	15.07	0.31	11.6
17/10/00	33.0	17.5	25.25	59	52	55.50	8	0.16	10.00	11.5	32.17	17.85	14.32	0.30	11.6
18/10/00	32.0	17.5	24.75	59	51	55.00	8	0.16	9.75	11.5	31.22	17.17	14.05	0.29	11.6
19.10.00	30.5	19.0	24.75	67	49	58.00	30	0.58	9.00	11.5	31.22	18.11	13.11	0.29	11.6
20/10/00	32.0	18.5	25.25	67	51	59.00	18	0.28	9.25	11.5	32.17	18.98	13.19	0.35	11.6
21/10/00	32.0	19.0	25.50	70	56	63.00	16	0.32	8.00	11.5	32.65	20.57	12.08	0.32	11.6
22/10/00	32.5	20.0	26.25	71	54	62.50	34	0.69	8.50	11.5	34.12	21.33	12.80	0.31	11.6
23/10/00	31.5	19.0	25.25	71	55	63.00	18	0.37	8.75	11.5	32.17	20.27	11.90	0.36	11.6
24/10/00	31.5	18.5	25.00	58	50	54.00	14	0.30	9.00	11.5	31.70	17.12	14.58	0.32	11.6
25/10/00	31.0	18.0	24.50	63	55	59.00	22	0.42	9.00	11.5	30.75	18.14	12.61	0.31	11.6

Date	n/N	Rs mm/da	Rns mm/day	F(T)	F(ed)	F(n/N)	Rnl mm/day	Rn mm/day	C	W	1-W	**Eto mm/day**	G.W.L. M.	Rainfall mm.	Evap. mm.
1	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1/10/00	0.89	8.06	6.05	15.90	0.13	0.90	1.86	4.18	1.04	0.76	0.24	**4.16**	2.20	0.0	2.8
2/10/00	0.89	8.06	6.05	16.05	0.14	0.90	2.03	4.02	1.03	0.76	0.24	**4.21**	2.25	0.0	3.0
3/10/00	0.87	7.95	5.96	16.15	0.13	0.88	1.85	4.11	1.04	0.77	0.23	**4.39**	2.30	0.0	2.7
4/10/00	0.87	7.95	5.96	16.25	0.12	0.88	1.72	4.24	1.05	0.77	0.23	**4.36**	2.30	0.0	2.1
5/10/00	0.87	7.95	5.96	16.35	0.12	0.88	1.73	4.23	1.04	0.78	0.22	**4.44**	2.35	0.0	2.0
6/10/00	0.78	7.42	5.57	16.30	0.12	0.80	1.57	3.99	1.03	0.78	0.22	**4.15**	2.35	0.0	2.6
7/10/00	0.83	7.71	5.78	16.40	0.12	0.84	1.66	4.12	1.03	0.78	0.22	**4.29**	2.40	0.0	2.5
8/10/00	0.85	7.83	5.87	16.35	0.12	0.86	1.69	4.18	1.03	0.78	0.22	**4.28**	2.40	0.0	2.5
9/10/00	0.85	7.83	5.87	16.20	0.13	0.86	1.82	4.05	1.03	0.77	0.23	**4.26**	2.50	0.0	2.0
10/10/00	0.87	7.95	5.96	15.95	0.14	0.88	1.97	3.99	1.03	0.76	0.24	**4.19**	2.50	0.0	2.5
11/10/00	0.83	7.71	5.78	15.84	0.14	0.84	1.87	3.91	1.03	0.75	0.25	**3.97**	2.50	0.0	3.5
12/10/00	0.87	7.95	5.96	15.52	0.17	0.88	2.33	3.63	1.00	0.74	0.26	**3.95**	2.60	0.0	2.2
13/10/00	0.87	7.95	5.96	15.40	0.17	0.88	2.31	3.65	1.00	0.74	0.26	**3.89**	2.60	0.0	2.8
14/10/00	0.87	7.95	5.96	15.20	0.18	0.88	2.41	3.55	1.00	0.73	0.27	**3.81**	2.65	0.0	2.2
15/10/00	0.87	7.95	5.96	15.35	0.18	0.88	2.44	3.52	1.00	0.73	0.27	**3.85**	2.65	0.0	2.0
16/10/00	0.87	7.95	5.96	15.52	0.17	0.88	2.33	3.63	1.01	0.74	0.26	**3.91**	2.70	0.0	2.5
17/10/00	0.87	7.95	5.96	15.71	0.15	0.88	2.08	3.88	1.02	0.75	0.25	**4.03**	2.70	0.0	2.3
18/10/00	0.85	7.83	5.87	15.59	0.16	0.86	2.15	3.72	1.01	0.74	0.26	**3.86**	2.75	0.0	2.2
19/10/00	0.78	7.42	5.57	15.59	0.15	0.80	1.88	3.68	1.01	0.74	0.26	**3.96**	2.80	0.0	2.1
20/10/00	0.80	7.54	5.66	15.71	0.15	0.82	1.94	3.71	1.01	0.75	0.25	**3.87**	2.85	0.0	2.2
21/10/00	0.70	6.96	5.22	15.77	0.14	0.73	1.60	3.62	1.01	0.75	0.25	**3.70**	2.90	0.0	1.6
22/10/00	0.74	7.19	5.39	15.95	0.14	0.77	1.71	3.68	1.02	0.76	0.24	**3.99**	2.90	0.0	1.9
23/10/00	0.76	7.31	5.48	15.71	0.14	0.78	1.73	3.76	1.02	0.75	0.25	**3.84**	2.95	0.0	2.0
24/10/00	0.78	7.42	5.57	15.65	0.16	0.80	2.01	3.55	1.00	0.75	0.25	**3.79**	2.95	0.0	1.7
25/10/00	0.78	7.42	5.57	15.52	0.15	0.80	1.87	3.69	1.01	0.74	0.26	**3.85**	3.00	0.0	1.6

Annexure -3

Field Observation of Lysimeters for evapotranspiration of rice at W.R.D.T.C. Farm

Date	Lysi -(I1F1)				Lysi -(I1F2)				Lysi -(I1F3)			
	Add. (mm)	Remove (mm)	Rainfall (mm)	Etc (mm)	Add. (mm)	Remove (mm)	Rainfall (mm)	Etc (mm)	Add. (mm)	Remove (mm)	Rainfall (mm)	Etc (mm)
1/7/00	-	-	-	-	-	-	-	-	-	-	-	-
2/7/00	-	-	-	-	-	-	-	-	-	-	-	-
3/7/00	-	-	-	-	-	-	-	-	-	-	-	-
4/7/00	-	-	-	-	-	-	-	-	-	-	-	-
5/7/00	-	-	-	-	-	-	-	-	-	-	-	-
6/7/00	-	-	-	-	-	-	-	-	-	-	-	-
7/7/00	-	-	-	-	-	-	-	-	-	-	-	-
8/7/00	-	-	-	-	-	-	-	-	-	-	-	-
9/7/00	-	-	-	-	-	-	-	-	-	-	-	-
10/7/00	-	-	-	-	-	-	-	-	-	-	-	-
11/7/00	-	-	-	-	-	-	-	-	-	-	-	-
12/7/00	-	-	-	-	-	-	-	-	-	-	-	-
13/7/00	-	-	-	-	-	-	-	-	-	-	-	-
14/7/00	-	-	-	-	-	-	-	-	-	-	-	-
15/7/00	-	-	-	-	-	-	-	-	-	-	-	-
16/7/00	-	-	-	-	-	-	-	-	-	-	-	-
17/7/00	-	-	-	-	-	-	-	-	-	-	-	-
18/7/00	-	-	-	-	-	-	-	-	-	-	-	-
19/7/00	-	-	-	-	-	-	-	-	-	-	-	-
20/7/00	-	-	-	-	-	-	-	-	-	-	-	-
21/7/00	-	-	-	-	-	-	-	-	-	-	-	-
22/7/00	-	-	-	-	-	-	-	-	-	-	-	-
23/7/00	-	-	-	-	-	-	-	-	-	-	-	-
24/7/00	-	-	-	-	-	-	-	-	-	-	-	-
25/7/00	-	-	-	-	-	-	-	-	-	-	-	-
26/7/00	-	-	-	-	-	-	-	-	-	-	-	-
27/7/00	-	-	-	-	-	-	-	-	-	-	-	-
28/7/00	2.16	0.00	0.00	2.16	1.74	0.00	0.00	1.74	1.83	0.00	0.00	1.83
29/7/00	0.00	5.98	8.00	2.02	0.00	6.28	8.00	1.72	0.00	6.11	8.00	1.89
30/7/00	0.00	11.00	14.80	3.80	0.00	11.57	14.80	3.23	0.00	11.26	14.80	3.54
31/7/00	0.00	31.00	33.00	2.00	0.00	30.96	33.00	2.04	0.00	31.09	33.00	1.91

Field Observation of Lysimeters for evapotranspiration of rice at W.R.D.T.C. Farm

Date	Lysi -(I1F1)				Lysi -(I1F2)				Lysi -(I1F3)			
	Add. (mm)	Remove (mm)	Rainfall (mm)	Etc (mm)	Add. (mm)	Remove (mm)	Rainfall (mm)	Etc (mm)	Add. (mm)	Remove (mm)	Rainfall (mm)	Etc (mm)
1/8/00	2.10	0.00	0.40	2.50	2.20	0.00	0.40	2.60	2.40	0.00	0.40	2.80
2/8/00	3.25	0.00	0.00	3.25	3.40	0.00	0.00	3.40	3.40	0.00	0.00	3.40
3/8/00	5.85	0.00	0.00	5.85	5.90	0.00	0.00	5.90	6.10	0.00	0.00	6.10
4/8/00	4.80	0.00	0.00	4.80	4.60	0.00	0.00	4.60	4.80	0.00	0.00	4.80
5/8/00	5.70	0.00	0.00	5.70	5.40	0.00	0.00	5.40	5.70	0.00	0.00	5.70
6/8/00	4.75	0.00	0.00	4.75	4.20	0.00	0.00	4.20	4.80	0.00	0.00	4.80
7/8/00	5.48	0.00	0.00	5.48	5.45	0.00	0.00	5.45	5.76	0.00	0.00	5.76
8/8/00	6.42	0.00	0.00	6.42	6.76	0.00	0.00	6.76	6.24	0.00	0.00	6.24
9/8/00	0.00	29.40	35.40	6.00	0.00	29.50	35.40	5.90	0.00	29.10	35.40	6.30
10/8/00	0.00	1.33	3.20	1.87	0.00	1.60	3.20	1.60	0.00	1.07	3.20	2.13
11/8/00	4.36	0.00	0.00	4.36	4.30	0.00	0.00	4.30	5.02	0.00	0.00	5.02
12/8/00	7.05	0.00	0.00	7.05	6.24	0.00	0.00	6.24	7.24	0.00	0.00	7.24
13/8/00	4.36	0.00	0.00	4.36	3.58	0.00	0.00	3.58	5.11	0.00	0.00	5.11
14/8/00	0.00	12.22	17.00	4.78	0.00	13.66	17.00	3.34	0.00	11.26	17.00	5.74
15/8/00	0.00	22.18	29.00	6.82	0.00	23.80	29.00	5.20	0.00	21.22	29.00	7.78
16/8/00	0.00	9.21	15.60	6.39	0.00	9.60	15.60	6.00	0.00	7.86	15.60	7.74
17/8/00	5.30	0.00	0.00	5.30	4.89	0.00	0.00	4.89	5.59	0.00	0.00	5.59
18/8/00	0.00	49.08	53.00	3.92	0.00	48.99	53.00	4.01	0.00	48.82	53.00	4.18
19/8/00	3.87	0.00	0.00	3.87	3.92	0.00	0.00	3.92	4.11	0.00	0.00	4.11
20/8/00	0.00	9.98	14.00	4.02	0.00	9.88	14.00	4.12	0.00	9.70	14.00	4.30
21/8/00	0.00	0.48	8.00	7.52	0.00	0.96	8.00	7.04	1.26	0.00	8.00	9.26
22/8/00	0.00	82.49	85.00	2.51	0.00	82.88	85.00	2.12	1.20	82.88	85.00	2.12
23/8/00	0.00	0.00	2.60	2.60	0.00	0.43	2.60	2.17	0.00	0.48	2.60	2.12
24/8/00	7.84	0.00	0.00	7.84	5.45	0.00	0.00	5.45	8.73	0.00	0.00	5.45
25/8/00	4.21	0.00	0.00	4.21	4.36	0.00	0.00	4.36	6.63	0.00	0.00	6.63
26/8/00	5.70	0.00	0.00	5.70	5.93	0.00	0.00	5.93	5.72	0.00	0.00	5.72
27/8/00	0.00	16.06	22.00	5.94	0.00	16.20	22.00	5.80	0.00	15.37	22.00	6.63
28/8/00	0.00	70.92	76.20	5.28	0.00	72.57	76.20	3.63	0.00	71.70	76.20	4.50
29/8/00	1.44	0.00	3.60	5.04	0.00	0.00	3.60	3.60	0.87	0.00	3.60	4.47
30/8/00	0.00	44.58	48.00	3.42	0.00	44.10	48.00	3.90	0.00	42.62	48.00	5.38
31/8/00	0.00	23.36	28.00	4.64	0.00	23.93	28.00	4.07	0.00	23.10	28.00	4.90

Field Observation of Lysimeters for evapotranspiration of rice at W.R.D.T.C. Farm

Date	Lysi -(I1F1)				Lysi -(I1F2)				Lysi -(I1F3)			
	Add. (mm)	Remove (mm)	Rainfall (mm)	Etc (mm)	Add. (mm)	Remove (mm)	Rainfall (mm)	Etc (mm)	Add. (mm)	Remove (mm)	Rainfall (mm)	Etc (mm)
1/9/00	7.64	0.00	0.00	7.64	7.46	0.00	0.00	7.46	10.48	0.00	0.00	10.48
2/9/00	7.47	0.00	0.00	7.47	6.81	0.00	0.00	6.81	10.08	0.00	0.00	10.08
3/9/00	9.34	0.00	0.00	9.34	8.12	0.00	0.00	8.12	11.35	0.00	0.00	11.35
4/9/00	0.00	24.23	31.40	7.17	0.00	24.27	31.40	7.13	0.00	22.66	31.40	8.74
5/9/00	0.00	32.96	37.00	4.04	0.00	32.57	37.00	4.43	0.00	30.56	37.00	6.44
6/9/00	4.43	0.00	0.00	4.43	3.27	0.00	0.00	3.27	5.24	0.00	0.00	5.24
7/9/00	7.57	0.00	0.00	7.57	7.46	0.00	0.00	7.46	10.04	0.00	0.00	10.04
8/9/00	7.64	0.00	0.00	7.64	5.63	0.00	0.00	5.63	8.73	0.00	0.00	8.73
9/9/00	9.34	0.00	0.00	9.34	8.64	0.00	0.00	8.64	10.61	0.00	0.00	10.61
10/9/00	9.69	0.00	0.00	9.69	8.47	0.00	0.00	8.47	11.66	0.00	0.00	11.66
11/9/00	8.25	0.00	0.00	8.25	7.82	0.00	0.00	7.82	10.26	0.00	0.00	10.26
12/9/00	8.99	0.00	0.00	8.99	8.73	0.00	0.00	8.73	12.09	0.00	0.00	12.09
13/9/00	9.39	0.00	0.00	9.39	8.73	0.00	0.00	8.73	11.26	0.00	0.00	11.26
14/9/00	9.30	0.00	0.00	9.30	8.73	0.00	0.00	8.73	11.53	0.00	0.00	11.53
15/9/00	9.76	0.00	0.00	9.76	8.73	0.00	0.00	8.73	12.53	0.00	0.00	12.53
16/9/00	7.97	0.00	0.00	7.97	6.81	0.00	0.00	6.81	11.13	0.00	0.00	11.13
17/9/00	10.09	0.00	0.00	10.09	8.73	0.00	0.00	8.73	12.44	0.00	0.00	12.44
18/9/00	7.79	0.00	0.00	7.79	7.90	0.00	0.00	7.90	10.96	0.00	0.00	10.96
19/9/00	6.05	0.00	0.00	6.05	5.24	0.00	0.00	5.24	7.20	0.00	0.00	7.20
20/9/00	7.57	0.00	0.00	7.57	6.81	0.00	0.00	6.81	10.00	0.00	0.00	10.00
21/9/00	0.81	0.00	8.60	9.41	0.00	0.00	8.60	8.60	2.10	0.00	8.60	10.70
22/9/00	8.27	0.00	0.00	8.27	8.20	0.00	0.00	8.20	10.56	0.00	0.00	10.56
23/9/00	9.34	0.00	0.00	9.34	7.90	0.00	0.00	7.90	11.35	0.00	0.00	11.35
24/9/00	8.98	0.00	0.00	8.98	8.73	0.00	0.00	8.73	11.66	0.00	0.00	11.66
25/9/00	5.83	0.00	2.00	7.83	4.76	0.00	2.00	6.76	7.46	0.00	2.00	9.46
26/9/00	6.96	0.00	0.00	6.96	7.25	0.00	0.00	7.25	10.00	0.00	0.00	10.00
27/9/00	9.13	0.00	0.00	9.13	8.73	0.00	0.00	8.73	12.31	0.00	0.00	12.31
28/9/00	8.73	0.00	0.00	8.73	8.73	0.00	0.00	8.73	12.66	0.00	0.00	12.66
29/9/00	8.73	0.00	0.00	8.73	8.73	0.00	0.00	8.73	11.44	0.00	0.00	11.44
30/9/00	9.58	0.00	0.00	9.58	9.56	0.00	0.00	9.56	11.87	0.00	0.00	11.87

Field Observation of Lysimeters for evapotranspiration of rice at W.R.D.T.C. Farm

Date	Lysi -(I1F1)				Lysi -(I1F2)				Lysi -(I1F3)			
	Add. (mm)	Remove (mm)	Rainfall (mm)	Etc (mm)	Add. (mm)	Remove (mm)	Rainfall (mm)	Etc (mm)	Add. (mm)	Remove (mm)	Rainfall (mm)	Etc (mm)
1/10/00	8.16	0.00	0.00	8.16	7.20	0.00	0.00	7.20	11.26	0.00	0.00	11.26
2/10/00	8.21	0.00	0.00	8.21	8.73	0.00	0.00	8.73	12.05	0.00	0.00	12.05
3/10/00	9.01	0.00	0.00	9.01	7.90	0.00	0.00	7.90	10.21	0.00	0.00	10.21
4/10/00	7.20	0.00	0.00	7.20	6.46	0.00	0.00	6.46	7.46	0.00	0.00	7.46
5/10/00	8.16	0.00	0.00	8.16	7.68	0.00	0.00	7.68	11.35	0.00	0.00	11.35
6/10/00	7.92	0.00	0.00	7.92	8.07	0.00	0.00	8.07	10.96	0.00	0.00	10.96
7/10/00	8.43	0.00	0.00	8.43	7.59	0.00	0.00	7.59	11.22	0.00	0.00	11.22
8/10/00	6.87	0.00	0.00	6.87	6.68	0.00	0.00	6.68	6.81	0.00	0.00	6.81
9/10/00	7.49	0.00	0.00	7.49	7.59	0.00	0.00	7.59	8.73	0.00	0.00	8.73
10/10/00	8.97	0.00	0.00	8.97	10.48	0.00	0.00	10.48	13.10	0.00	0.00	13.10
11/10/00	8.78	0.00	0.00	8.78	8.73	0.00	0.00	8.73	10.43	0.00	0.00	10.43
12/10/00	8.58	0.00	0.00	8.58	7.90	0.00	0.00	7.90	11.44	0.00	0.00	11.44
13/10/00	9.17	0.00	0.00	9.17	9.65	0.00	0.00	9.65	11.79	0.00	0.00	11.79
14/10/00	8.88	0.00	0.00	8.88	8.73	0.00	0.00	8.73	11.44	0.00	0.00	11.44
15/10/00	9.35	0.00	0.00	9.35	8.73	0.00	0.00	8.73	9.86	0.00	0.00	9.86
16/10/00	7.86	0.00	0.00	7.86	7.94	0.00	0.00	7.94	9.51	0.00	0.00	9.51
17/10/00	8.01	0.00	0.00	8.01	8.73	0.00	0.00	8.73	9.74	0.00	0.00	9.74
18/10/00	7.62	0.00	0.00	7.62	6.28	0.00	0.00	6.28	8.73	0.00	0.00	8.73
19/10/00	5.54	0.00	0.00	5.54	5.72	0.00	0.00	5.72	6.63	0.00	0.00	6.63
20/10/00	6.05	0.00	0.00	6.05	5.89	0.00	0.00	5.89	7.29	0.00	0.00	7.29
21/10/00	4.36	0.00	0.00	4.36	4.36	0.00	0.00	4.36	4.71	0.00	0.00	4.71
22/10/00	5.35	0.00	0.00	5.35	4.36	0.00	0.00	4.36	6.28	0.00	0.00	6.28
23/10/00	4.36	0.00	0.00	4.36	5.89	0.00	0.00	5.89	5.54	0.00	0.00	5.54
24/10/00	4.91	0.00	0.00	4.91	4.36	0.00	0.00	4.36	6.06	0.00	0.00	6.06
25/10/00	4.69	0.00	0.00	4.69	4.36	0.00	0.00	4.36	5.45	0.00	0.00	5.45

Annexure -4

TOTAL WATER USE IN THE EXPERIMENTAL FIELD OF RICE

DATE	I1F1-I1F2-I1F3				I2F1-I2F2-I2F3				I3F1-I3F2-I3F3			
	IRR (mm)	RAINFAL (mm)	RUNOFF (mm)	T.W.U. (mm)	IRR (mm)	RAINFAL (mm)	RUNOFF (mm)	T.W.U. (mm)	IRR (mm)	RAINFALL (mm)	RUNOFF (mm)	T.W.U. (mm)
	1	2	3	4	5	6	7	8	9	10	11	12
1/7/00	-	-	-	-	-	-	-	-	-	-	-	-
2/7/00	-	-	-	-	-	-	-	-	-	-	-	-
3/7/00	-	-	-	-	-	-	-	-	-	-	-	-
4/7/00	-	-	-	-	-	-	-	-	-	-	-	-
5/7/00	-	-	-	-	-	-	-	-	-	-	-	-
6/7/00	-	-	-	-	-	-	-	-	-	-	-	-
7/7/00	-	-	-	-	-	-	-	-	-	-	-	-
8/7/00	-	-	-	-	-	-	-	-	-	-	-	-
9/7/00	-	-	-	-	-	-	-	-	-	-	-	-
10/7/00	-	-	-	-	-	-	-	-	-	-	-	-
11/7/00	-	-	-	-	-	-	-	-	-	-	-	-
12/7/00	-	-	-	-	-	-	-	-	-	-	-	-
13/7/00	-	-	-	-	-	-	-	-	-	-	-	-
14/7/00	-	-	-	-	-	-	-	-	-	-	-	-
15/7/00	-	-	-	-	-	-	-	-	-	-	-	-
16/7/00	-	-	-	-	-	-	-	-	-	-	-	-
17/7/00	-	-	-	-	-	-	-	-	-	-	-	-
18/7/00	-	-	-	-	-	-	-	-	-	-	-	-
19/7/00	-	-	-	-	-	-	-	-	-	-	-	-
20/7/00	-	-	-	-	-	-	-	-	-	-	-	-
21/7/00	-	-	-	-	-	-	-	-	-	-	-	-
22/7/00	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0
23/7/00	-	-	-	-	-	-	-	-	-	-	-	-
24/7/00	-	10.6	-	10.6	-	10.6	-	10.6	-	10.6	-	10.6
25/7/00	-	4.2	-	4.2	-	4.2	-	4.2	-	4.2	-	4.2
26/7/00	-	35.6	-	35.6	-	35.6	-	35.6	-	35.6	-	35.6
27/7/00	-	1.0	-	1.0	-	1.0	-	1.0	-	1.0	-	1.0
28/7/00	-	-	-	-	-	-	-	-	-	-	-	-
29/7/00	-	8.0	-	8.0	-	8.0	-	8.0	-	8.0	-	8.0
30/7/00	-	14.8	-	14.8	-	14.8	-	14.8	-	14.8	-	14.8
31/7/00	-	33.0	-	33.0	-	33.0	-	33.0	-	33.0	-	33.0

TOTAL WATER USE IN THE EXPERIMENTAL FIELD OF RICE

DATE	I1F1-I1F2-I1F3				I2F1-I2F2-I2F3				I3F1-I3F2-I3F3			
	IRR (mm)	RAINFAL (mm)	RUNOFF (mm)	T.W.U. (mm)	IRR (mm)	RAINFAL (mm)	RUNOFF (mm)	T.W.U. (mm)	IRR (mm)	RAINFALL (mm)	RUNOFF (mm)	T.W.U. (mm)
	1	2	3	4	5	6	7	8	9	10	11	12
1/8/00	-	0.4	-	0.4	-	0.4	-	0.4	-	0.4	-	0.4
2/8/00	-	-	-	-	-	-	-	-	-	-	-	-
3/8/00	40.0	-	-	40.0	80.0	-	-	80.0	120.0	-	-	120.0
4/8/00	-	-	-	-	-	-	-	-	-	-	-	-
5/8/00	-	-	-	-	-	-	-	-	-	-	-	-
6/8/00	-	-	-	-	-	-	-	-	-	-	-	-
7/8/00	-	-	-	-	-	-	-	-	-	-	-	-
8/8/00	-	-	-	-	-	-	-	-	-	-	-	-
9/8/00	-	35.4	-	35.4	-	35.4	-	35.4	-	35.4	-	35.4
10/8/00	-	3.2	-	3.2	-	3.2	-	3.2	-	3.2	-	3.2
11/8/00	-	-	-	-	-	-	-	-	-	-	-	-
12/8/00	-	-	-	-	-	-	-	-	-	-	-	-
13/8/00	-	-	-	-	-	-	-	-	-	-	-	-
14/8/00	-	17.0	-	17.0	-	17.0	-	17.0	-	17.0	-	17.0
15/8/00	-	29.0	-	29.0	-	29.0	-	29.0	-	29.0	-	29.0
16/8/00	-	15.6	-	15.6	-	15.6	-	15.6	-	15.6	-	15.6
17/8/00	-	-	-	-	-	-	-	-	-	-	-	-
18/8/00	-	53.0	-	53.0	-	53.0	-	53.0	-	53.0	-	53.0
19/8/00	-	-	-	-	-	-	-	-	-	-	-	-
20/8/00	-	14.0	-	14.0	-	14.0	-	14.0	-	14.0	-	14.0
21/8/00	-	8.0	-	8.0	-	8.0	-	8.0	-	8.0	-	8.0
22/8/00	-	85.0	-	85.0	-	85.0	-	85.0	-	85.0	-	85.0
23/8/00	-	2.6	-	2.6	-	2.6	-	2.6	-	2.6	-	2.6
24/8/00	-	-	-	-	-	-	-	-	-	-	-	-
25/8/00	-	-	-	-	-	-	-	-	-	-	-	-
26/8/00	-	-	-	-	-	-	-	-	-	-	-	-
27/8/00	-	22.0	-	22.0	-	22.0	-	22.0	-	22.0	-	22.0
28/8/00	-	76.2	-	76.2	-	76.2	-	76.2	-	76.2	-	76.2
29/8/00	-	3.6	-	3.6	-	3.6	-	3.6	-	3.6	-	3.6
30/8/00	-	48.0	-	48.0	-	48.0	-	48.0	-	48.0	-	48.0
31/8/00	-	28.0	-	28.0	-	28.0	-	28.0	-	28.0	-	28.0

TOTAL WATER USE IN THE EXPERIMENTAL FIELD OF RICE

DATE	I1F1-I1F2-I1F3				I2F1-I2F2-I2F3				I3F1-I3F2-I3F3			
	IRR (mm)	RAINFAL (mm)	RUNOFF (mm)	T.W.U. (mm)	IRR (mm)	RAINFAL (mm)	RUNOFF (mm)	T.W.U. (mm)	IRR (mm)	RAINFALL (mm)	RUNOFF (mm)	T.W.U. (mm)
	1	2	3	4	5	6	7	8	9	10	11	12
1/9/00	-	-	-	-	-	-	-	-	-	-	-	-
2/9/00	-	-	-	-	-	-	-	-	-	-	-	-
3/9/00	-	-	-	-	-	-	-	-	-	-	-	-
4/9/00	-	31.4	-	31.4	-	31.4	-	31.4	-	31.4	-	31.4
5/9/00	-	37.0	-	37.0	-	37.0	-	37.0	-	37.0	-	37.0
6/9/00	-	-	-	-	-	-	-	-	-	-	-	-
7/9/00	-	-	-	-	-	-	-	-	-	-	-	-
8/9/00	-	-	-	-	-	-	-	-	-	-	-	-
9/9/00	-	-	-	-	-	-	-	-	-	-	-	-
10/9/00	-	-	-	-	-	-	-	-	-	-	-	-
11/9/00	-	-	-	-	-	-	-	-	-	-	-	-
12/9/00	-	-	-	-	-	-	-	-	-	-	-	-
13/9/00	-	-	-	-	-	-	-	-	-	-	-	-
14/9/00	-	-	-	-	-	-	-	-	-	-	-	-
15/9/00	-	-	-	-	-	-	-	-	-	-	-	-
16/9/00	40.0	-	-	40.0	80.0	-	-	80.0	120.0	-	-	120.0
17/9/00	-	-	-	-	-	-	-	-	-	-	-	-
18/9/00	-	-	-	-	-	-	-	-	-	-	-	-
19/9/00	-	-	-	-	-	-	-	-	-	-	-	-
20/9/00	-	-	-	-	-	-	-	-	-	-	-	-
21/9/00	-	8.6	-	8.6	-	8.6	-	8.6	-	8.6	-	8.6
22/9/00	-	-	-	-	-	-	-	-	-	-	-	-
23/9/00	-	-	-	-	-	-	-	-	-	-	-	-
24/9/00	-	-	-	-	-	-	-	-	-	-	-	-
25/9/00	-	2.0	-	2.0	-	2.0	-	2.0	-	2.0	-	2.0
26/9/00	-	-	-	-	-	-	-	-	-	-	-	-
27/9/00	-	-	-	-	-	-	-	-	-	-	-	-
28/9/00	-	-	-	-	-	-	-	-	-	-	-	-
29/9/00	-	-	-	-	-	-	-	-	-	-	-	-
30/9/00	40.0	-	-	40.0	80.0	-	-	80.0	120.0	-	-	120.0

TOTAL WATER USE IN THE EXPERIMENTAL FIELD OF RICE

Date	I1F1-I1F2-I1F3				I2F1-I2F2-I2F3				I3F1-I3F2-I3F3			
	IRR	RAINFAL	RUNOFF	T.W.U.	IRR	RAINFAL	RUNOFF	T.W.U.	IRR	RAINFALL	RUNOFF	T.W.U.
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
	1	2	3	4	5	6	7	8	9	10	11	12
1/10/00	-	-	-	-	-	-	-	-	-	-	-	-
2/10/00	-	-	-	-	-	-	-	-	-	-	-	-
3/10/00	-	-	-	-	-	-	-	-	-	-	-	-
4/10/00	-	-	-	-	-	-	-	-	-	-	-	-
5/10/00	-	-	-	-	-	-	-	-	-	-	-	-
6/10/00	-	-	-	-	-	-	-	-	-	-	-	-
7/10/00	-	-	-	-	-	-	-	-	-	-	-	-
8/10/00	-	-	-	-	-	-	-	-	-	-	-	-
9/10/00	-	-	-	-	-	-	-	-	-	-	-	-
10/10/00	-	-	-	-	-	-	-	-	-	-	-	-
11/10/00	40.0	-	-	40.0	80.0	-	-	80.0	120.0	-	-	120.0
12/10/00	-	-	-	-	-	-	-	-	-	-	-	-
13/10/00	-	-	-	-	-	-	-	-	-	-	-	-
14/10/00	-	-	-	-	-	-	-	-	-	-	-	-
15/10/00	-	-	-	-	-	-	-	-	-	-	-	-
16/10/00	-	-	-	-	-	-	-	-	-	-	-	-
17/10/00	-	-	-	-	-	-	-	-	-	-	-	-
18/10/00	-	-	-	-	-	-	-	-	-	-	-	-
19/10/00	40.0	-	-	40.0	80.0	-	-	80.0	120.0	-	-	120.0
20/10/00	-	-	-	-	-	-	-	-	-	-	-	-
21/10/00	-	-	-	-	-	-	-	-	-	-	-	-
22/10/00	-	-	-	-	-	-	-	-	-	-	-	-
23/10/00	-	-	-	-	-	-	-	-	-	-	-	-
24/10/00	-	-	-	-	-	-	-	-	-	-	-	-
25/10/00	-	-	-	-	-	-	-	-	-	-	-	-

Height

Anova for 20 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	40.51	20.25	2.09	0.15
i	2	87.62	45.81	4.52	0.02
f * i	4	33.03	8.25	0.85	0.51
Error	18	174.66	9.7		

Anova for 40 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	94.29	47.14	5.35	0.01
i	2	44.51	22.25	2.53	0.1
f * i	4	174.37	43.59	4.95	0
Error	18	158.66	8.8		

Anova for 60 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	56.51	28.25	2.17	0.14
i	2	89.18	44.59	3.43	0.05
f * i	4	12.59	3.14	0.24	0.21
Error	18	234	13		

Anova for 80 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	43.62	21.81	2.83	0.08
i	2	9.18	4.59	0.6	0.56
f * i	4	7.7	1.92	0.25	0.9
Error	18	138.66	7.7		

Anova for 100 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	32	16	2.06	0.15
i	2	1.55	0.77	0.1	0.9
f * i	4	3.11	0.77	0.1	0.98
Error	18	140	7.77		

Tiller Number

Anova for 20 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f		0.96	0.48	0.37	0.69
i	2	0.57	0.28	0.22	0.8
f * i	4	0.59	1.65	1.25	0.32
Error	18	23.66	1.31		

Anova for 40 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	11.16	5.58	2.77	0.08
i	2	3.38	1.69	0.84	0.44
f * i	4	8.77	2.19	1.09	0.39
Error	18	36.33	2.01		

Anova for 60 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	5.24	2.62	1.61	0.22
i	2	2.9	1.45	0.89	0.42
f * i	4	4.64	1.16	0.71	0.59
Error	18	29.33	1.62		

Anova for 80 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	0.05	0.02	0.02	0.98
i	2	1.16	0.58	0.4	0.67
f * i	4	6.11	1.52	1.05	0.4
Error	18	26.16	1.45		

Anova for 100 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	0.9	0.45	0.8	0.46
i	2	0.25	0.12	0.21	0.8
f * i	4	4.03	1	1.79	0.17
Error	18	10.16	0.56		

Dry weight

Anova for 20 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	1.37	0.66	0.75	0.48
i	2	2.49	1.24	1.35	0.28
f * i	4	2.95	0.73	0.8	0.54
Error	18	16.62	0.92		

Anova for 40 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	6.09	3.04	1.59	0.23
i	2	13.32	6.66	3.47	0.05
f * i	4	4.27	1.06	0.56	0.69
Error	18	34.59	1.92		

Anova for 60 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	16.88	8.44	0.99	0.39
i	2	11.45	5.72	0.67	0.52
f * i	4	22.67	5.66	0.66	0.62
Error	18	154.13	8.56		

Anova for 80 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	52.64	26.32	2.51	0.1
i	2	7.15	3.57	0.34	0.71
f * i	4	28.4	7.1	0.68	0.61
Error	18	188.66	10.48		

Anova for 100 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	95.75	47.87	5.75	0.01
i	2	8.08	4.04	0.49	0.62
f * i	4	34.56	8.64	1.04	0.41
Error	18	150	8.33		

Leaf area index

Anova for 20 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	0.96	0.48	3.69	0.04
i	2	0.02	0.01	0.09	0.91
f * i	4	0.24	0.06	0.46	0.76
Error	18	2.34	0.13		

Anova for 40 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	2.37	1.18	1.84	0.18
i	2	0.64	0.32	0.5	0.61
f * i	4	1.03	0.25	0.4	0.8
Error	18	11.65	0.64		

Anova for 60 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	4.42	2.21	2.3	0.12
i	2	2.17	1.08	1.13	0.34
f * i	4	3.66	0.91	0.95	0.45
Error	18	17.26	0.95		

Anova for 80 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	0.15	0.07	0.25	0.77
i	2	2.22	1.11	3.56	0.04
f * i	4	1.72	0.43	1.38	0.28
Error	18	5.63	0.31		

Anova for 100 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	0.54	0.27	6.33	0
i	2	0.08	0.04	0.98	0.39
f * i	4	0.56	0.14	3.32	0.03
Error	18	0.77	0.04		

Rooting depth

Anova for 20 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	22.22	11.11	1.97	0.16
i	2	54.88	27.44	4.88	0.02
f * i	4	27.55	6.88	1.22	0.33
Error	18	101.33	5.62		

Anova for 40 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	96.29	48.14	1.36	0.28
i	2	23.18	11.59	0.33	0.72
f * i	4	333.92	83.48	2.36	0.09
Error	18	637.33	35.4		

Anova for 60 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	1.4	0.7	0.02	0.97
i	2	90.96	45.48	1.6	0.22
f * i	4	64.14	16.03	0.57	0.69
Error	18	510.66	28.37		

Anova for 80 dat

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	257.55	128.77	4.01	0.03
i	2	62	31	0.96	0.4
f * i	4	16.44	4.11	0.13	0.97
Error	18	578.66	32.14		

Anova for straw yield

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	3095.72	1547.86	10.16	0
i	2	160.51	80.25	0.53	0.59
f * i	4	366.59	91.64	0.6	0.66
Error	18	2742.33	152.35		

Anova for grain yield

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	25.88	12.94	0.34	0.71
i	2	29.24	14.62	0.38	0.68
f * i	4	31.05	7.76	0.2	0.93
Error	18	690.22	38.31		

Anova for filled grain / earhead

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	20.47	10.03	0.03	0.97
i	2	712.51	356.25	0.99	0.38
f * i	4	1894.59	470.64	1.32	0.3
Error	18	6456.66	358.7		

Anova for unfilled grain /earhead

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	8.07	4.03	0.03	0.97
i	2	129.4	64.7	0.43	0.65
f * i	4	282.81	70.7	0.47	0.75
Error	18	2726.66	151.48		

Anova for spikes / earhead

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	77.55	38.77	0.16	0.85
i	2	605.55	302.77	1.22	0.31
f * i	4	781.55	195.38	0.79	0.54
Error	18	4468	248.22		

Anova for test wt. Of grain

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	7.17	3.58	1.06	0.36
i	2	1.33	0.66	0.2	0.82
f * i	4	5.68	1.42	0.42	0.79
Error	18	61.19	3.39		

Anova for grain length

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	0.24	0.12	1.57	0.23
i	2	0	0	0.05	0.94
f * i	4	0.13	0.03	0.44	0.78
Error	18	1.38	0.07		

Anova for grain width

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	0.04	0.02	2.38	0.12
i	2	0.03	0.01	1.85	0.18
f * i	4	0.02	0	0.64	0.64
Error	18	0.16	0		

Anova for test wt. Of kernel

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	2.16	1.08	0.61	0.55
i	2	0.5	0.25	0.14	0.86
f * i	4	4.03	1	0.57	0.69
Error	18	32.12	1.78		

Anova for kernel length

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	0.72	0.36	1.36	0.28
i	2	0.22	0.11	0.42	0.66
f * i	4	1.12	0.28	1.05	0.4
Error	18	4.8	0.26		

Anova for kernel width

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	0.01	0	1.42	0.26
i	2	0.02	0.01	1.63	0.22
f * i	4	0.01	0	0.58	0.68
Error	18	0.11	0		

Anova for shelling %

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	9.27	4.62	2.7	0.09
i	2	1.63	0.81	0.48	0.62
f * i	4	1.73	0.43	0.26	0.9
Error	18	30.66	1.7		

Anova for kernel l:r

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	0.44	0.22	1.49	0.25
i	2	0.04	0.02	0.15	0.85
f * i	4	0.55	0.13	0.93	0.46
Error	18	2.67	0.14		

Anova for grain : straw

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	0.01	0	1.4	0.27
i	2	0	0	0.09	0.91
f * i	4	0.01	0	0.44	0.77
Error	18	0.11	0		

Anova for % filled grain

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	0.01	0	0.38	0.69
i	2	0.04	0.02	1.47	0.25
f * i	4	0.03	0	0.7	0.6
Error	18	0.24	0.01		

Anova for earhead

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	21398.22	10699.11	11.85	0
i	2	2170.88	1085.44	1.2	0.32
f * i	4	782.22	195.55	0.22	0.92
Error	18	16251.33	902.85		

Anova for water use efficiency(irrigation)

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	0.02	0.01	0.51	0.61
i	2	1.47	0.73	32.93	0
f * i	4	0.02	0	0.32	0.86
Error	18	0.4	0.02		

Anova for water use efficiency (irr+rain fall)

source of varience	d.f.	s.s.	m.s.	F.value	F.prob
f	2	0	0	0.28	0.76
i	2	0	0	1.52	0.24
f * i	4	0	0	0.33	0.85
Error	18	0.02	0		