ANALYSIS OF RICE CROP YIELD GROWN UNDER THE TREATMENTS OF NITROGEN AND WATER

A DISSERTATION

submitted in partial fulfillment of the
requirements for the award of the degree
of
MASTER OF ENGINEERING
in
IRRIGATION WATER MANAGEMENT

By
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CANDIDATE'S DECLARATION

I hereby declare that the dissertation titled "**ANALYSIS OF RICE CROP YIELD GROWN UNDER THE TREATMENTS OF NITROGEN AND WATER**" 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), Indian Institute of Technology, Roorkee, is an authentic record of my own work carried out during the period of 16th July to 30th November 2001, under the supervision and guidance of **Dr. S. K. Tripathi**, Professor, WRDTC, Indian Institute of Technology, Roorkee.

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

Place : IIT Roorkee **(SHAILENDRA KUMAR JHA)**
Dated : 7.12.2001

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 study entitled "**Analysis of Rice Crop Yield Grown Under the Treatments of Nitrogen and Water**" was undertaken during Kharif 2001 at the Demonstration Farm of WRDTC, IIT Roorkee. The experiment consisted of 3 irrigation levels, 2 levels of nitrogen treatments and 3 replications.

Observations were recorded at 20 days interval regarding growth and development, i.e., plant height, tiller number, leaf area index, dry weight, rooting depth, leaf length, leaf width and leaf number in each treatment. Weather parameters were recorded daily from agro meteorological lab of WRDTC, at 9.00 AM in forenoon and 2.30 PM in the afternoon such as DBT & WBT, wind speed, minimum and maximum temperature, soil temperature, evaporation, rainfall and sunshine hours. Daily calculation of evapotranspiration (E_{TO}) from the data of transplanting.

Six lysimeters installed at demonstration farm were used for reading daily crop evapotranspiration (E_{TC}). Water level was maintained in lysimeters daily by adding or removing the water to the level of pointer fixed in the lysimeters.

The crop coefficients (K_c) were developed daily dividing actual evapotranspiration (E_{TC}) by evapotranspiration (E_{TO}) of reference crop recorded daily and tabulated at 10 days interval for the growing period.

The study shows that under climatic condition of Roorkee the rice recorded *improved productivity with nitrogen application @ 100 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 at 0.45 in the beginning whereas the maximum was 2.73 in the middle stage.

CONTENTS

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
N_1	50 kgs N/ha
N_2	100 kgs N/ha
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	30 mm/irrigation
I_2	60 mm/irrigation
I_3	90 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 (Urea)
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
$ZnSO_4$	Zinc sulphate

Chapter 1
INTRODUCTION

Rice is as a source of life and wealth and as a gift from the God was born from a union of the divine creative forces represented in earth and water. Rice is the most important crop of India and second most important crop of world. It is the principal crop of about half of the world population. 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.

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 5.6 ton/ha in Egypt, 6.0 ton/ha in Korea and 5.8 ton/ha in Japan.

Assam, Bihar, Orissa, Madhya Pradesh, Uttar Pradesh, West Bengal 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 the following reasons like poor infrastructural facilities, low input use, poor production technology and dependence on monsoon.

In Nepal, 15-20% of 1.3 million hectare of rice land are in a temperate region. Large areas of that land are at altitude of 1000-2000 m and cold damage to rice is common. The highest altitude at which rice is grown is in Nepal's Jumla valley (2621 m) in the far western region of the Himalayas.

IARI has also developed some new varieties of short duration superfine and exportable varieties of rice, suitable for cultivation in the North and North West India. These varieties of rice can be harvested within 100-110 days. These varieties are Semi dwarf, non lodging and giving almost double the yield, i.e., 5 to 7 tonnes/hectare in 140 days to that of traditional varieties. Recent variety IR-64 grown at WRDTC farm was ready in 95 days and yield was 40 Q/ha.

In view of the above facts a field study entitled, "Analysis of Rice Crop Yield Grown Under the Treatments of Nitrogen and Water", was undertaken with following objectives.

(1) To test the different treatment of nitrogen application on growth and production of rice crop yield.

(2) To test the different treatment of irrigation application on growth and production of rice crop yield.

(3) To determine the crop evapotranspiration (E_{TC}) and crop coefficient (K_c) of rice-IR64 grown in lysimeters.

Chapter 2
REVIEW OF LITERATURE

2.1 YIELD, YIELD ATTRIBUTES AND QUALITY

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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 10th 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.

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

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.

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.

Rajput (2000) conducted the field experiment during kharif 2000 at Roorkee on Pusa Basmati-1 taking different level of fertilizer and irrigation, determining the evapotranspiration, crop coefficient tested the growth development, yield and yield attributes. He found that the application of nitrogen showed an insignificant change in growth and development of crop. Application of irrigation also did not affect the growth and development of crop because it rained constantly during the growing period.

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 lheavy 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.

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.

Chapter 3

MATERIALS AND METHODS

This chapter deals with the materials and methods adopted in the conduct of the experiment during Kharif 2001 on demonstration farm of WRDTC located in the campus of the IIT, Roorkee (UA).

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 252 m.

3.2 EXPERIMENTAL LAYOUT

The experiment was laid out with 3 irrigation levels, 2 nitrogen treatments and 3 replication. Details are shown in Fig. 1.

3.3 FIELD PREPARATION

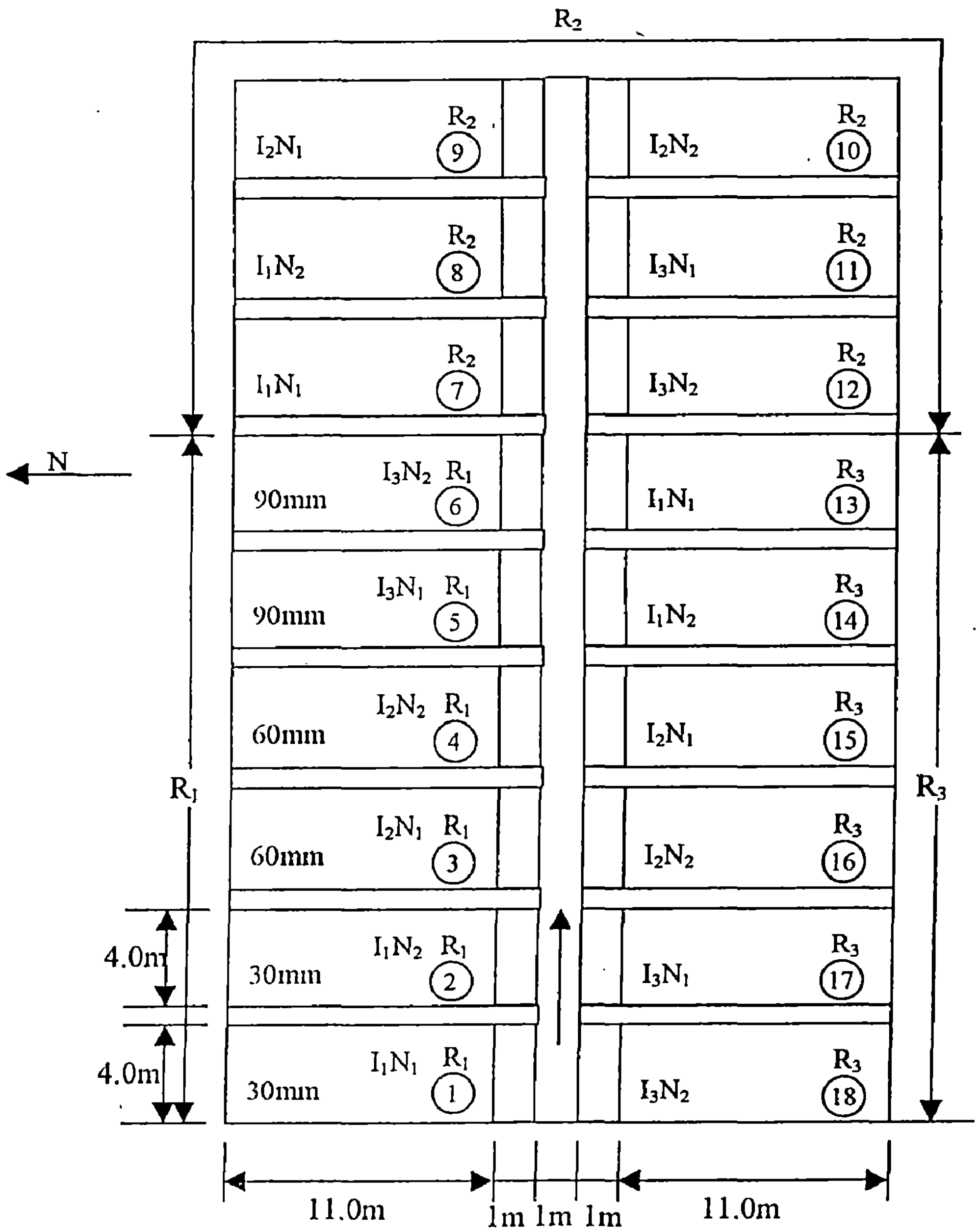
Field preparation done by puddling for nursery and then transplanting the crop.

Date of sowing	:	11th June 2001
Fertilizer application	:	DAP (2.5 kg) Potash (2.0 kg)
Quantity of seed	:	4.0 kg
Nursery area	:	15.6 m x 4.0 m = 62.4 m^2
Water application	:	No application

3.3.1 Nursery

Nursery was prepared giving three ploughing with tractor drawn cultivator and puddling was done. The area of nursery was 62.4 m^2.

LAYOUT PLAN OF EXPERIMENTAL PLOT



PLOT SIZE

Net size = 11.0 x 4.0 m = 44.0 m^2
Total No. = 18
Net area = 792 m^2
Gross Area = 44 x 25 = 1100 m^2

IRRIGATION LEVELS

I_1 = 30 mm/irrigation; I_2 = 60 mm/irrigation
I_3 = 90 mm/irrigation

FERTILIZER LEVELS

N_1 = 160 gm/plot; N_2 = 320 gm/plot

REPLICATION = 3

FIG-1

Fertilizers applied are DAP @ 2.5 kg and potassium sulphate @ 2.0 kg. The seed used in nursery was rice IR-64 of 4.0 kg. The total depth of water used in the nursery was 101.6 mm and total rainfall received during nursery was 101.6 mm.

The nursery to transplanted area ratio was 1:17.

3.3.2 Transplanting

The seedling grew in the nursery from 11th June 2001 to 16th July 2001 for 35 days. The two seedlings were planted per hill maintaining a random spacing of about 15 cm x 15 cm. The field was prepared for transplanting by puddling the field on 16.07.2001 with 120 mm watering.

3.4 FERTILISER APPLICATION

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

(1) Nursery was fertilised with 2.5 kg DAP and 2.0 kg before sowing 10.6.2001.

(2) The experimental field was applied with the fertilizer as per the treatments as given below.

N_1 = 50 kg/ha, 160 gm per dose

N_2 = 100 kg/ha, 320 gm per dose

At the time of puddling in each plot 100 gm DAP and 50 gm potassium sulphate was applied. The nitrogen was applied 1/3 at tilling and 1/3 at flowering.

3.5 IRRIGATION

The irrigation was applied as per the treatments described below :

I_1 = @ 30 mm/irrigation

I_2 = @ 60 mm/irrigation

I_3 = @ 90 mm/irrigation

Weeds were removed manually as and when required.

3.6 SOIL ANALYSIS

As per old record, 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 DATA

Weather parameters were recorded daily at 9.0 AM on agrometerological lab of the WRDTC demonstration farm from the date of nursery 11.6.2001 till the harvest of the crop. 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 52.5 cm dia and 85 cm length were used as a lysimeter and embedded in the field keeping 15 cm above the ground. The lysimeter filled with soil resembling their profile condition existing in the plot. There are six lysimeters installed in I_1N_1, I_1N_2, I_2N_1, I_2N_2, I_3N_1, I_3N_2. The 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 fertilizsr dose was only variability and that was followed as per the treatment given in the plot.

Evapotranspiration study was conducted daily by the water balance study. 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*

The study 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. In summer, the minimum possible error of 10% and under low evaporative conditions upto 20%.

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.

In our case the wind data is measured at 2 m height so no need to apply any correction factor.

(c) Weighting Factor (W)

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

(d) 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 cover), temperature and humidity data.

For the determination of net radiation following relationships are recommended :

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

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

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

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

where,

R_{ns} is net shortwave radiation

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.

(e) Adjustment Factor (c)

The most common conditions where radiation is medium to high, maximum relative humidity is medium to high and moderate day time wind about double the night time wind. These conditions are not always fulfilled. Therefore, correction to Panman equation is required. This correction is made by applying adjustment factor (c).

Available table shows the 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.

A sample calculation is illustrated below for the 23rd August 2001. The climatic data of August 2001 is shown for the calculation of E_{TO}.

Calculations

(1) Maximum air temperature in °C = 33.5 (from climatic data)

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

(3) Mean air temperature in °C = (33.5 + 25.0)/2 = 29.25 (calculated)

(4) Maximum relative humidity (RHmax%) = 73.41 (from Table)

(5) Minimum relative humidity (RHmin%) = 71.21 (from Table)

(6) Mean relative humidity (RHmean%) = 72.31 (calculated)

(7) Average wind speed in km/day (u) = 14 (climatic data)

(8) Wind speed (day) in m/sec = 0.30 (calculated)

(9) Sunshine hours (n) = 6 (from climatic data)

(10) Maximum possible sunshine hours (N) = 13.2 (from Table)

(11) Saturation vapour pressure (e_a) in mbar corresponding to mean temperature of 29.25°C = 40.67 (from Table)

(12) Actual vapour pressure (e_d) = (e_a x RHmean)/100
= (40.67 x 72.31)/100 = 29.40 (calculated)

(13) Vapour pressure deficit (e_a-e_d) = 40.67 – 29.40 = 11.27 (calculated)

(14) Wind function $f(u) = 0.27 (1 + u/100) = 0.30$ (calculated)

(15) Extra terrestrial radiation (R_a) corresponding to latitude 29°52' N and month August in northern hemisphere = 15.7 (From Table)

(16) Ratio n/N corresponding to sunshine hour 6 = 0.52 (calculated)

(17) Short wave radiation $R_s = (0.25 + 0.5\ n/N)\ R_a = 7.50$ (calculated)

(18) $R_{ns} = 0.75 R_s = 0.75 \times 7.50 = 4.78$ (calculated)

(19) Function of temperature f(T) corresponding to mean temperature 29.25°C = 16.55 (from Table)

(20) Function of vapour pressure $f(e_d)$ corresponding to $e_d = 29.40 = 0.095$ (from Table)

(21) Function of sunshine duration f(n/N) corresponding to n/N = 0.52 (from table)

(22) Net longwave radiation $R_{nl} = f(T) \times f(e_d) \times f(n/N) = 0.84$ (calculated)

(23) Net radiation $R_n = R_{ns} - R_{nl} = 4.78$ (calculated)

(24) Adjustment factor 'C' corresponding to RHmax = 85%, $R_s = 7.50$ mm/day, $U_{day} = 0.16$ m/sec and $U_{day}/U_{night} = 1$ (from Table)

(25) Weighing factor W corresponding to mean temperature 29.25°C and altitude 260 m = 0.78

(26) $1 - W = 1 - 0.78 = 0.22$ (calculated)

(27) $E_{TO} = C [W \times R_n + (1\text{-}W) \times f(u) \times (e_a\text{-}e_d)]$ in mm/day = 4.47 (calculated)

3.10 GROWTH AND DEVELOPMENT STUDY

3.10.1 Plant Height

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

3.10.2 Tiller Number

The tiller number was recorded per hill 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 was also observed at 20 days interval for each observation. 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

The soil sample was taken 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 Earhead Density : 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 present.

3.11.3 Unfilled Grains

This was counted from 10 earhead collected from different treatments.

3.11.4 Test Weight

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

3.11.5 Hulling Percent : 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 after harvesting the plants of 1 m^2 area from each treatment. Harvesting was done and 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, 5 kernels were collected from each treatment and the kernels were put on the graph sheet and average length of 5 kernels was recorded.

3.12.2 Breadth of Kernel

The 5 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

At 20 days interval data was collected on growth and development of paddy plant. 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					
F					
I					
F x I					
Error					
Total					

3.15 GRAPHICS AND CURVE FITTING

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

Chapter 4

OBSERVATIONS

During the experiment observations were recorded as follows :

4.1 WEATHER AND HYDRAULIC CONDITION

Weather and hydraulic conditions recorded were rainfall (mm), E_{TO} (mm), sunshine (hrs), evaporation (mm), average ground water level (m) are presented in Table 4.1. The total rainfall was 627.60 mm, E_{TO} was 706.19 mm, average ground water level varied between 0.68 m to 5.0 m, total evaporation was 357.8 mm.

Table 4.1 : Weather and hydrologic condition during experimental period (01/06/2001 – 15/10/2001)

Period (date)	Rainfall mm)	E_{TO} (mm)	Evap. (mm)	Humidity %	Sunshine (hrs)	Av. GWL (m)
1.6-10.6	19.80	57.34	24.00	61.42	9.30	5.00
11.6-20.6	116.80	53.89	21.20	65.40	7.50	2.87
21.6-30.6	85.60	54.29	20.70	67.84	8.00	2.51
1.7-10.7	0.00	61.10	29.00	71.02	9.00	3.05
11.7-20.7	139.40	52.60	24.80	73.18	5.65	2.40
21.7-31.7	107.80	47.25	22.80	75.46	5.13	0.54
1.8-10.8	0.00	63.58	33.20	68.11	10.89	1.92
11.8-20.8	152.20	48.50	26.00	74.47	7.20	0.68
21.8-31.8	4.60	57.49	30.80	79.81	8.59	1.58
1.9-10.9	0.00	53.06	30.20	65.10	9.40	2.49
11.9-20.9	0.00	48.56	30.70	63.57	9.20	3.07
21.9-30.9	0.00	49.90	30.80	58.24	9.50	3.55
1.10-10.10	2.60	38.85	20.10	69.47	7.20	3.90
11.10-15.10	0.00	19.78	13.00	60.75	9.25	4.05
Total	627.60	706.19	357.8	-	-	-

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 1024.00 mm, 1534.00 mm and 2044.00 mm respectively. The period in which the water use recorded maximum was in the last decadal of August 2001.

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

Period (date)	I_1N_1 (mm)	I_1N_2 (mm)	I_2N_1 (mm)	I_2N_2 (mm)	I_3N_1 (mm)	I_3N_2 (mm)
11.6-20.6	72.80	72.80	72.80	72.80	72.80	72.80
21.6-30.6	35.60	35.60	35.60	35.60	35.60	35.60
1.7-10.7	-	-	-	-	-	-
11.7-20.7	139.40	139.40	139.40	139.40	139.40	139.40
21.7-31.7	106.80	106.80	106.80	106.80	106.80	106.80
1.8-10.8	120.00	120.00	240.00	240.00	360.00	360.00
11.8-20.8	182.20	182.20	212.20	212.20	242.20	242.20
21.8-31.8	94.60	94.60	184.60	184.60	274.60	274.60
1.9-10.9	120.00	120.00	240.00	240.00	360.00	360.00
11.9-20.9	60.00	60.00	120.00	120.00	180.00	180.00
21.9-30.9	60.00	60.00	120.00	120.00	180.00	180.00
1.10-10.10	32.60	32.60	62.60	62.60	92.60	92.60
11.10-15.10	0.00	0.00	0.00	0.00	0.00	0.00
Total	1024.00	1024.00	1534.00	1534.00	2044.00	2044.00

4.3 EVAPOTRANSPIRATION

Lysimetric experiment conducted with three treatments and evapotranspiration during different periods of growth is presented in Table 4.3. The average evapotranspiration of the treatments was 763.17 mm. The average actual evapotranspiration was recorded maximum at last decadal of September, i.e., 13.28 mm/day.

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

Period (date)	I_1N_1 (mm)	I_1N_2 (mm)	I_2N_1 (mm)	I_2N_2 (mm)	I_3N_1 (mm)	I_3N_2 (mm)	Daily Avg. (mm)
28.7-31.7	38.64	32.92	36.21	42.27	35.13	43.08	2.92
1.8-10.8	52.01	53.07	59.44	55.43	53.71	56.36	5.50
11.8-20.8	45.78	48.94	53.76	48.06	47.93	52.22	4.94
21.8-31.8	98.60	112.91	123.44	99.62	107.40	103.87	9.78
1.9-10.9	110.49	125.08	136.67	109.85	120.23	120.54	12.04
11.9-20.9	125.96	140.36	144.79	125.12	133.15	127.66	13.28
21.9-30.9	124.01	137.19	148.56	119.57	131.19	117.27	12.96
1.10-10.10	71.19	87.84	97.12	85.95	88.79	83.80	8.57
11.10-15.10	34.49	44.58	46.20	41.87	46.24	39.45	8.42
Total	708.10	789.53	855.86	743.84	772.02	753.38	-
Average	7.86	8.77	9.50	8.36	8.57	8.37	-

4.4 CROP COEFFICIENT

The crop coefficient developed from three different lysimeters are given in Table 4.4. In general the average coefficient through out growing period recorded was 1.74. Details of K_C data are shown in Table 4.4.

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

Period (date)	I_1N_1 (mm) Lys-1	I_1N_2 (mm) Lys-2	I_2N_1 (mm)	I_2N_2 (mm)	I_3N_1 (mm)	I_3N_2 (mm)	Average
18.7-20.7	1.28	1.07	1.07	1.41	1.09	1.26	1.19
21.7-31.7	0.44	0.38	0.46	0.48	0.42	0.54	0.45
1.8-10.8	0.82	0.83	0.93	0.87	0.84	0.89	0.86
11.8-20.8	1.08	1.18	1.31	1.15	1.15	1.26	1.19
21.8-31.8	1.71	1.93	2.14	1.81	1.87	1.80	1.87
1.9-10.9	2.08	2.35	2.56	2.07	2.26	2.26	2.26
11.9-20.9	2.59	2.89	2.98	2.57	2.74	2.62	2.73
21.9-30.9	2.48	2.74	2.97	2.39	2.62	2.35	2.59
1.10-10.10	1.83	2.26	2.49	2.21	2.28	2.15	2.20
11.10-15.10	1.74	2.26	2.33	2.11	2.33	1.98	2.12
Total	16.05	17.88	19.24	17.07	17.60	17.12	17.46
Average	1.60	1.78	1.92	1.70	1.76	1.71	1.74

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_3N_2 (13.68) and minimum was recorded in treatment I_2N_2 (7.95) at 60 days after transplanting.

Table 4.5 : Leaf area index of rice grown in Lysimeter

Period (date)	I_1N_1 (mm) Lys-1	I_1N_2 (mm) Lys-2	I_2N_1 (mm) Lys-3	I_2N_2 (mm) Lys-4	I_3N_1 (mm) Lys-5	I_3N_2 (mm) Lys-6	Average
20 dat	4.89	5.67	5.56	5.40	5.63	7.18	5.72
40 dat	6.05	7.70	6.79	5.91	7.32	8.72	7.08
60 dat	8.88	12.20	10.02	7.95	10.36	13.68	10.51
80 dat	5.02	8.29	8.87	9.42	6.98	8.63	7.86

4.6 YIELD AND YIELD ATTRIBUTES

Yield and yield attributes of the rice grown in lysimeter on an area of 2165 cm^2 are recorded. The average biomass production was 588.33 gm.

Table 4.6 Yield and yield attributes of rice in Lysimeter.

Observation	I_1N_1 (mm) Lys-1	I_1N_2 (mm) Lys-2	I_2N_1 (mm) Lys-3	I_2N_2 (mm) Lys-4	I_3N_1 (mm) Lys-5	I_3N_2 (mm) Lys-6	Average
Grain wt. (g)	265	330	335	275	290	280	295.83
Straw wt (g)	240	330	335	275	300	275	292.50
Total wt (g)	505	660	670	550	590	555	588.33
G : S	1.10	1.0	1.0	1.0	0.97	1.01	1.011

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 cv IR64 grown under different Nitrogen and Irrigation Treatments

Replication	Treatment	20 DAT	40 DAT	60 DAT	80 DAT
R1	I1N1	55.00	57.00	66.00	70.00
	I1N2	53.00	55.00	70.00	72.00
	I2N1	50.00	51.00	65.00	71.00
	I2N2	55.00	57.00	69.00	72.00
	I3N1	50.00	53.00	67.00	69.00
	I3N2	45.00	52.00	70.00	70.00
R2	I1N1	40.00	42.00	60.00	69.00
	I1N2	39.00	43.00	62.00	72.00
	I2N1	38.00	45.00	65.00	69.00
	I2N2	38.00	50.00	68.00	72.00
	I3N1	40.00	43.00	66.00	70.00
	I3N2	38.00	50.00	70.00	72.00
R3	I1N1	50.00	52.00	62.00	69.00
	I1N2	48.00	52.00	64.00	72.00
	I2N1	45.00	47.00	65.00	69.00
	I2N2	44.00	47.00	68.00	72.00
	I3N1	45.00	48.00	68.00	65.00
	I3N2	40.00	45.00	70.00	71.00
	Test of Sig				
	I	N.S.	N.S.	Sig	N.S.
	N	N.S.	N.S.	Sig	Sig
	I x N	N.S.	N.S.	N.S.	N.S.

4.8 TILLER NUMBER PER HILL

Tillers were recorded per hill at 20 days interval after transplanting. The data of transplanting presented in table 4.8:

Table 4.8: Tiller per Hill recorded in Rice cv IR64 grown under different Nitrogen and Irrigation Treatments.

Replication	Treatment	20 DAT	40 DAT	60 DAT	80 DAT
R1	I1N1	5.50	14.00	15.00	10.00
	I1N2	4.50	10.50	12.00	12.50
	I2N1	7.50	16.50	16.00	11.00
	I2N2	9.00	13.00	14.00	13.00
	I3N1	8.00	10.00	11.00	11.00
	I3N2	5.00	14.00	15.00	13.00
R2	I1N1	3.00	10.00	10.50	10.00
	I1N2	6.00	15.50	15.00	12.00
	I2N1	7.00	10.00	9.00	10.00
	I2N2	5.50	18.00	17.50	12.50
	I3N1	6.00	9.00	10.00	10.00
	I3N2	5.50	12.00	11.00	12.00
R3	I1N1	6.50	11.00	12.00	10.00
	I1N2	5.00	10.00	10.50	14.00
	I2N1	6.50	11.50	11.00	11.00
	I2N2	6.00	12.50	12.50	12.00
	I3N1	6.00	13.00	13.50	10.50
	I3N2	5.00	11.50	12.00	12.00
	Test of Sig				
	I	N.S.	N.S.	N.S.	N.S.
	N	N.S.	N.S.	N.S.	Sig
	I x N	N.S.	N.S.	N.S.	N.S.

4.9 LEAF AREA INDEX

Leaf Area Index was recorded at 20 days interval from the date of transplanting under different Nitrogen and Irrigation management are presented in table 4.9:

Table 4.9: Leaf Area Index

Replication	Treatment	20 DAT	40 DAT	60 DAT	80 DAT
R1	I1N1	1.28	4.73	6.09	2.05
	I1N2	0.63	8.83	6.42	4.75
	I2N1	1.27	6.20	7.07	3.08
	I2N2	1.24	5.60	7.36	4.64
	I3N1	1.43	4.74	5.70	2.98
	I3N2	0.76	5.59	5.78	4.73
R2	I1N1	0.51	3.75	4.54	2.84
	I1N2	0.67	3.61	5.65	4.47
	I2N1	0.82	1.31	2.82	2.77
	I2N2	0.68	3.65	5.20	4.17
	I3N1	0.88	2.70	3.58	3.15
	I3N2	0.66	3.29	4.31	4.70
R3	I1N1	1.39	3.19	3.87	2.73
	I1N2	0.85	2.66	4.49	3.06
	I2N1	1.08	2.43	3.56	4.65
	I2N2	1.13	3.37	4.85	4.02
	I3N1	1.17	2.84	3.53	2.47
	I3N2	0.85	3.70	4.40	4.07
	Test of Sig				
	I	N.S.	N.S.	N.S.	N.S.
	N	N.S.	N.S.	N.S.	Sig
	I x N	N.S.	N.S.	N.S.	N.S.

4.10 ROOTING DEPTH

Root depth of Rice plant was recorded at 20 days interval after transplanting and data is tabulated in Table 4.10

Table 4.10: Rooting Depth (cm) recorded in Rice cv IR64

Replication	Treatment	20 DAT	40 DAT	60 DAT	80 DAT
R1	I1N1	20.00	22.00	25.00	28.00
	I1N2	18.00	20.00	28.00	30.00
	I2N1	20.00	21.00	27.00	28.00
	I2N2	20.00	23.00	29.00	30.00
	I3N1	22.00	23.00	26.00	27.00
	I3N2	25.00	26.00	29.00	30.00
R2	I1N1	20.00	21.00	26.00	27.00
	I1N2	22.00	23.00	27.00	28.00
	I2N1	21.00	23.00	28.00	29.00
	I2N2	22.00	23.00	29.00	30.00
	I3N1	20.00	24.00	27.00	28.00
	I3N2	21.00	26.00	30.00	30.00
R3	I1N1	20.00	22.00	27.00	27.00
	I1N2	20.00	23.00	26.00	27.00
	I2N1	18.00	20.00	28.00	28.00
	I2N2	19.00	24.00	29.00	30.00
	I3N1	20.00	22.00	28.00	29.00
	I3N2	21.00	26.00	30.00	30.00
	Test of Sig				
	I	N.S.	Sig	Sig	N.S.
	N	N.S.	Sig	Sig	Sig
	I x N	N.S.	N.S.	N.S.	N.S.

4.11 DRY MATTER

The Dry Matter of Rice plant was recorded at 20 days interval after transplanting and data is tabulated in Table 4.11.

Table 4.11: Dry Matter (gm/hill) recorded in Rice cv IR64.

Replication	Treatment	20 DAT	40 DAT	60 DAT	80 DAT
R1	I1N1	1.05	7.80	13.90	30.05
	I1N2	1.30	10.00	18.55	29.65
	I2N1	1.15	8.05	11.90	21.90
	I2N2	1.70	10.01	18.65	29.00
	I3N1	1.97	7.60	13.90	22.20
	I3N2	1.67	10.65	28.00	34.00
R2	I1N1	1.20	6.70	13.65	20.55
	I1N2	1.65	9.67	18.70	31.67
	I2N1	1.55	7.90	8.10	17.50
	I2N2	2.15	9.95	21.75	32.30
	I3N1	1.10	6.95	11.35	15.90
	I3N2	1.10	9.90	16.90	34.07
R3	I1N1	1.90	8.25	21.90	34.30
	I1N2	1.97	11.99	16.95	40.65
	I2N1	1.80	8.20	12.20	23.05
	I2N2	1.65	10.20	25.40	36.50
	I3N1	1.67	7.90	13.60	13.25
	I3N2	1.55	9.10	19.10	32.65
	Test of Sig				
	I	N.S.	N.S.	N.S.	N.S.
	N	N.S.	Sig	Sig	Sig
	I x N	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 4.12 : YIELD & YIELD ATTRIBUTES recorded in rice cv. IR64

	Gy (q/ha)	Sy q/ha)	Earhead / sqm	Fg (Nos)	Ufg (Nos)	Gtw (g) (g/th)	Ktw (g/th)	Gl (mm)	Gw (mm)	Kl (mm)	Kw (mm)	G:S (	% Fg	Shelling %	TWU (mm)	Nitrogen
I1N1	35.00	46.67	234.33	71.67	7.00	23.33	21.87	9.44	2.55	6.94	1.86	0.74	91.00	93.00	1024.00	50.00
I1N2	45.17	53.33	279.33	88.33	22.33	23.50	21.10	9.42	2.58	7.00	1.70	0.84	80.00	90.00	1024.00	100.00
I2N1	32.83	44.67	237.67	86.67	8.67	23.20	21.00	9.59	2.70	6.76	1.82	0.73	91.00	90.00	1534.00	50.00
I2N2	46.00	62.17	260.00	93.00	22.00	24.14	21.46	9.44	2.54	6.93	1.83	0.74	81.00	89.00	1534.00	100.00
I3N1	37.33	49.33	246.00	66.33	15.33	22.68	20.43	9.40	2.66	6.86	1.81	0.75	81.00	90.00	2044.00	50.00
I3N2	41.67	55.17	262.67	101.00	19.00	23.83	19.63	9.60	2.70	6.94	1.83	0.75	83.00	82.00	2044.00	100.00
	Test of 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
N	Sig	Sig	Sig	Sig	Sig	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
I x N	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

Chapter 5

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 627.60 mm rainfall, 706.19 mm E_{TO}, 357.8 mm evaporation. The ground water table ranged between 0.54 M to 5.0 M. The sunshine was between 5.13 hours to 10.89 hours and humidity between 58.24% to 75.46%. This indicates that the rainfall was less 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), Verma (1999) and Rajput (2000).

5.2 TOTAL WATER USE

The pattern of total water use presented in Fig. 5.2 and Table 4.2 indicates that there is no sufficient rainfall and irrigation was done by electric pump when needed. Whereas September and October period needed irrigation, but there is no rainfall. The total water use (irrigation and rainfall) was 1024.0 mm, 1534.0 mm and 2044.0 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 Verma (1999), Rajput (2000).

5.3 EVAPOTRANSPIRATION

The evapotranspiration of rice grown in Lysimeter under different treatments presented in Fig. 5.3a, 5.3b and Table 4.3 indicated that nitrogen

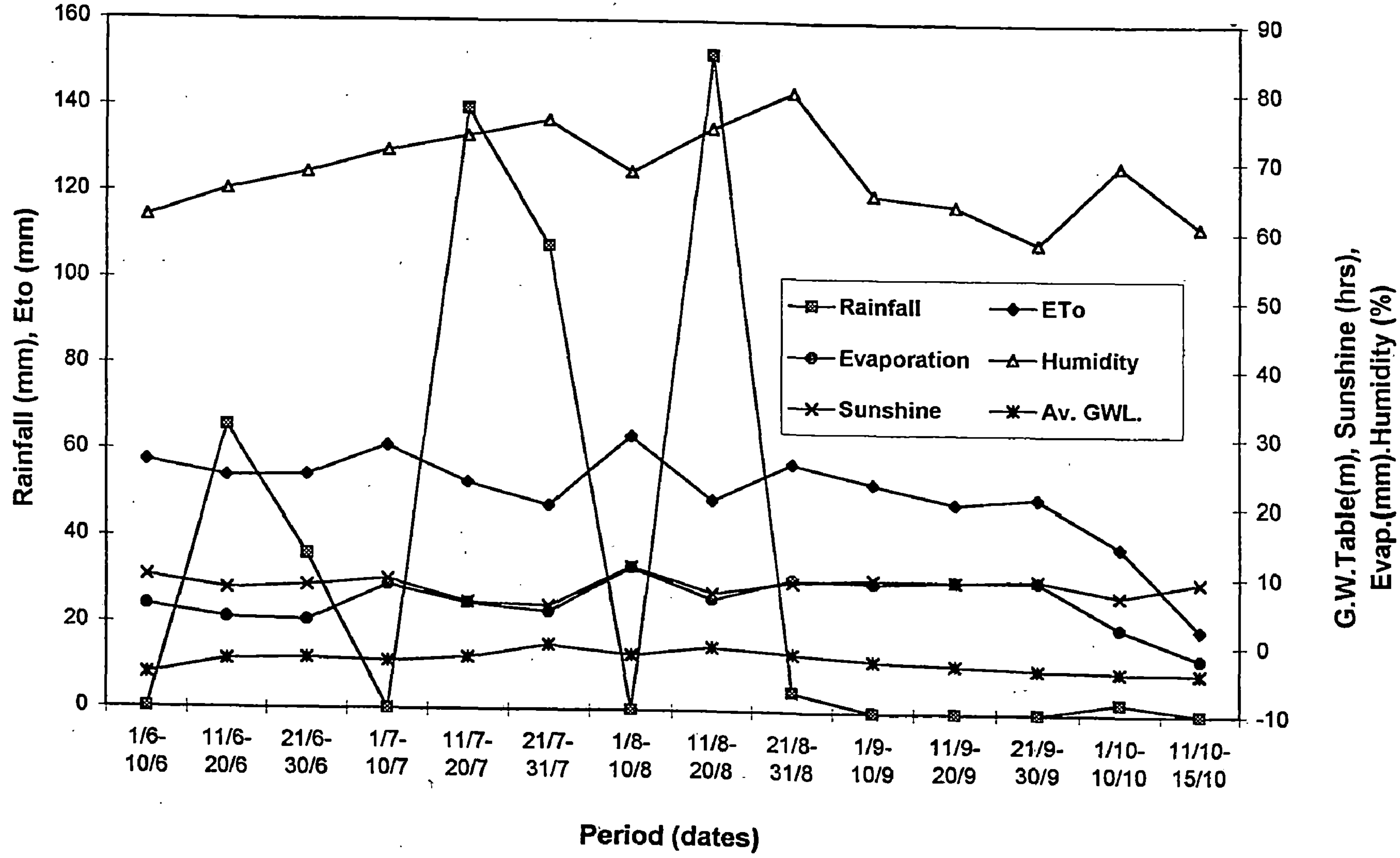


Fig. 5.1: Weather and Hydrologic Condition of the Demonstration Farm during experimental period (Kharif 2001)

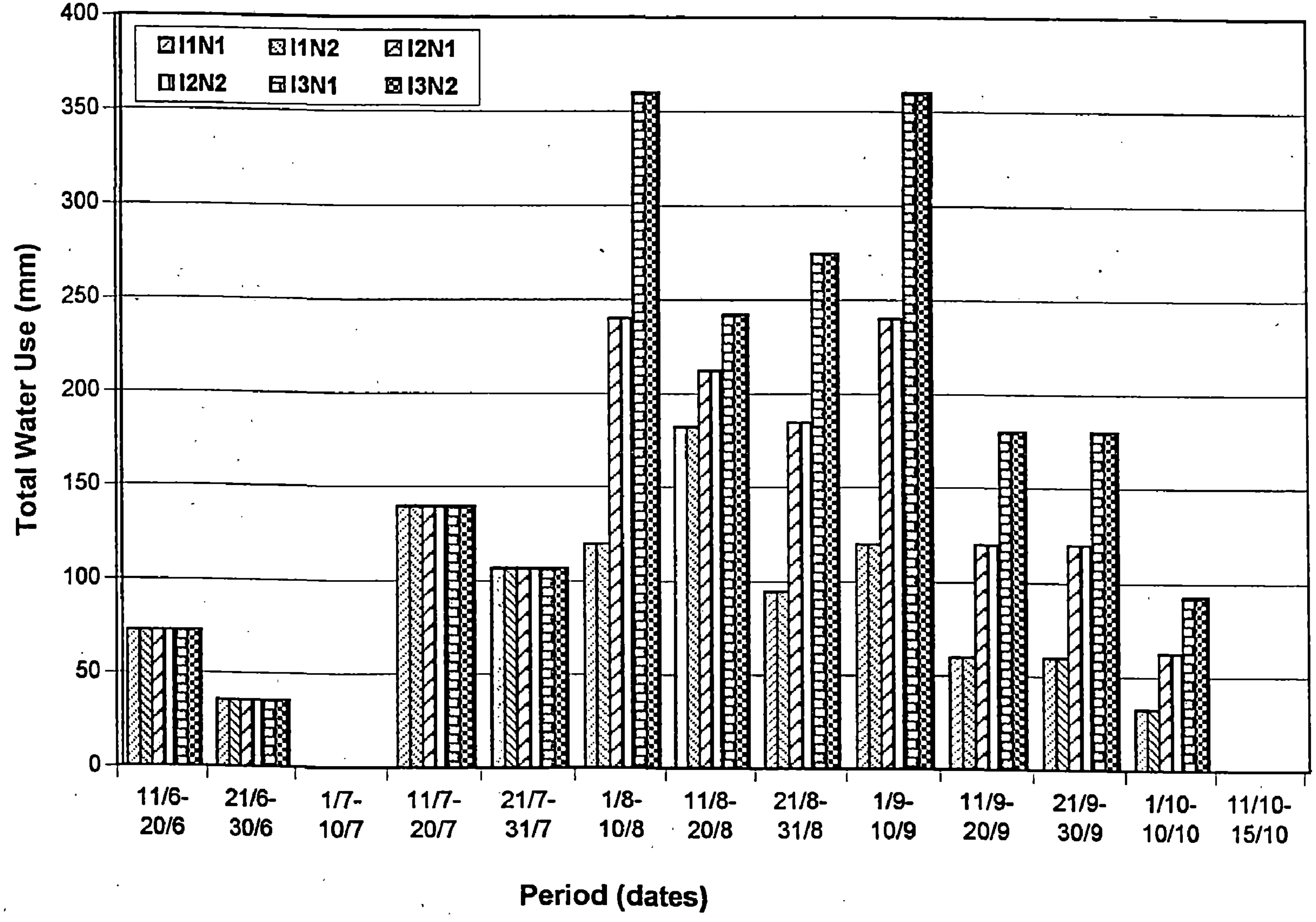


Fig. 5.2: Total Water Use in Rice cv IR64 grown under different Irrigation and nitrogen Treatments during Kharif 2001

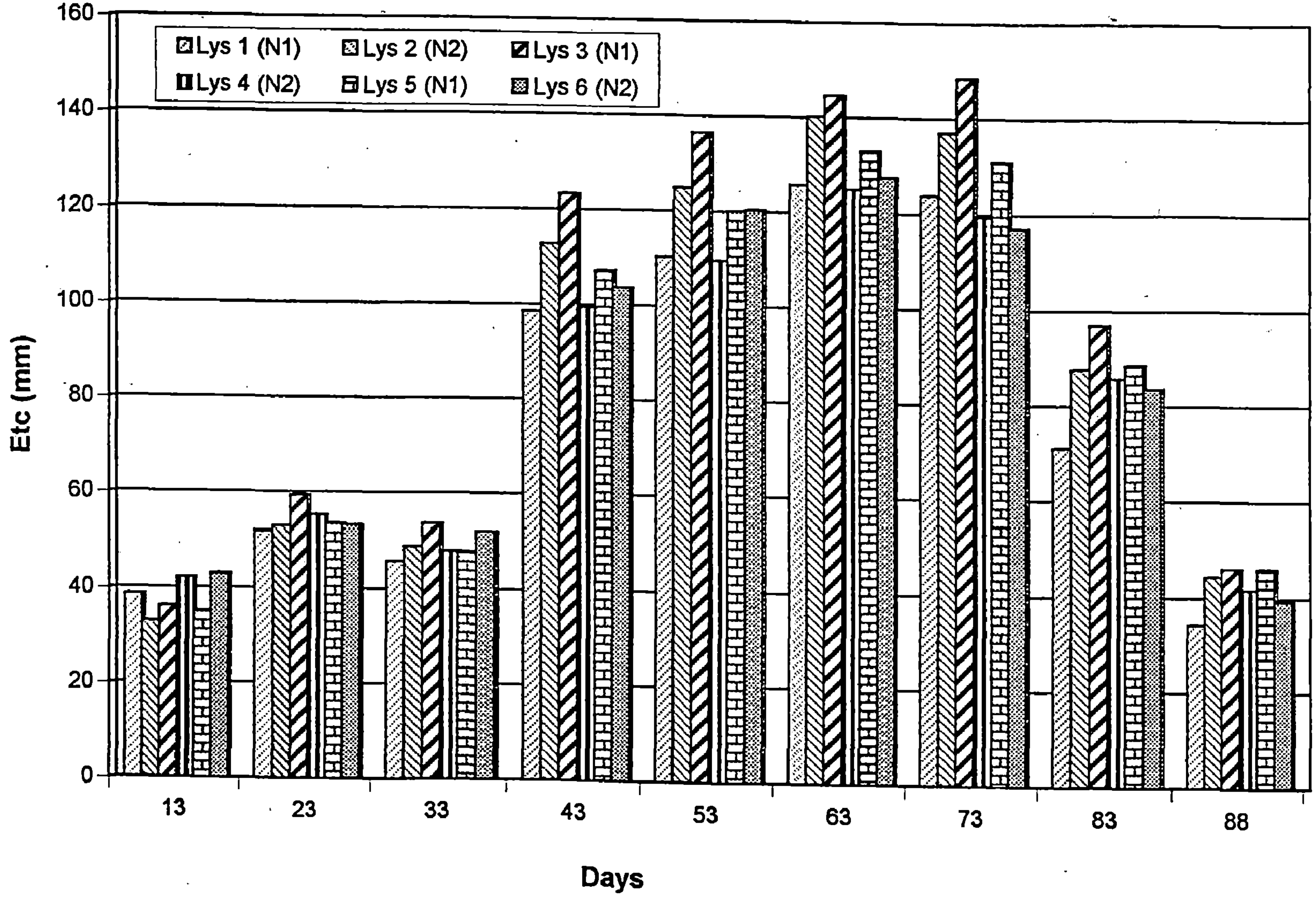


Fig. 5.3a: Crop Evapotranspiration (mm) in Rice cv IR64 grown under different Nitrogen treatment in Lysimeter

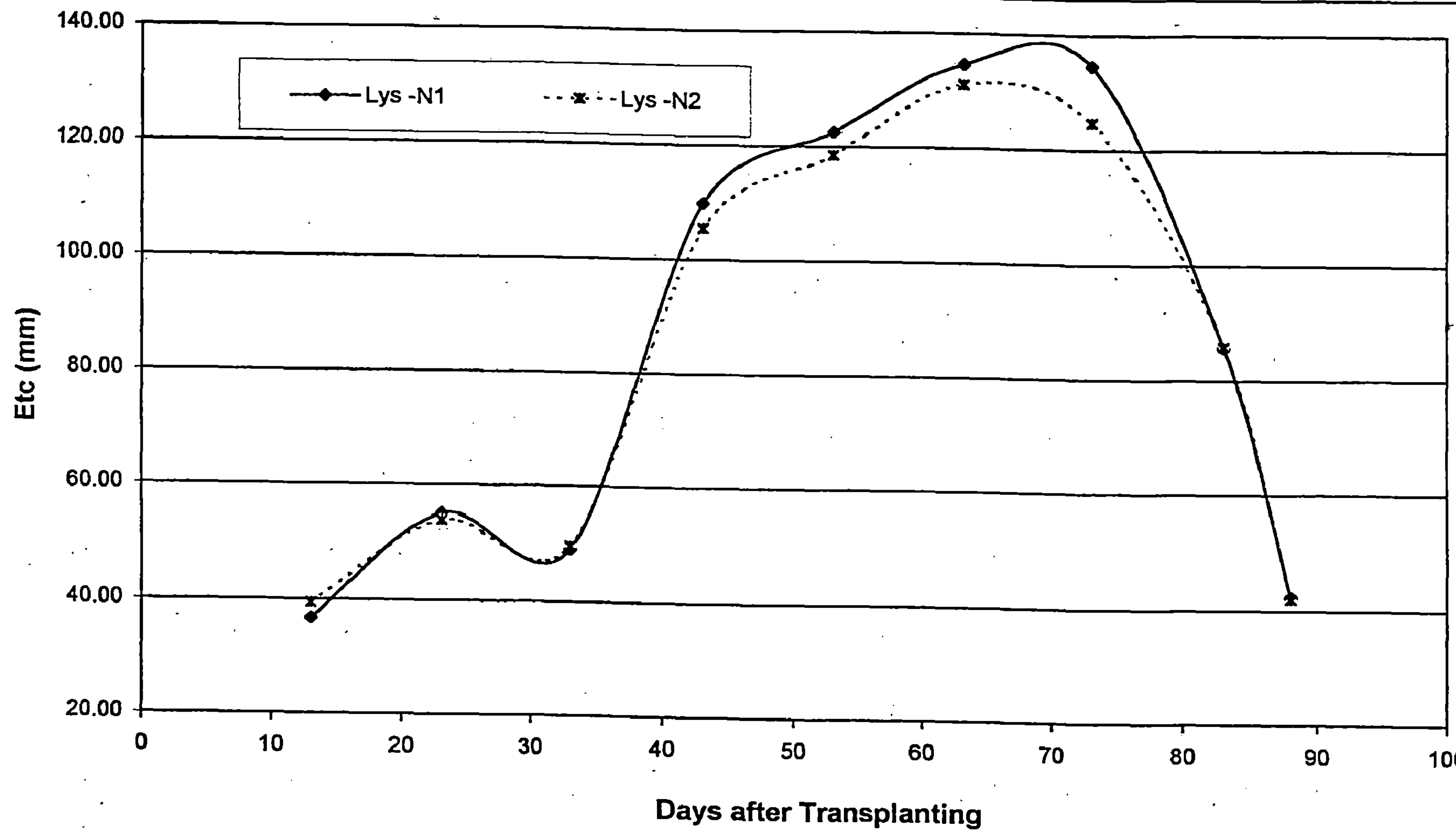


Fig. 5.3b: Crop Evapotranspiration (mm) in Rice cv IR64 grown under different Nitrogen treatment in Lysimeters.

influenced the consumptive use favourable 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 2001 but afterwards all the treatments started showing change in the evapotranspirative demand. The maximum evapotranspiration was 855.46 mm in the Lysimeter No. 3 and minimum was 708.10 mm in Lysimeter No. 1. Results are in conformity to the reports of Mishra and Sharma (1997), 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. 5.4a, 5.4b 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 0.45 in the beginning and it rose to 2.73 at the time of maturity and at the time of harvest, it reduced to 2.12. Different treatment recorded different crop coefficients the maximum was 2.98 in the treatment receiving nitrogen 100 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 Mishra and Sharma (1997), 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 different treatments is presented in Fig. 5.5 and Table 4.7. The effect of irrigation application was significant at 60th day whereas the nitrogen application left a significant effect at 60th day observation. The plant height through fertilisation has

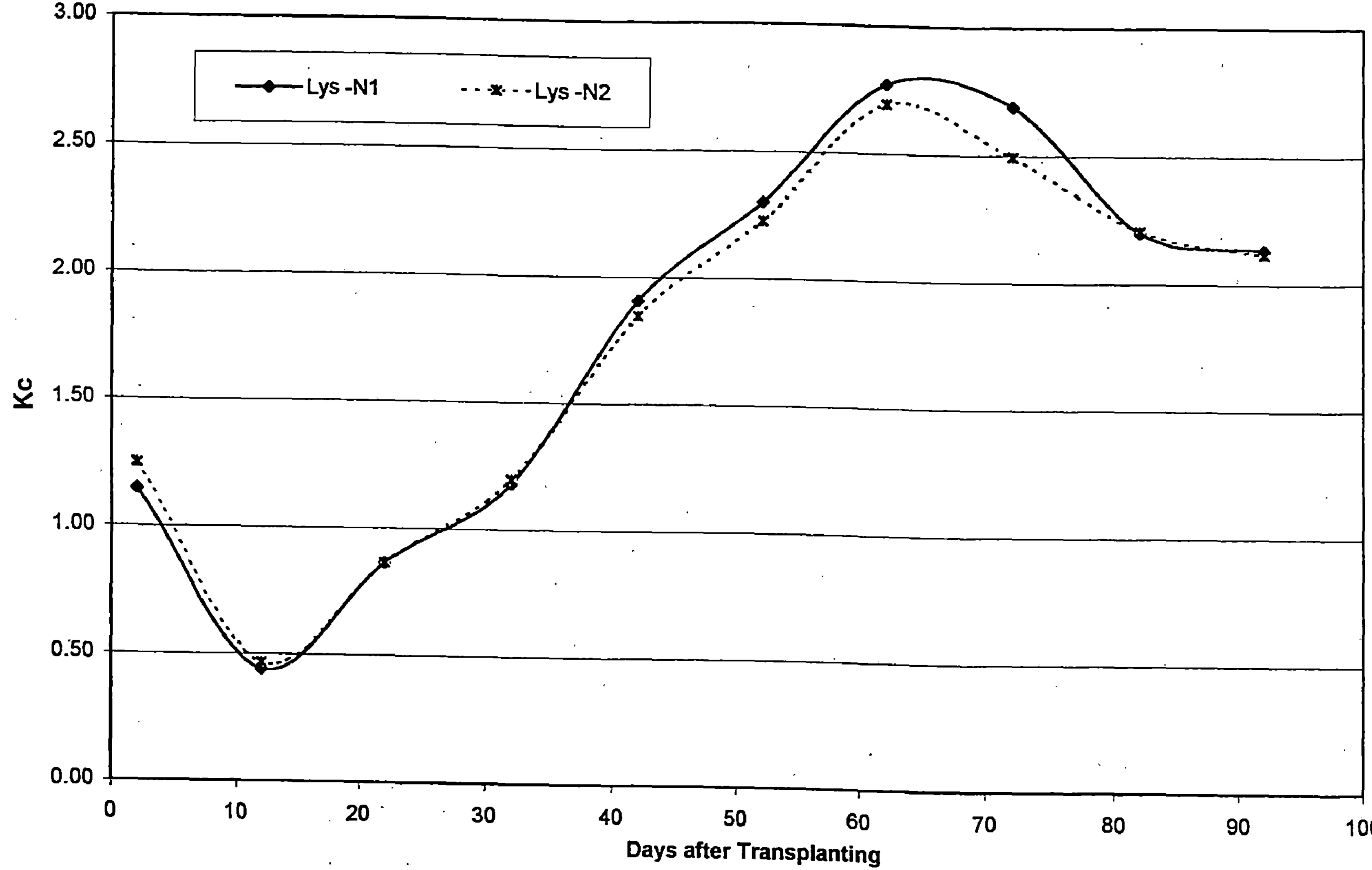


Fig. 5.4b: Crop Coefficient (Kc) of Rice cv IR64 grown under different Nitrogen treatment in Lysimeters

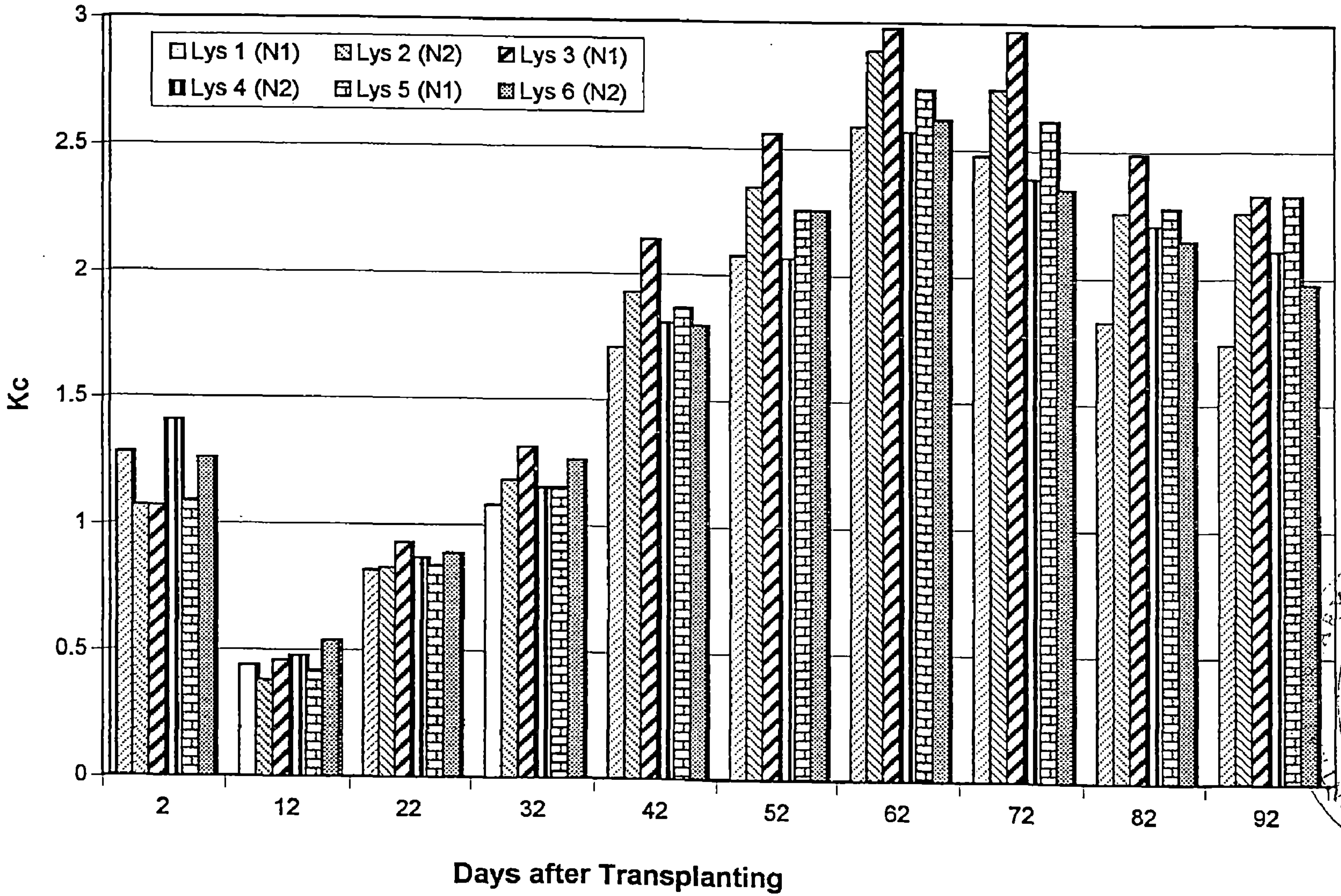


Fig. 5.4a: Crop Coefficient (Kc) of Rice cv IR64 grown under different Nitrogen treatment in Lysimeter

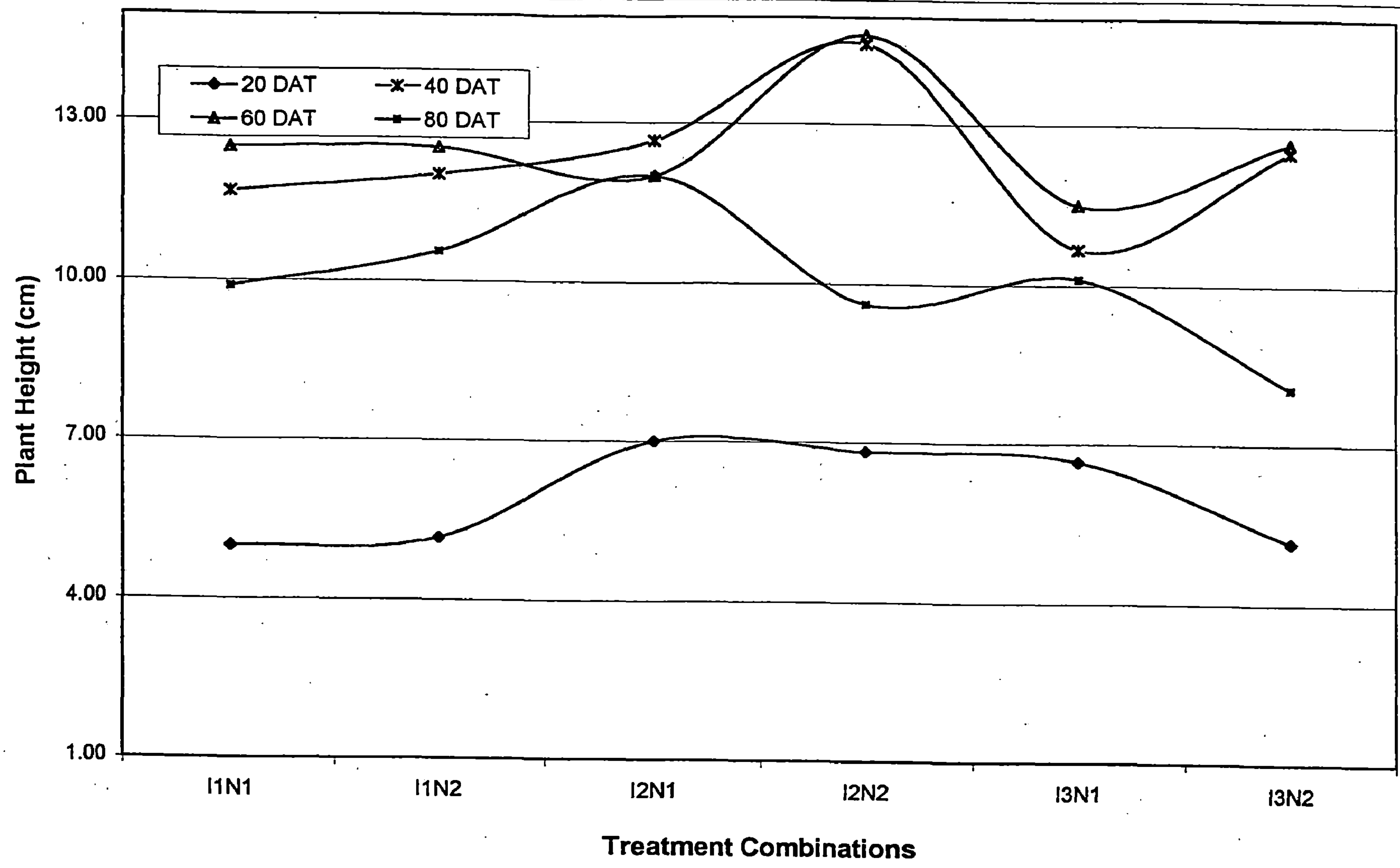


Fig. 5.5: Plant Height of Rice cv IR64 as Influenced by Irrgation and Nirtogen Treatments.

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 40 days. The report confirmed with Reddy and Reddy (1992), Kulmi (1992), Kurray (1998), Verma (1999) and Rajput (2000).

5.7 LEAF AREA INDEX

Leaf area index data presented in Fig. 5.9 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 Kurray (1998), Kulmi (1992), Verma (1999) and Rajput (2000).

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 Kulmi (1992), Kurray (1998), Verma (1999) and Rajput (2000).

5.9 DRY MATTER/HILL

Dry matter production recorded at different stages of growth and presented in Fig. 5.7 and Table No. 4.11 indicated that there was no effect of irrigation application and only at the time of 40 DAT to harvesting nitrogen showed its significant influence. the result reported by Kulmi (1992), Kurray (1998) and Verma (1999).

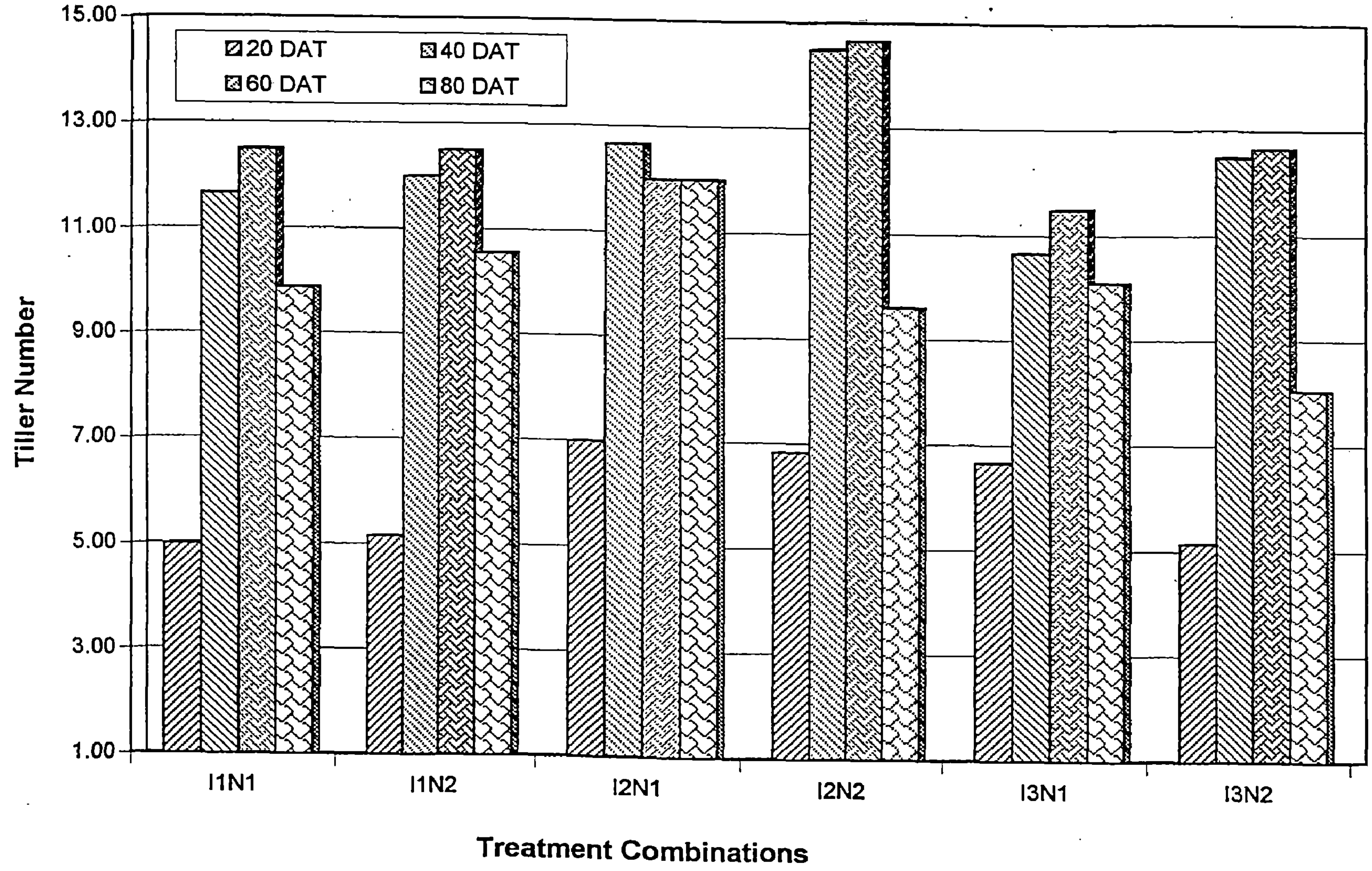


Fig. 5.6: Tiller Numer of Rice cv IR64 as Influenced by Irrgation and Nirtogen Treatments.

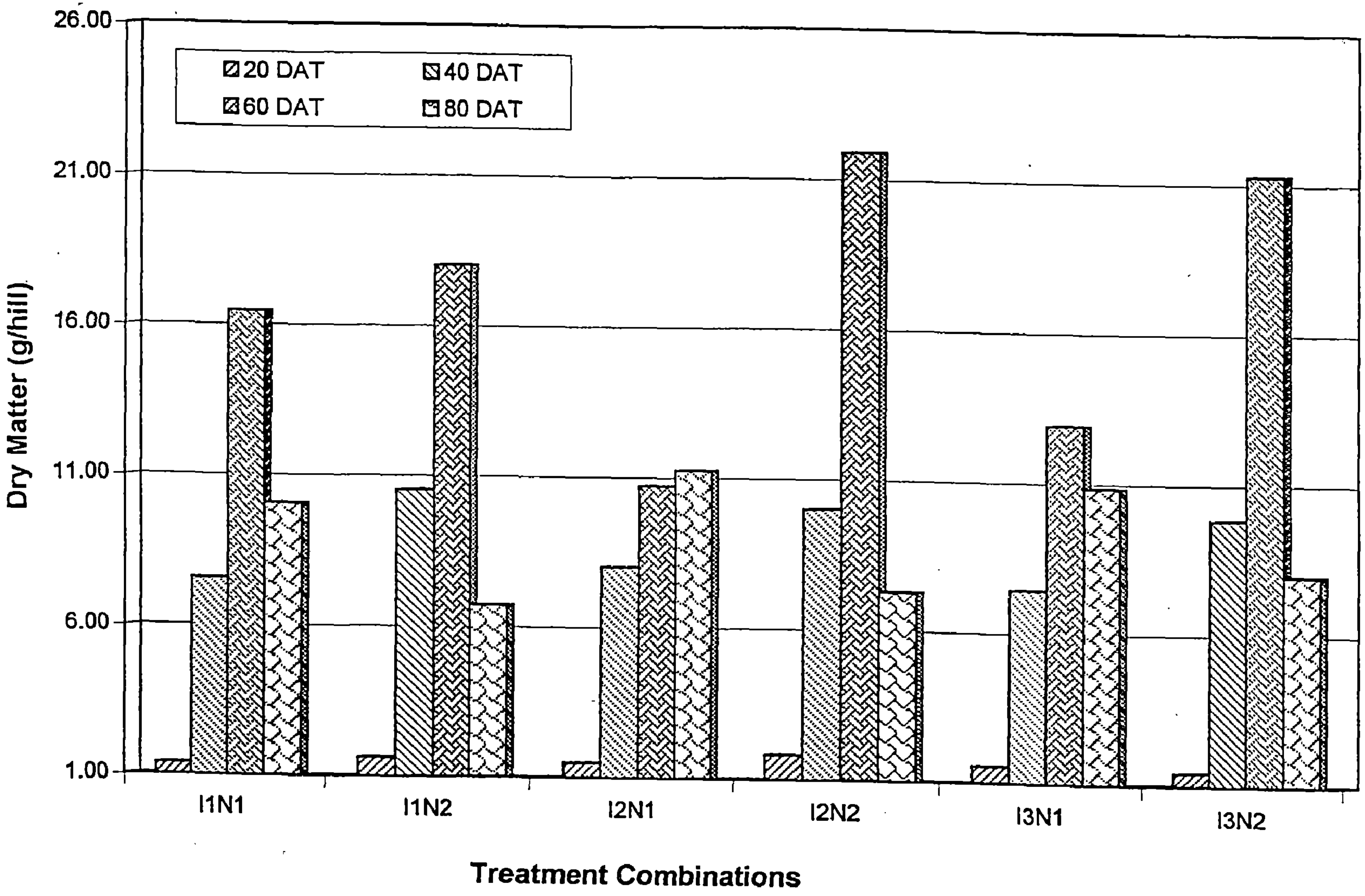


Fig. 5.7: Dry Matter Production (g/hill) of Rice cv IR64 as Influenced by Irrgation and Nirtogen Treatments.

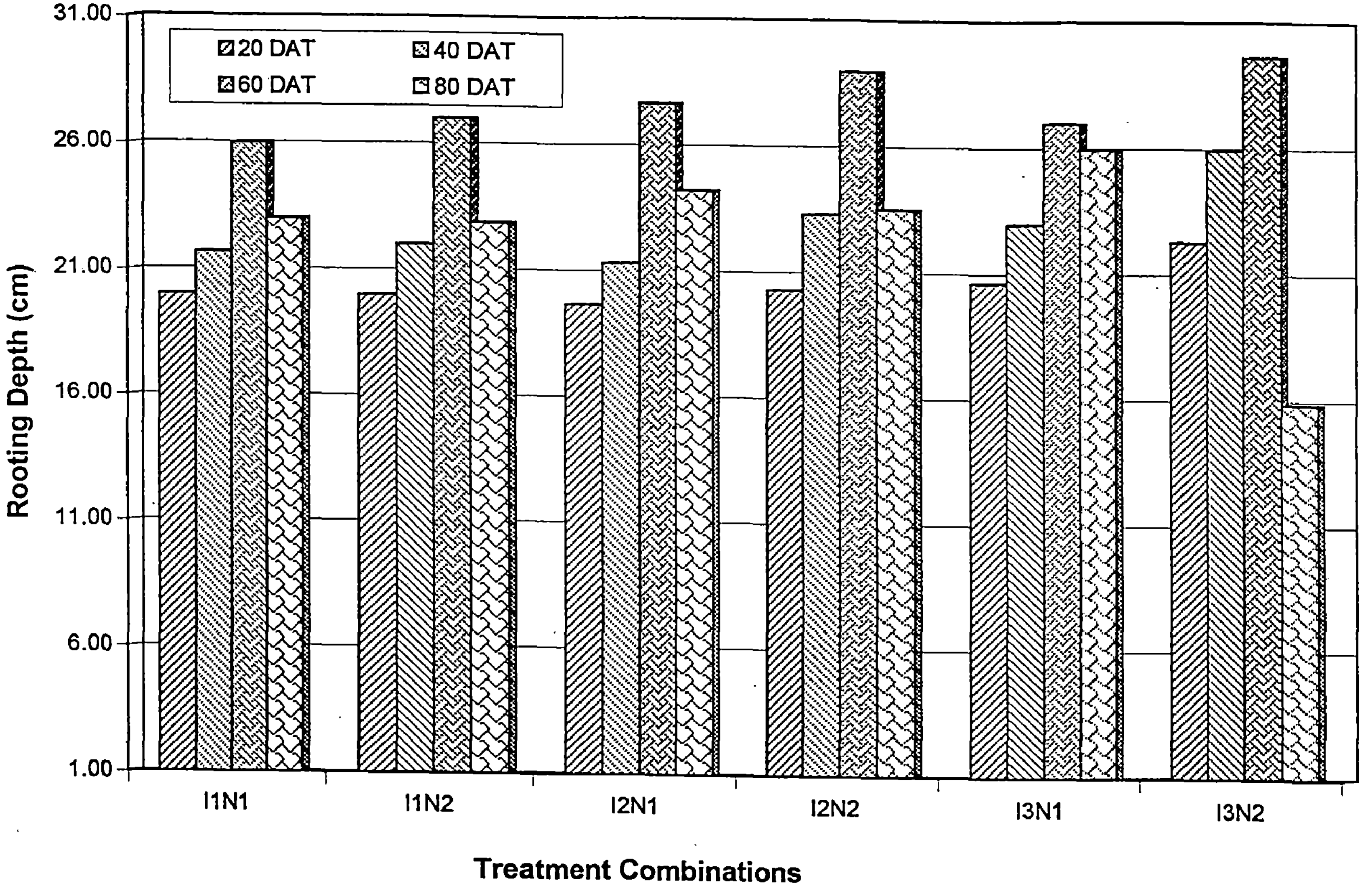


Fig. 5.8: Rooting Depth of Rice cv IR64 as Influenced by Irrgation and Nirtogen Treatments.

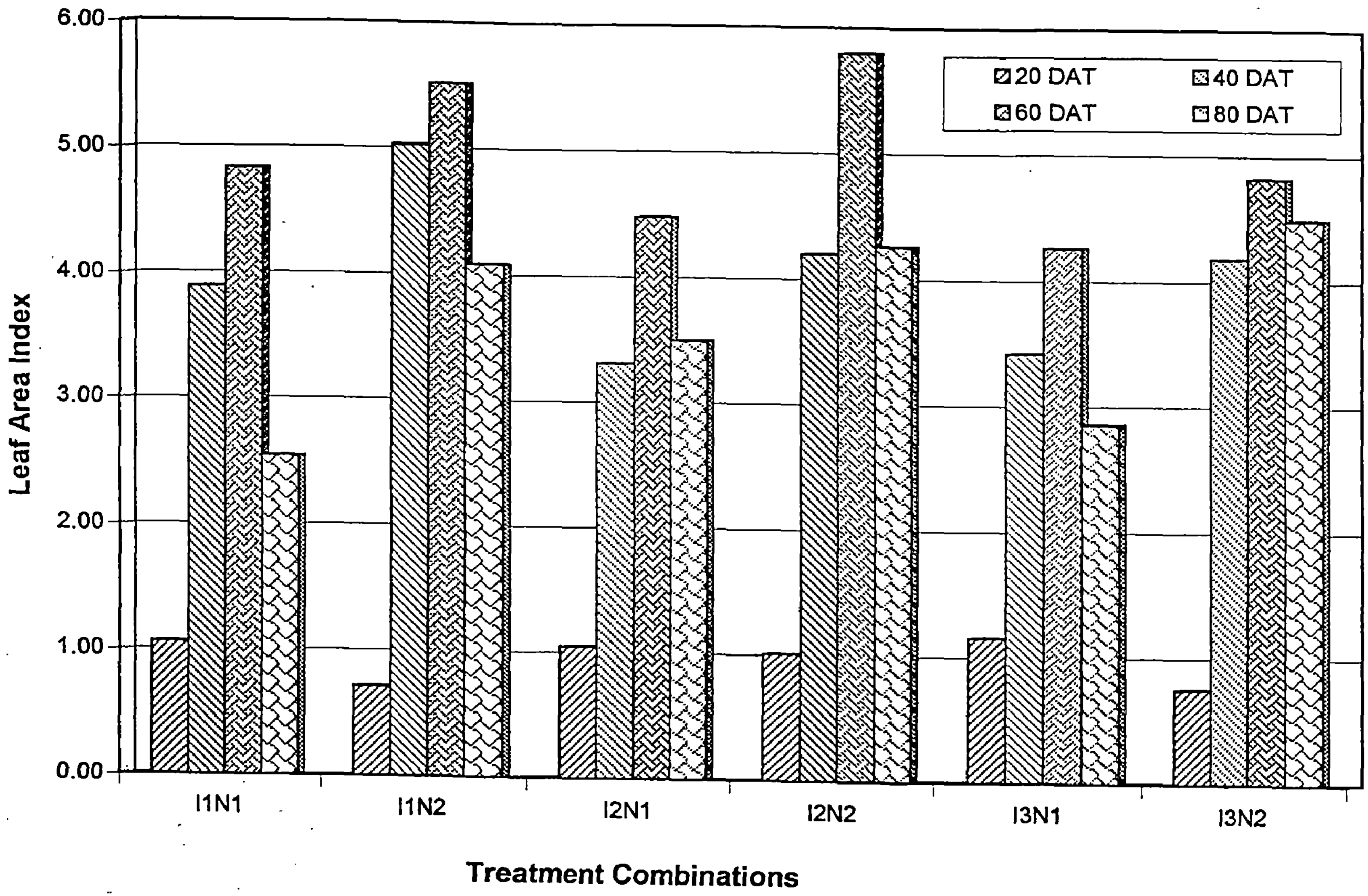


Fig. 5.9: Leaf Area Index of Rice cv IR64 as Influenced by Irrgation and Nirtogen Treatments.

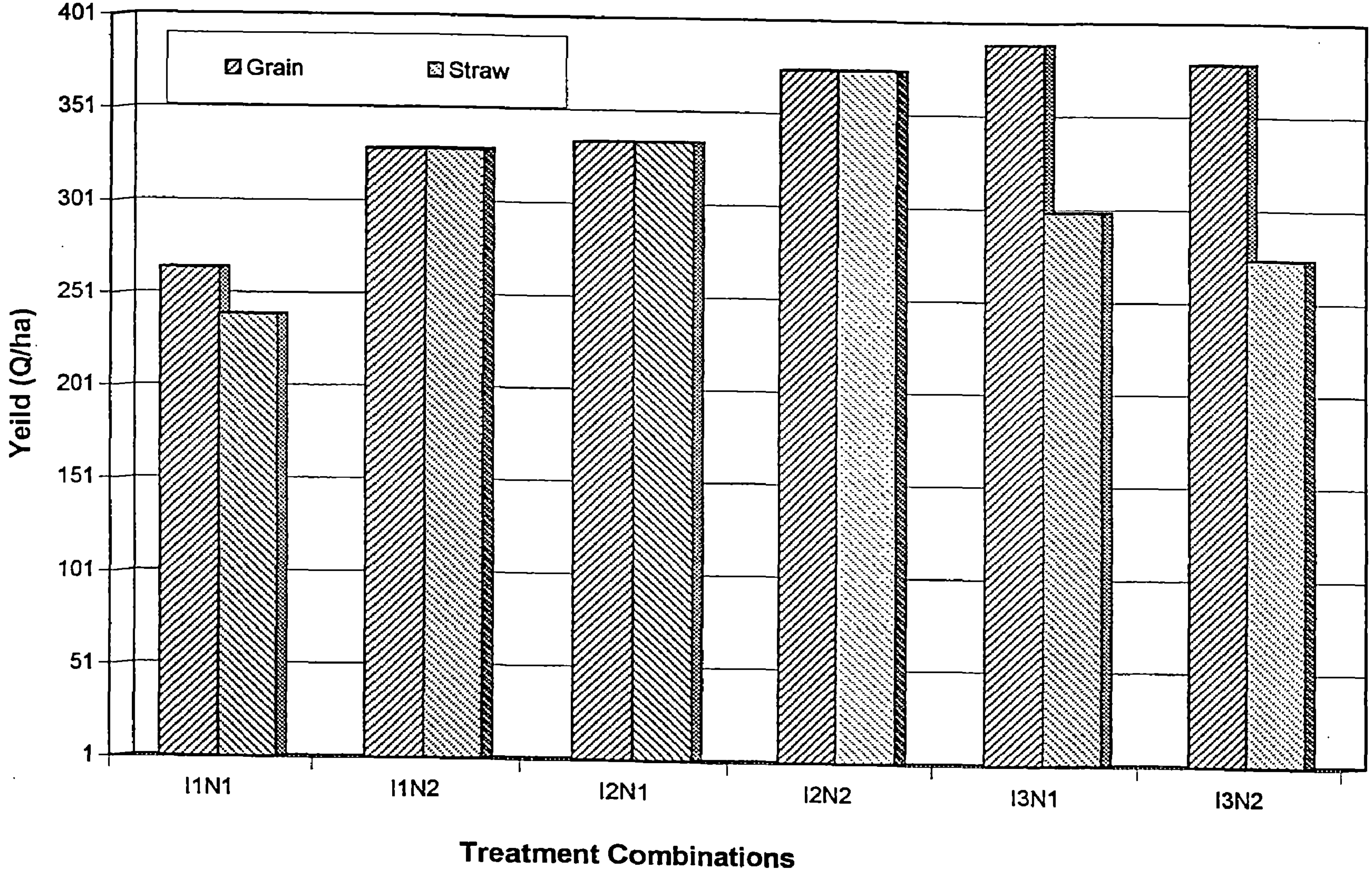


Fig. 5.10: Grain and Straw Yield (Q/ha) of Rice cv IR64 as Influenced by Irrgation and Nirtogen Treatments.

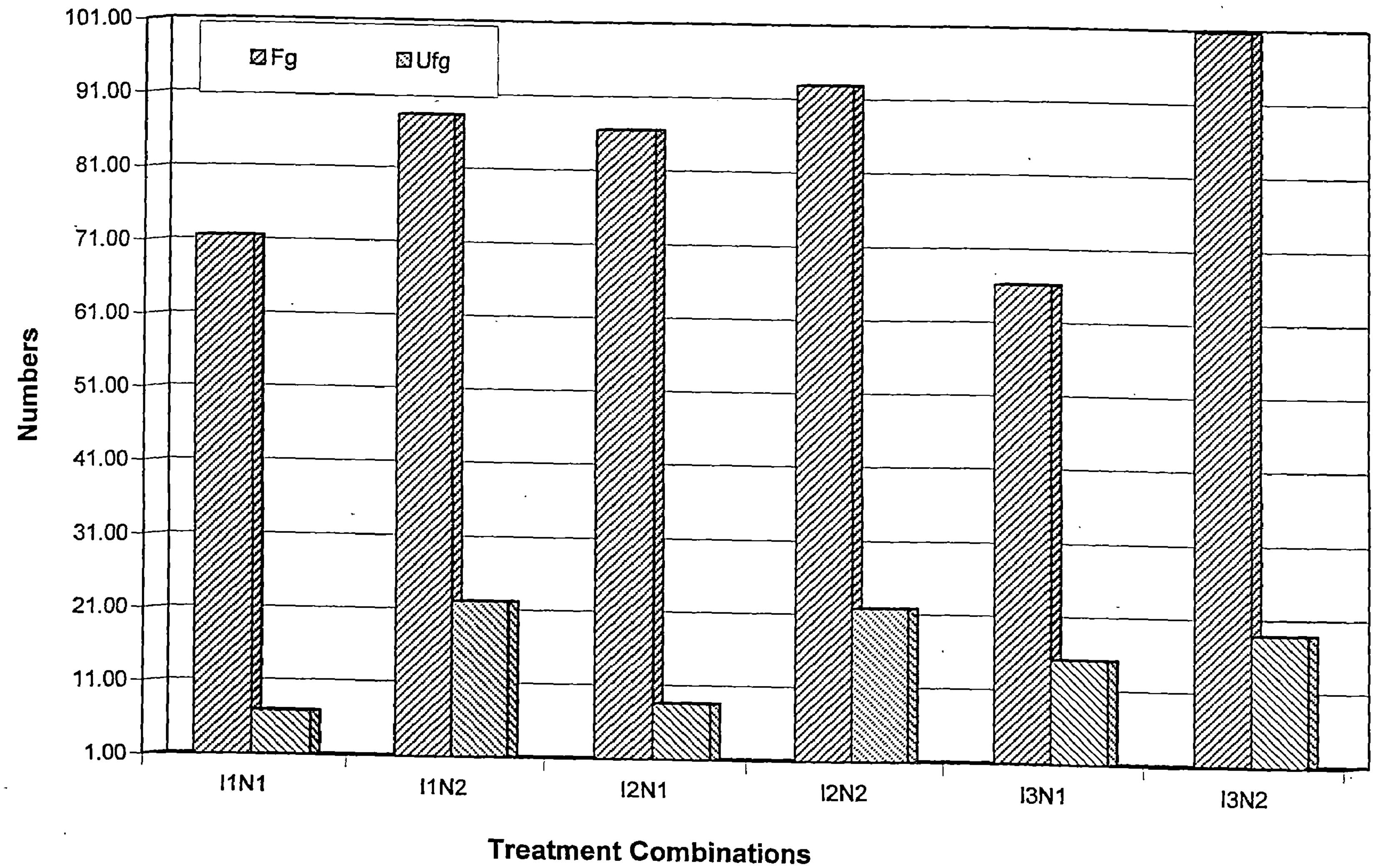


Fig. 5.11: Filled Grain and Unfilled Grain per erhead of Rice cv IR64 as Influenced by Irrgation and Nirtogen Treatments

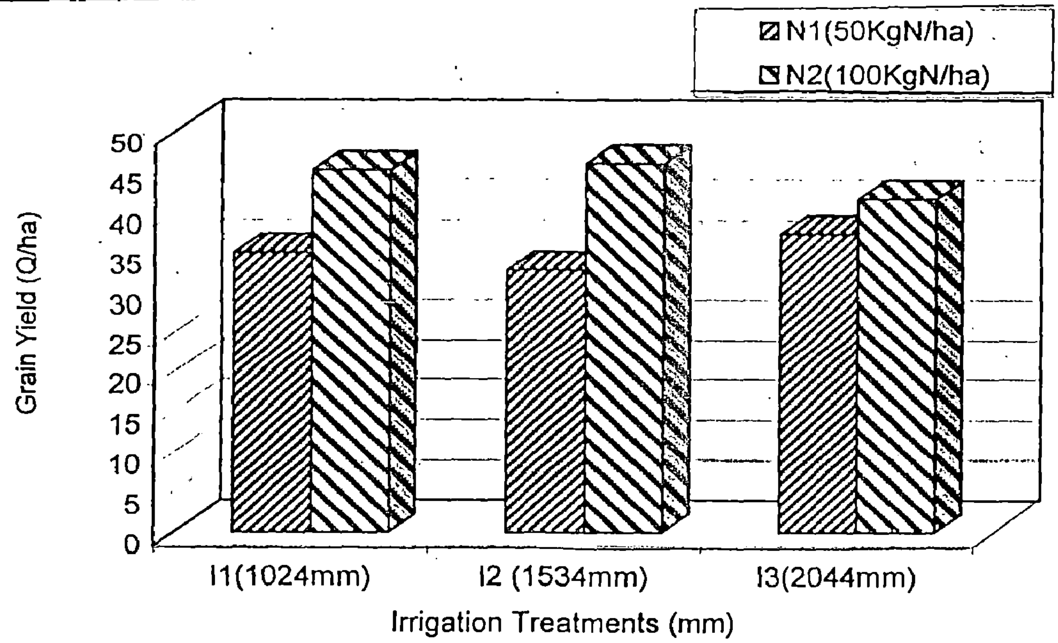


Fig. 5.12: Grain Yield in Rice cv IR64 as influenced by Irrigation and Nitrogen treatments.

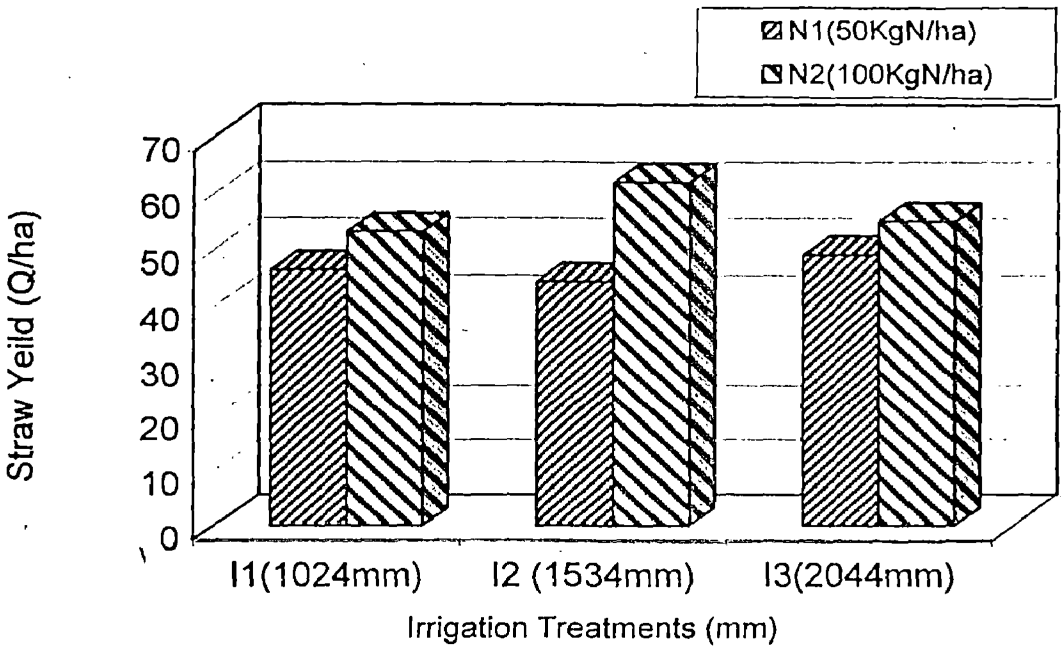


Fig. 5.13: Straw Yield in Rice cv IR64 as influenced by Irrigation and Nitrogen treatments.

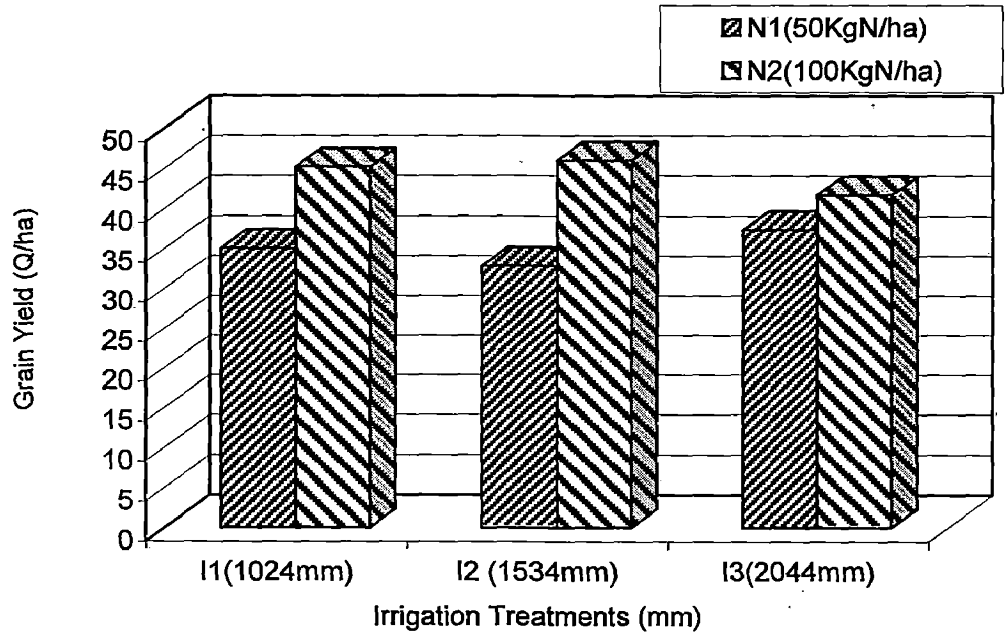


Fig. 5.12: Grain Yield in Rice cv IR64 as influenced by Irrigation and Nitrogen treatments.

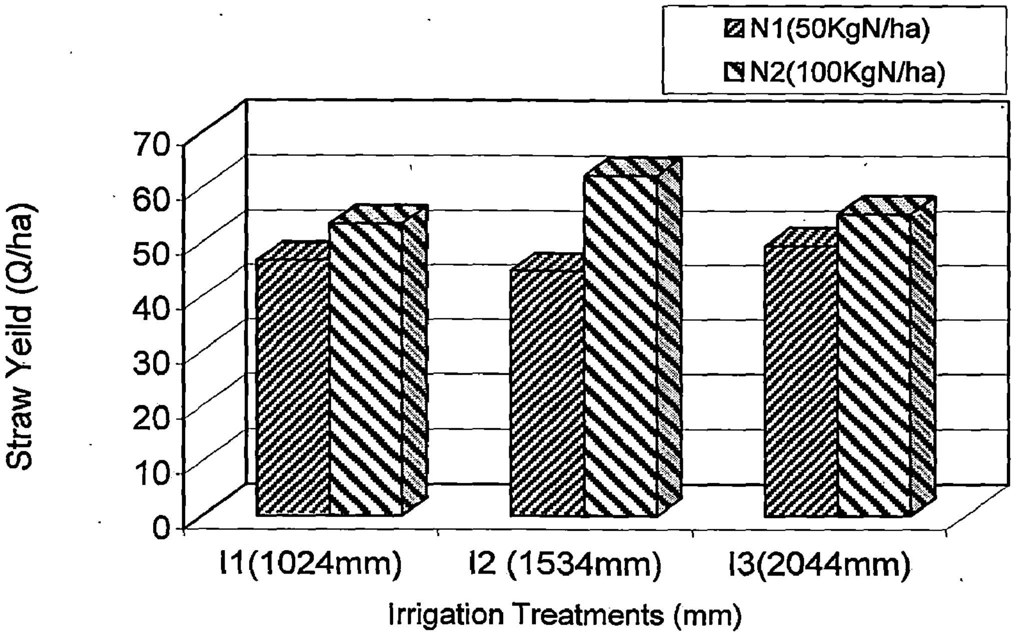


Fig. 5.13: Straw Yield in Rice cv IR64 as influenced by Irrigation and Nitrogen treatments.

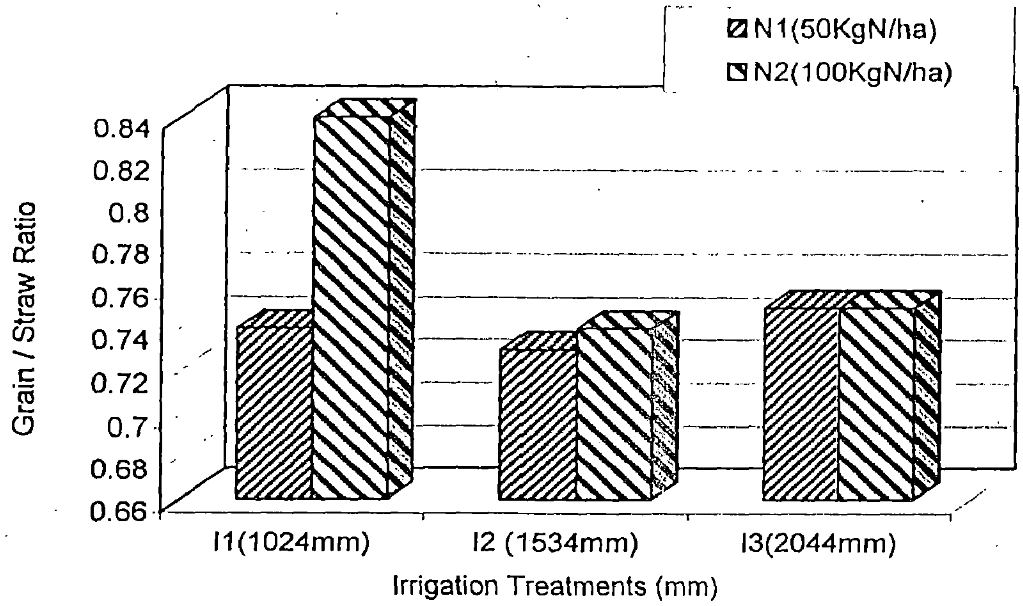


Fig. 5.14: Grain : Straw in Rice cv IR64 as influenced by Irrigation and Nitrogen treatments.

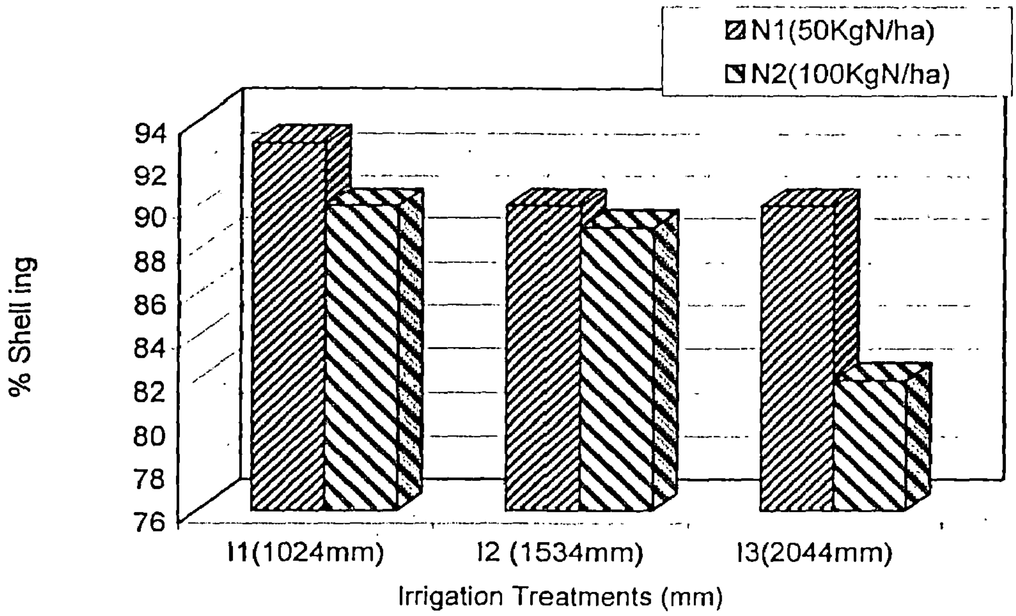


Fig. 5.15: % Shelling in Rice cv IR64 as influenced by Irrigation and Nitrogen treatments.

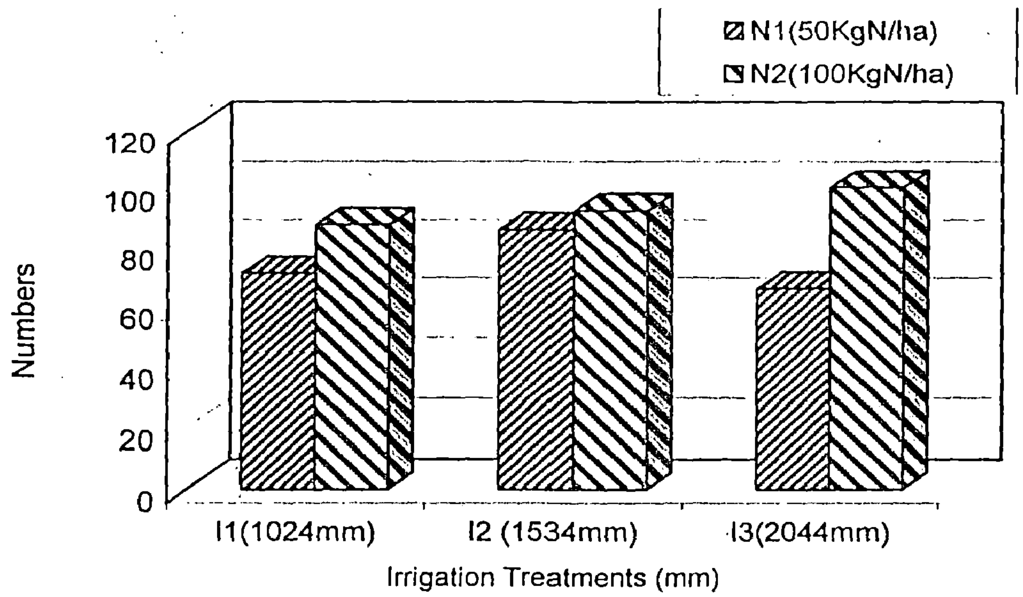


Fig. 5.16: Filled grain in Rice cv IR64 as influenced by Irrigation and Nitrogen treatments.

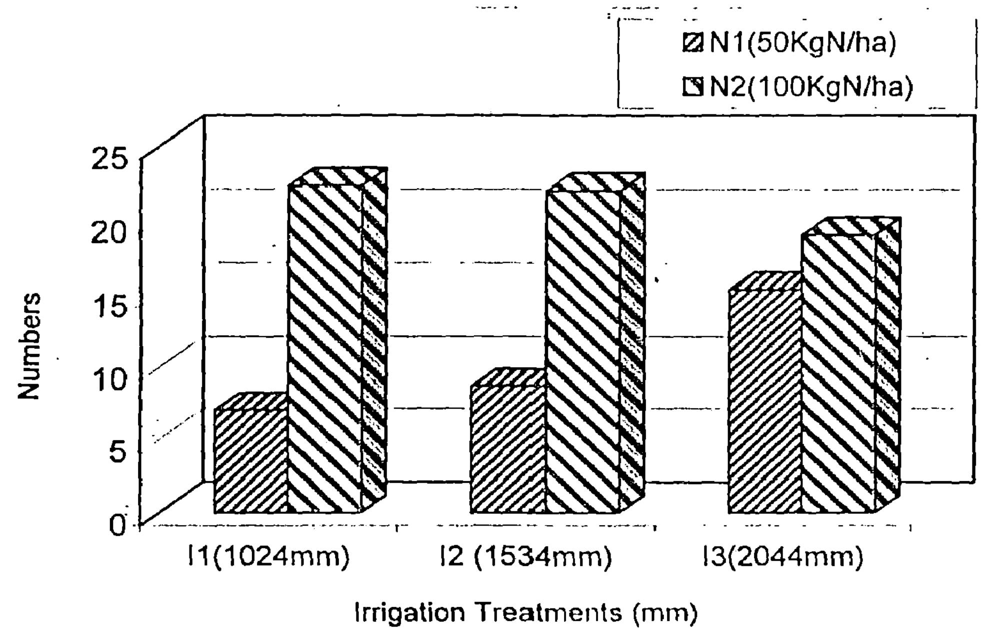


Fig. 5.17: Unfilled grain in Rice cv IR64 as influenced by Irrigation and Nitrogen treatments.

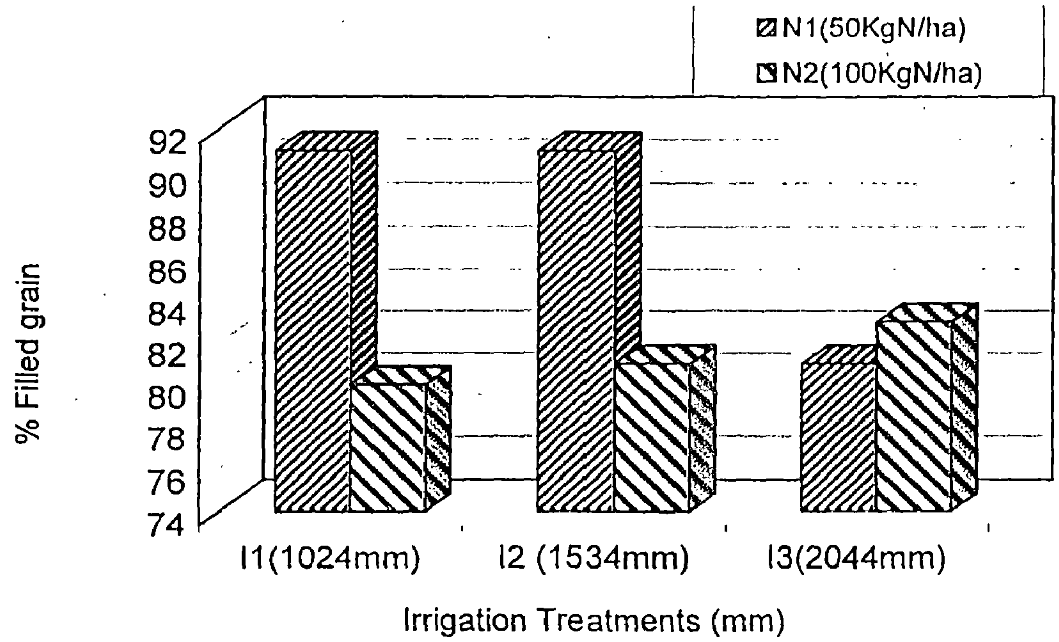


Fig. 5.18: % Filled Grain in Rice cv IR64 as influenced by Irrigation and Nitrogen treatments.

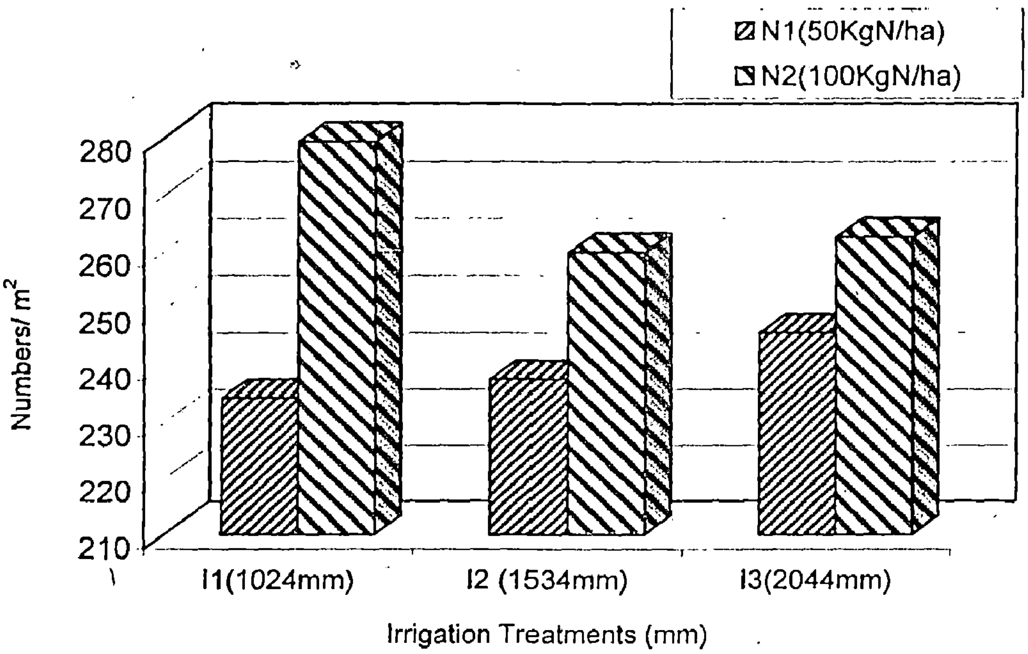


Fig. 5.19: Earhead density in Rice cv IR64 as influenced by Irrigation and Nitrogen treatments.

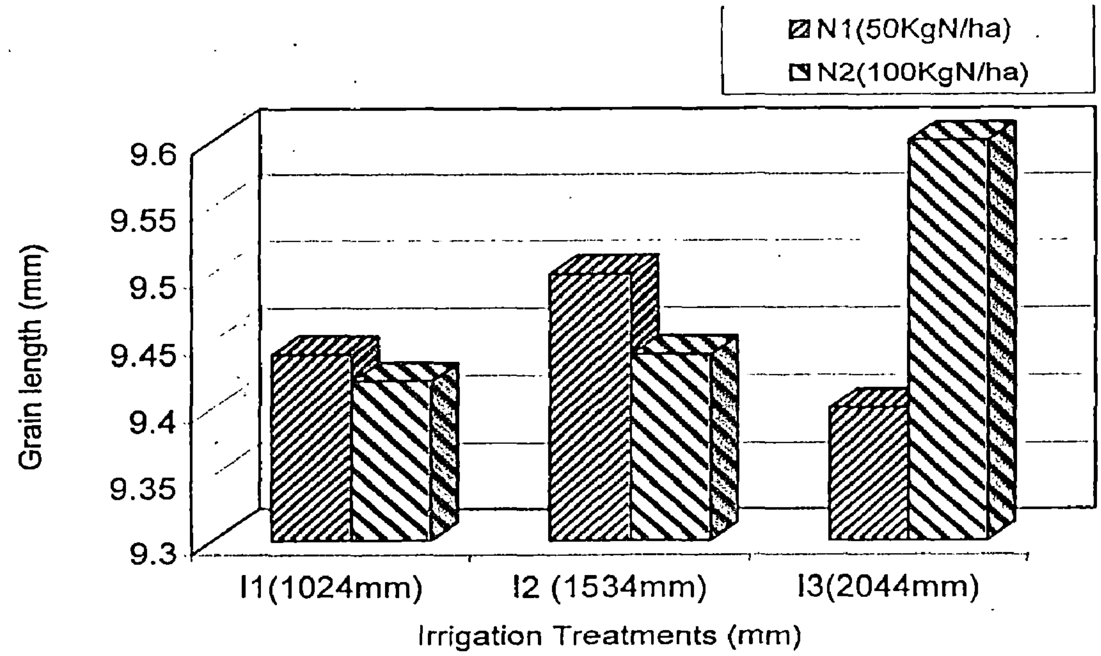


Fig. 5.20: Grain Length in Rice cv IR64 as influenced by Irrigation and Nitrogen treatments.

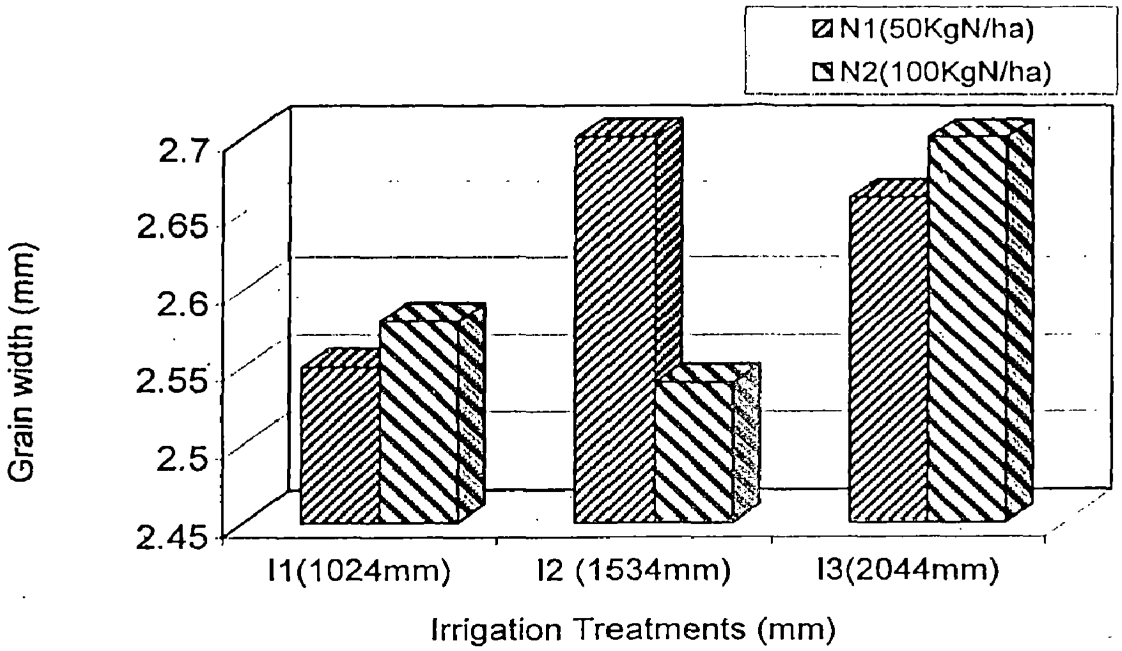


Fig. 5.21: Grain Width in Rice cv IR64 as influenced by Irrigation and Nitrogen treatments.

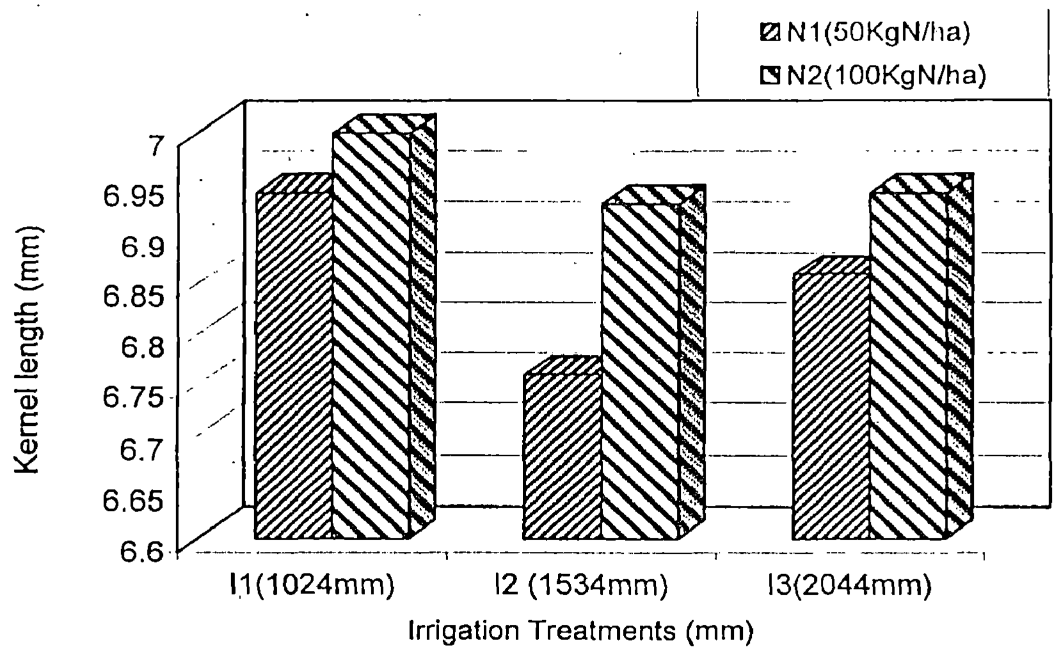


Fig. 5.22: Kernel Length in Rice cv IR64 as influenced by Irrigation and Nitrogen treatments.

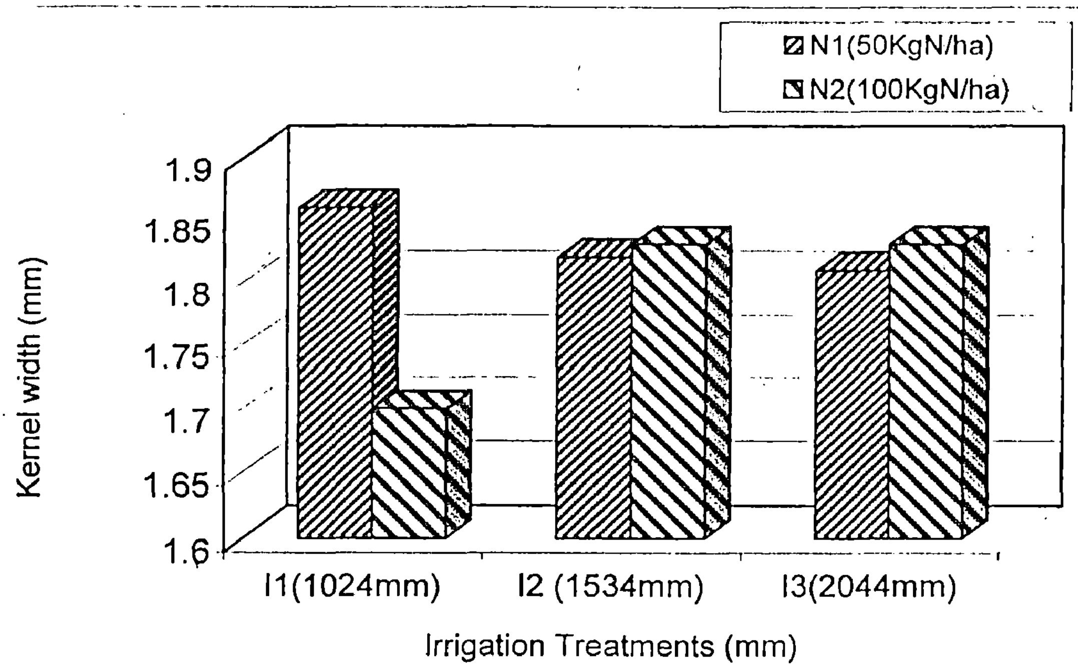


Fig. 5.23: Kernel Width in Rice cv IR64 as influenced by Irrigation and Nitrogen treatments.

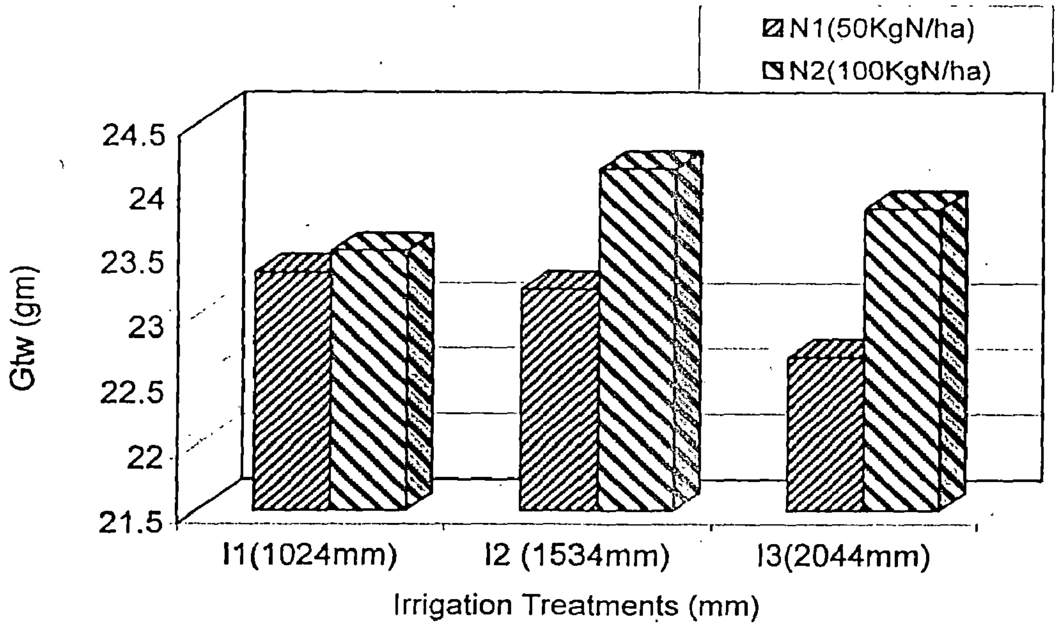


Fig. 5.24: Grain Test Weight in Rice cv IR64 as influenced by Irrigation and Nitrogen treatments.

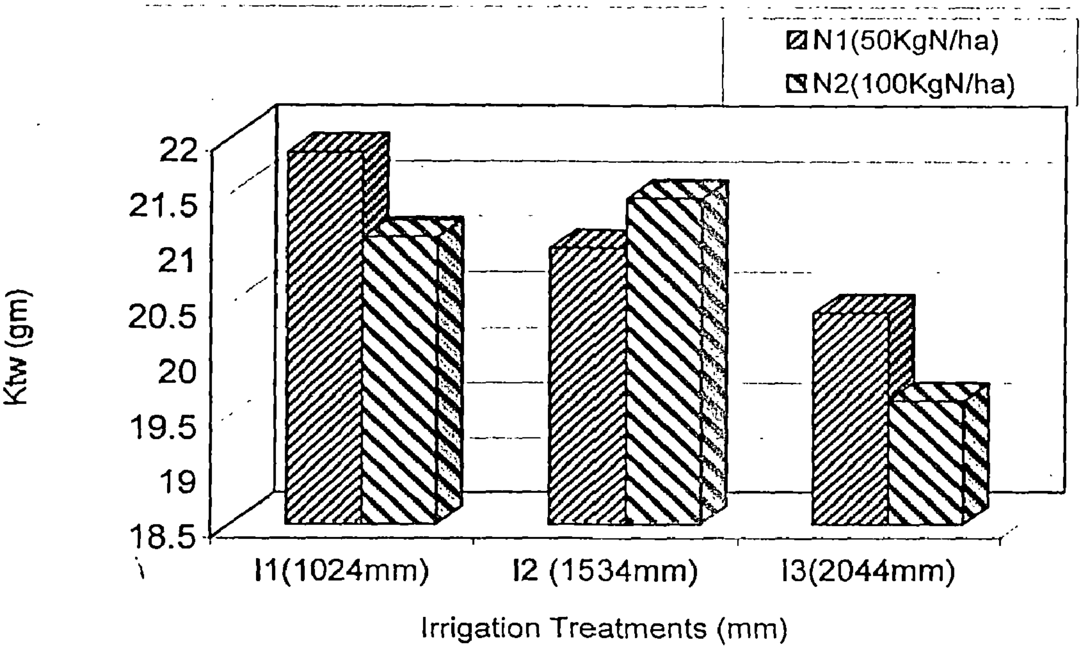


Fig. 5.25: Kernel Test Weight in Rice cv IR64 as influenced by Irrigation and Nitrogen treatments.

5.10 YIELD AND YIELD ATTRIBUTES

Data presented in Fig. 5.12-5.25 and Table 4.12 indicated a significant influence of fertilizer on straw 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 CORRELATIONS STUDIES

Correlation matrix prepared from the yield and yield attributes is presented in Table 4.13. 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).

Table 13 : Correlation Matrix of Yield and Yield Attributes of Rice cv IR64 grown under different Irrigation and Nitrogen Treatments.

	Column 1	*Column 2*	*Column 3*	*Column 4*	*Column 5*	*Column 6*	*Column 7*	*Column 8*	*Column 9*	*Column 10*	*Column 11*	*Column 12*	*Column 13*	*Column 14*
Column 1	1													
Column 2	0.914629	1												
Column 3	0.89333	0.671177	1											
Column 4	0.54759	0.584368	0.58201	1										
Column 5	0.955331	0.859795	0.921421	0.544374	1									
Column 6	0.684095	0.788231	0.488785	0.81985	0.535087	1								
Column 7	-0.093116	-0.106735	-0.287058	-0.368355	-0.316371	0.06684	1							
Column 8	-0.297353	-0.170136	-0.141808	0.619418	-0.220001	0.238122	-0.502092	1						
Column 9	-0.437487	-0.394709	-0.164734	0.171836	-0.193412	-0.368293	-0.797295	0.716725	1					
Column 10	0.737534	0.555081	0.682096	0.219851	0.588012	0.478501	0.087785	-0.435098	-0.608695	1				
Column 11	-0.488421	-0.123878	-0.764911	-0.148402	-0.565066	0.05207	0.061029	0.295173	0.083523	-0.383644	1			
Column 12	0.555048	0.171671	0.796255	0.129214	0.563429	0.038333	-0.00031	-0.379658	-0.251665	0.635864	-0.946291	1		
Column 13	-0.834208	-0.72748	-0.80577	-0.230432	-0.928126	-0.223957	0.37641	0.422435	0.139905	-0.523271	0.550142	-0.541356	1	
Column 14	-0.361967	-0.442554	-0.437996	-0.740747	-0.479917	-0.438362	0.862705	-0.627016	-0.557969	-0.129364	-0.038983	0.039973	0.370127	1

Note:

Column 1: Grain Yield Q/ha
Column 2:Straw Yield Q/ha
Column 3: Earhead density/m ^{2}
Column 4: Filled Grains / earhead
Column 5: Unfilled grains / earhead
Column 6: Test weight grain (g/1000)
Column 7: Test weight Kernel (g/1000)
Column 8: Grain length (mm)
Column 9: Grain width (mm)
Column 10: Kernel length (mm)
Column 11: Kernel width (mm)
Column 12: Grain : Straw
Column 13: % filled grains
Column 14: % Shelling

Chapter 6

SUMMARY AND CONCLUSIONS

The study on water and nutrient management in rice was conducted during the Kharif 2001 at WRDTC Demonstration Farm, IIT, Roorkee (Uttaranchal), India. The treatment consisted two levels of nitrogen and three levels of irrigation applications.

The nitrogen application were used

N_1 = 50 kg/ha
N_2 = 100 kg/ha

The irrigation application were used

I_1 = 30 mm/irrigation
I_2 = 60 mm/irrigation
I_3 = 90 mm/irrigation

1/3 nitrogen and full dose of DAP (22 kg/ha) and potassium sulphate (11 kg/ha) was applied at the time of puddling. The nitrogen was applied, 1/3 at tillering and 1/3 at flowering. A uniform dose of 34.0 kg/ha $ZnSO_4$ was applied in the plot. Application of insecticides Fenvale rate 0.4% DF, SriFen DP was applied and next time Delgim and Sriphos-40 was also applied in the plot. Data were collected and results obtained are summarised as following.

(1) Total water use (irrigation + rainfall) (11.6.2001 to 15.10.2001) in different irrigation treatments was 1024.0 mm, 1534.0 mm and 2044.0 mm in I_1, I_2 and I_3 respectively. Rice crop not received sufficient rainfall upto first decadal of August 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 203.03 mm during nursery and 445.82 during the period of crop. The rainfall during nursery was 111.6 whereas during the cropping period was 516.00 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 708.10 mm, 789.53 mm, 855.86 mm, 772.02 mm, 753.38 mm in the Lysi1, Lysi2, Lysi3, Lysi4, Lysi5, Lysi6, respectively.

(4) The crop coefficient (K_c) was recorded as 1.74 on an average and 1.60, 1.78, 1.92, 1.70, 1.76, 1.71 in the Lysi1, Lysi2, Lysi3, Lysi4, Lysi5, Lysi6, respectively.

(5) The leaf area index was recorded in the plants grown in Lysimeter. The average leaf area index was 5.72 at 20 dat, 7.08 at 40 dat, 10.51 at 60 dat and 7.86 at 80 dat. The maximum leaf area index was recorded in the Lysimeter in which 100 kg/ha nitrogen was applied.

(6) The average plant height was 45.15 cm at 20 dat, 49.28 cm at 40 dat, 66.38 cm at 60 dat, 70.27 cm at 80 dat and 86.22 m at harvesting. The nitrogen application showed the response at the age of 60 dat and the irrigation showed the response at the age of 60 dat. The interaction of a nitrogen and irrigation showed the response at the age of 60 dat after that no response of nitrogen and irrigation.

(7) The average tiller/hill was recorded 5.95 at 20 dat, 12.36 at 40 dat, 12.69 at 60 dat, 11.56 at 80 dat, 7.98 at the time of harvesting. We

saw that there is no appreciable change in the tiller number, from 40 dat to harvesting.

(8) The average dry matter/hill was 1.56 gm/hill at 20 dat, 8.90 gm/hill at 40 dat, 20.25 gm/hill at 60 dat, 27.76 gm/hill at 80 dat and 24.16 gm/hill at the time of harvest. Nitrogen application significant at the age of 80 dat onwards.

(9) The average leaf area index recorded was 0.95 at the age of 20 dat, 4.01 at the age of 40 dat, 4.79 at the age of 60 dat, 3.62 at the age of 80 dat and 1.38 at the time of harvest. The nitrogen application significant at the age of 80 dat and at the time of harvest and the irrigation application not significant at the age of 80 dat.

(10) The average rooting depth was recorded 20.55 cm at the age of 20 dat, 22.88 cm at the age of 40 dat, 27.73 cm at the age of 60 dat and 28.77 cm at the age of 80 dat. The nitrogen application significant at the age of 40 dat and the irrigation application was significant at the age of 40 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 39.66 q/ha, 53.55 q/ha, 253.05/m^2, 84.5, 15.61, 23.36 gm, 20.91 gm, 128.1, 9.46 mm, 2.60 mm, 6.74 mm and 1.81 mm, respectively. Nitrogen application significant only for straw yield, grain yield, filled grain, unfilled grain.

(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. Nitrogen application significant for irrigation + rainfall.

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

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

(2) Application of irrigation also did not affect the growth and development of crop significantly.

REFERENCES

1. Jee, R. C. and A. K. Mahapatra (1989) Effect of time of application of some slow release 'N' fertilisers on rice.Indian J. of Agron., 34(4) : 435-436.
2. Ghosh B. C.; C. V. Raghavaian and M. K. Jana (1991) Effect of seed rate and nitrogen on growth and yield of direct-sown rice (Oryza sativa) under intermediate deep-water condition. Indian J. of Agron., 36 : 227-228.
3. Gupta A. K. and R. S. Sharma (1991) Effect of plant spacing and fertility level on grain yield of early medium indica rice (Oryza sativa). Indian J. of Agron., 36 : 223-225.
4. Mishra S. S.; S. J. Singh; A. K. Gogoi and K. K. Sinha (1991) Nitrogen use efficiency as influenced by nitrogen and weed management in rice (Oryza sativa)-Wheat (Triticum aestivum) sequence.Indian J. of Agron., 36(3) : 308-312.
5. Rajput, A. L. and A. S. Warsi (1991) Contribution of organic materials to nitrogen economy in rice (Oryza sativa) production.Indian J. of Agron., 36(3) : 455-456.
6. Singh G., O. P. Singh and R. A. Yadav (1991) Nitrogen management in transplanted rice (Oryza sativa) under rainfed lowland condition. Indian J. of Agron. 36 : 234-236.
7. Kulmi, G. S. (1992) Analysis of growth and productivity of transplanted rice (Oryza sativa) in relation to methods of weeding. Indian J. of Agron., 37(2) : 312-316.
8. Muthukrishnan, O. and S. Purushothaman (1992) Effect of irrigation, weed and biofertilizer management on weed growth and yield of 'IR50' rice (Oryza sativa). Indian J. of Agron. 37 (3) : 456-460.
9. Reddy, K. Surender and B. Bucha Reddy (1992) Effect of transplanting time, plant density and seedlings age on growth and yield of rice (Oryza sativa) Indian J. of Agron. 37(1) : 18-21.

10. Kalita, H. and K. Gogoi (1994) Effect of calcium peroxide and butachlor on growth and yield of rice (Oryza sativa).Indian J. of Agron. 39(2) : 297-299.

11. Matiwade, P. S. and M. N. Sheelavantar (1994) Influence of green-manuring of Sesbania rostrata on rice (Oryza sativa). Indian J. of Agron., 39(1) : 19-22.

12. Mohapatra, B. K.; R. K. Raj; M. P. Nayak and P. Das (1997) Adoption of packages of rice cultivation. Oryza 34(4) : 376-380.

13. Bhardwaj, A. K. and Y. Singh (1992) Nitrogen management effect on soil ammonia and nitrate-nitrogen and its uptake under submerged rice (Oryza sativa) culture. Indian J. of Agron., 37(2) : 250-254.

14. Mishra, V. K. and R. B. Sharma (1997) percolation and evapotranspiration rates of rice field as influenced by integrated nutrient management. J. of Indian Soc. of Soil Sci., 45(2):220-223.

15. Sahoo, N.; B. C. Sahoo and S. M. Mohapatra (1996) Water requirement of crops grown in Puri Canal Command. Environment and Ecology, 14(1) : 7-10.

16. Zhou, Y.; S. H. Shen and R. Sun (1993) A study of paddy rice evapotranspiration in the Nanjing area.Journal of Nanjing institute of Meteorology, 14(4) : 492-499.

17. Prasad, U. K. (1992) Effect of irrigation on nutrient balance in the rice (Oryza sativa) based crop sequence. Indian J. of Agron. 39(3) : 356-362.

18. Rajput, U. S. (2000) Water & Nutrient Management in Rice on Sandy Loam Soil Verma, B. (1999), " Improving the productivity of rice cv Pusa Basmati-1 through irrigation and fertility management", Thesis submitted to University of Roorkee in partial fulfilment of M.E. (IWM) degree.

WEATHER DATA AND DAILY REFERENCE EVAPOTRANSPII Jun-01

Date	Jub-Day	Rain fall	Evap.	T min	Tmax	Tmean	Rh max	Rh min	Rh mean	Wind-spead	U	Sun-shine	N	n/N
		mm	mm	°c	°c	°c	%	%	%	km/day(U)	m/sec	hrs (n)	hrs	
1.6.01	136	0	5.7	26	36.5	31.25	58	52.48	55.24	26.00	0.30	11.00	13.59	0.81
2.6.01	137	0	3.6	25.5	35.5	30.5	70.21	60	65.11	24.00	0.28	10.50	13.60	0.77
3.6.01	138	9	5.5	25.5	35.5	30.5	71	60	65.50	20	0.23	10	13.61	0.73
4.6.01	139	4	1.6	22	26	24	84.34	77.36	80.85	34	0.39	4.5	13.62	0.33
5.6.01	140	0	2.3	22	32	27	64.94	54.2	59.57	13	0.15	8	13.63	0.59
6.6.01	141	0	3.1	23.5	33	28.25	64.94	48.1	56.52	19	0.22	8	13.63	0.59
7.6.01	142	0	2.7	23	33	28	65	49	57.00	20	0.23	9	13.64	0.66
8.6.01	143	0	2.6	23	32	27.5	65	50	57.50	20	0.23	10	13.65	0.73
9.6.01	144	0	3.4	23	32	27.5	66	51	58.50	20	0.23	11	13.65	0.81
10.6.01	145	0	3.5	23	33	28	66	51	58.50	15	0.17	11	13.66	0.81
11.6.01	146	0	5.3	22.5	37	29.75	58.06	49.67	53.87	67	0.78	11.5	13.66	0.84
12.6.01	147	0	4.8	28	38	33	63	46.1	54.55	60	0.69	11	13.67	0.80
13.6.01	148	0	4.1	28.5	38	33.25	55.41	50	52.71	58	0.67	10	13.67	0.73
14.6.01	149	0	3	24.5	27.2	25.85	88	78.29	83.15	28	0.32	7	13.68	0.51
15.6.01	150	6	1.8	22.5	31	26.75	85	78.29	81.65	19	0.22	6	13.68	0.44
16.6.01	151	1	2.5	24.5	29	26.75	84.82	75	79.91	19	0.22	6	13.69	0.44
17.6.01	152	0	2.5	24.5	29	26.75	85	74	79.50	18	0.21	7	13.69	0.51
18.6.01	153	44.6	2.5	23	35	29	67.96	55	61.48	30	0.35	2.5	13.69	0.18
19.6.01	154	21	2.9	22	34	28	76.18	68.73	72.46	12	0.14	7	13.70	0.51
20.6.01	155	0	3.6	25.5	35.5	30.5	60.94	50	55.47	24	0.28	8	13.70	0.58
21.6.01	156	0	3.8	26.5	36	31.25	63.89	50	56.95	43	0.50	7	13.70	0.51
22.6.01	157	14.6	4.8	22.5	35.5	29	72.87	59.16	66.02	35	0.41	7.5	13.70	0.55
23.6.01	158	3.6	2.4	25.5	27.5	26.5	78.7	65	71.85	30	0.35	7.25	13.71	0.53
24.6.01	159	0	2	24	30	27	75	60	67.50	20	0.23	7	13.71	0.51
25.6.01	160	8	2.3	23	31	27	74	63	68.50	19	0.22	8	13.71	0.58
26.6.01	161	1.8	1.1	22.5	31.5	27	75.77	73.2	74.49	7	0.08	8.25	13.71	0.60
27.6.01	162	8	3	25	35.5	30.25	62.16	52.77	57.47	22	0.25	12.5	13.71	0.91
28.6.01	163	0	4.6	25.5	35	30.25	68.36	63.89	66.13	20	0.23	12.5	13.71	0.91
29.6.01	164	0	2.2	28	35	31.5	76.17	73	74.59	53	0.61	5	13.71	0.36
30.6.01	165	0	1.7	28	35	31.5	76.9	73	74.95	41	0.47	4	13.71	0.29

JUN. 2001.

ea	ed	ea-ed	Ra	Rs	f(T)	f(ed)	f(n/N)	Rnl	Rn	f(U)	w	(1-w)	c	Eto
mbar	mbar	mbar	mm/day	mm/day										
45.72	25.26	20.46	16.10	10.54	17.25	0.12	0.83	1.70	6.20	0.34	0.79	0.21	1.04	6.64
43.63	28.41	15.22	16.11	10.25	17.10	0.11	0.79	1.43	6.25	0.33	0.78	0.22	1.07	6.43
43.63	28.58	15.05	16.13	9.96	17.10	0.10	0.76	1.36	6.10	0.32	0.78	0.22	1.07	6.25
29.08	23.51	5.57	16.14	6.70	15.80	0.13	0.40	0.80	4.23	0.36	0.71	0.29	1.04	3.72
35.07	20.89	14.18	16.16	8.78	16.40	0.14	0.63	1.43	5.15	0.31	0.74	0.26	1.04	5.12
37.91	21.43	16.49	16.17	8.79	16.65	0.14	0.63	1.43	5.16	0.32	0.76	0.24	1.03	5.36
37.33	21.28	16.05	16.18	9.38	16.60	0.14	0.69	1.58	5.46	0.32	0.75	0.25	1.04	5.63
36.18	20.80	15.38	16.19	9.98	16.50	0.14	0.76	1.75	5.74	0.32	0.75	0.25	1.05	5.85
36.18	21.17	15.02	16.20	10.58	16.50	0.14	0.83	1.87	6.06	0.32	0.75	0.25	1.07	6.15
37.33	21.84	15.49	16.21	10.58	16.60	0.13	0.82	1.84	6.10	0.31	0.75	0.25	1.07	6.19
41.63	22.43	19.21	16.22	10.88	16.95	0.13	0.86	1.91	6.25	0.45	0.77	0.23	1.03	6.99
51.00	27.82	23.18	16.23	10.59	17.60	0.11	0.82	1.57	6.37	0.43	0.81	0.19	1.04	7.35
51.80	27.30	24.50	16.23	9.99	17.65	0.11	0.76	1.47	6.02	0.43	0.81	0.19	1.01	6.92
32.64	27.14	5.50	16.24	8.22	16.17	0.11	0.56	1.00	5.16	0.35	0.73	0.27	1.08	4.61
34.53	28.19	6.34	16.25	7.62	16.35	0.11	0.49	0.86	4.86	0.32	0.74	0.26	1.06	4.39
34.53	27.59	6.94	16.25	7.63	16.35	0.11	0.49	0.88	4.84	0.32	0.74	0.26	1.06	4.42
34.53	27.45	7.08	16.26	8.22	16.35	0.11	0.56	1.00	5.16	0.32	0.74	0.26	1.08	4.74
39.73	24.43	15.30	16.26	5.55	16.80	0.12	0.26	0.54	3.62	0.35	0.76	0.24	0.97	3.92
37.33	27.05	10.28	16.26	8.22	16.60	0.11	0.56	1.03	5.13	0.30	0.75	0.25	1.06	4.89
43.63	24.20	19.43	16.26	8.82	17.10	0.12	0.63	1.32	5.29	0.33	0.78	0.22	1.02	5.66
45.72	26.04	19.68	16.27	8.22	17.25	0.12	0.56	1.12	5.05	0.39	0.79	0.21	1.01	5.62
39.73	26.23	13.50	16.27	8.52	16.80	0.11	0.59	1.14	5.25	0.36	0.76	0.24	1.04	5.38
33.99	24.42	9.57	16.27	8.37	16.30	0.12	0.58	1.15	5.13	0.35	0.74	0.26	1.06	4.92
35.07	23.67	11.40	16.27	8.22	16.40	0.13	0.56	1.16	5.01	0.32	0.74	0.26	1.05	4.89
35.07	24.02	11.05	16.27	8.81	16.40	0.12	0.63	1.27	5.33	0.32	0.74	0.26	1.06	5.15
35.07	26.12	8.95	16.26	8.96	16.40	0.12	0.64	1.21	5.51	0.29	0.74	0.26	1.07	5.09
42.95	24.68	18.27	16.26	11.48	17.05	0.12	0.92	1.91	6.70	0.33	0.78	0.22	1.07	7.04
42.95	28.40	14.55	16.26	11.47	17.05	0.11	0.92	1.66	6.95	0.32	0.78	0.22	1.09	7.05
46.44	34.64	11.80	16.25	7.03	17.30	0.08	0.43	0.60	4.67	0.41	0.79	0.21	1.01	4.77
46.44	34.81	11.63	16.25	6.43	17.30	0.08	0.36	0.50	4.32	0.38	0.79	0.21	1.01	4.38

WEATHER DATA AND DAILY REFERENCE EVAPOTRANSPIRATION FOR THE MONTH Jul-01

Date	Jub-Day	Rain fall	Evaporation	T min	Tmax	Tmean	Rh max	Rh min	Rh mean	Wind-spead	U	Sun-shine	N	n/N
		mm	mm	°c	°c	°c	%	%	%	km/day(U)	m/sec	hrs (n)	hrs	
1.7.01	166	0	2	27.5	33	30.25	70.8	60.4	65.60	25.00	0.29	9.00	13.71	0.66
2.7.01	167	0	3	25.5	33	29.25	73.73	73.73	73.73	42.00	0.49	9.00	13.71	0.66
3.7.01	168	0	2.5	27.5	34	30.75	68	63.53	65.77	30.00	0.35	10.00	13.71	0.73
4.7.01	169	0	4.1	27.5	35	31.25	69	63	66.00	30.00	0.35	10.00	13.71	0.73
5.7.01	170	0	4.1	27.5	35	31.25	70	64	67.00	20.00	0.23	11.00	13.70	0.80
6.7.01	171	0	2.8	25.5	32	28.75	79.72	68	73.86	25.00	0.29	12.00	13.70	0.88
7.7.01	172	0	2.4	26.5	28	27.25	85.43	71	78.22	20.00	0.23	11.00	13.70	0.80
8.7.01	173	0	2.8	26.5	28	27.25	85	71	78.00	20.00	0.23	11.00	13.70	0.80
9.7.01	174	0	3.1	26.5	30	28.25	84	70	77.00	20.00	0.23	11.00	13.69	0.80
10.7.01	175	0	2.2	34	24	29	66.1	64	65.05	134.00	1.55	4.00	13.69	0.29
11.7.01	176	3	2.1	32	26	29	71	60	65.50	59.00	0.68	10.00	13.69	0.73
12.7.01	177	0	3.5	27.5	34	30.75	57.25	50	53.63	49.00	0.57	10.00	13.68	0.73
13.7.01	178	0	3.7	35	27	31	68	60	64.00	41.00	0.47	12.25	13.68	0.90
14.7.01	179	0	2.9	26	30	28	79.5	70	74.75	39.00	0.45	9.00	13.68	0.66
15.7.01	180	0	1	26	30	28	80	70	75.00	25.00	0.29	10.00	13.67	0.73
16.7.01	181	130.4	0.4	24	28	26	88.83	88.4	88.62	17.00	0.20	0.00	13.67	0.00
17.7.01	182	4	3.8	24	31	27.5	92.41	79.48	85.95	23.00	0.27	7.50	13.66	0.55
18.7.01	183	0	3	24.5	31	27.75	67.59	66.95	67.27	23.00	0.27	7.50	13.65	0.55
19.7.01	184	0	1.5	26.5	29	27.75	85.44	68.73	77.09	56.00	0.65	8.00	13.65	0.59
20.7.01	185	2	2.9	26	29	27.5	82	77.9	79.95	75.00	0.87	3.00	13.64	0.22
21.7.01	186	28.2	0.7	24	27	25.5	92.5	85.6	89.05	26.00	0.30	2.00	13.64	0.15
22.7.01	187	0	1.7	25	28	26.5	85.6	85.4	85.50	8.00	0.09	0.00	13.63	0.00
23.7.01	188	8	0.5	26	30	28	79.5	63	71.25	17.00	0.20	11.00	13.62	0.81
24.7.01	189	0	1.5	27.5	33	30.25	70.8	60.4	65.60	29.00	0.34	9.00	13.61	0.66
25.7.01	190	26	2	25	33	29	89.2	68.35	78.78	10.00	0.12	3.00	13.61	0.22
26.7.01	191	1	2.9	25.5	32	28.75	85.6	79.95	82.78	19.00	0.22	4.00	13.60	0.29
27.7.01	192	21.4	1.6	26.5	31	28.75	85.6	73.5	79.55	8.00	0.09	4.00	13.59	0.29
28.7.01	193	22.2	2.5	25	29	27	92.4	85.1	88.75	17.00	0.20	2.00	13.58	0.15
29.7.01	194	0	2.2	25	34	29.5	79.5	63	71.25	9.00	0.10	7.50	13.57	0.55
30.7.01	195	0	3.8	27	34.5	30.75	66.8	66.27	66.54	15.00	0.17	7.00	13.56	0.52
31.7.01	196	0	3.4	27.5	34	30.75	68.48	43.83	56.16	14.00	0.16	7.00	13.56	0.52

JULY – 2001

ea	ed	ea-ed	Ra	Rs	f(T)	f(ed)	f(n/N)	Rnl	Rn	f(U)	w	(1-w)	c	Eto
mbar	mbar	mbar	mm/day	mm/day										
42.95	28.18	14.78	16.24	9.39	17.05	0.11	0.69	1.25	5.79	0.34	0.78	0.22	1.06	5.93
40.36	29.75	10.60	16.24	9.39	16.85	0.10	0.69	1.16	5.88	0.38	0.77	0.23	1.06	5.76
44.32	29.14	15.17	16.23	9.98	17.15	0.10	0.76	1.33	6.15	0.35	0.78	0.22	1.06	6.32
45.72	30.18	15.54	16.22	9.97	17.25	0.10	0.76	1.28	6.20	0.35	0.79	0.21	1.06	6.40
45.72	30.63	15.09	16.21	10.56	17.25	0.10	0.82	1.37	6.55	0.32	0.79	0.21	1.08	6.69
39.12	28.89	10.23	16.20	11.15	16.75	0.10	0.89	1.54	6.82	0.34	0.76	0.24	1.11	6.70
35.62	27.86	7.76	16.19	10.55	16.45	0.11	0.82	1.46	6.45	0.32	0.74	0.26	1.12	6.11
35.62	27.78	7.84	16.18	10.54	16.45	0.11	0.82	1.46	6.44	0.32	0.74	0.26	1.12	6.10
37.91	29.19	8.72	16.17	10.54	16.65	0.10	0.82	1.40	6.50	0.32	0.76	0.24	1.12	6.26
39.73	25.85	13.89	16.16	6.40	16.80	0.12	0.36	0.71	4.09	0.63	0.76	0.24	0.93	4.83
39.73	26.02	13.71	16.15	9.94	16.80	0.12	0.76	1.47	5.98	0.43	0.76	0.24	1.05	6.25
44.32	23.76	20.55	16.13	9.93	17.15	0.13	0.76	1.63	5.82	0.40	0.78	0.22	1.02	6.46
45.01	28.81	16.20	16.12	11.25	17.20	0.10	0.91	1.62	6.82	0.38	0.79	0.21	1.08	7.19
37.33	27.90	9.43	16.11	9.33	16.60	0.11	0.69	1.24	5.76	0.38	0.75	0.25	1.07	5.58
37.33	28.00	9.33	16.09	9.91	16.60	0.11	0.76	1.35	6.08	0.34	0.75	0.25	1.09	5.85
32.95	29.20	3.75	16.07	4.02	16.20	0.10	0.10	0.17	2.85	0.32	0.73	0.27	1.01	2.42
36.18	31.10	5.09	16.06	8.42	16.50	0.09	0.59	0.93	5.39	0.33	0.75	0.25	1.10	4.89
36.75	24.72	12.03	16.04	8.42	16.55	0.12	0.59	1.19	5.12	0.33	0.75	0.25	1.03	4.99
36.75	28.33	8.42	16.02	8.70	16.55	0.11	0.63	1.10	5.43	0.42	0.75	0.25	1.07	5.29
36.18	28.93	7.25	16.00	5.76	16.50	0.10	0.30	0.51	3.81	0.47	0.75	0.25	0.99	3.68
31.94	28.44	3.50	15.98	5.17	16.10	0.11	0.23	0.39	3.48	0.34	0.73	0.27	1.03	2.95
33.99	29.06	4.93	15.96	3.99	16.30	0.10	0.10	0.17	2.83	0.29	0.74	0.26	1.00	2.47
37.33	26.60	10.73	15.94	10.42	16.60	0.11	0.83	1.55	6.27	0.32	0.75	0.25	1.10	6.13
42.95	28.18	14.78	15.92	9.24	17.05	0.11	0.69	1.26	5.67	0.35	0.78	0.22	1.05	5.84
39.73	31.30	8.43	15.90	5.73	16.80	0.09	0.30	0.47	3.83	0.30	0.76	0.24	1.04	3.67
39.12	32.38	6.74	15.88	6.30	16.75	0.09	0.36	0.55	4.18	0.32	0.76	0.24	1.04	3.85
39.12	31.12	8.00	15.85	6.30	16.75	0.09	0.36	0.58	4.14	0.29	0.76	0.24	1.05	3.89
35.07	31.12	3.95	15.83	5.12	16.40	0.09	0.23	0.36	3.48	0.32	0.74	0.26	1.04	3.02
40.99	29.21	11.78	15.81	8.32	16.90	0.10	0.60	1.03	5.21	0.29	0.77	0.23	1.07	5.13
44.32	29.49	14.83	15.78	8.02	17.15	0.10	0.56	0.98	5.03	0.31	0.78	0.22	1.02	5.06
44.32	24.89	19.43	15.75	8.01	17.15	0.12	0.56	1.17	4.84	0.31	0.78	0.22	1.03	5.24

WEATHER DATA AND DAILY REFERENCE EVAPOTRANSPIRATION FOR THE MONTH–Aug.2001

Date	Jub-Day	Rain fall	Evap	T min	Tmax	Tmean	Rh max	Rh min	Rh mean	Wind-spead	U	Sun-shine	N	n/N
		mm	mm	° c	∝	∝	%	%	%	km/day(U)	m/sec	hrs (n)	hrs	
1.8.01	197.00	-	2.20	26.00	34.00	30.00	79.10	68.73	73.92	25.00	0.29	10.00	13.55	0.74
2.8.01	198.00	-	4.10	25.50	35.00	30.25	73.62	63.53	68.58	32.00	0.37	11.50	13.54	0.85
3.8.01	199.00	-	2.00	26.50	34.00	30.25	67.23	66.10	66.67	45.00	0.52	9.00	13.53	0.67
4.8.01	200.00	-	2.90	26.50	30.00	28.25	81.70	75.80	78.75	15.00	0.17	9.50	13.52	0.70
5.8.01	201.00	-	3.80	26.00	34.50	30.25	79.72	58.36	69.04	20.00	0.23	11.00	13.50	0.81
6.8.01	202.00	-	4.00	26.50	35.00	30.75	60.00	58.80	59.40	37.00	0.43	11.50	13.49	0.85
7.8.01	203.00	-	3.00	27.50	31.00	29.25	79.48	65.07	72.28	33.00	0.38	11.50	13.48	0.85
8.8.01	204.00	-	2.90	27.00	34.00	30.50	70.21	60.34	65.28	59.00	0.68	11.75	13.47	0.87
9.8.01	205.00	-	5.00	25.50	34.50	30.00	67.60	58.36	62.98	48.00	0.56	12.00	13.46	0.89
10.8.01	206.00	-	3.30	27.00	35.00	31.00	70.21	58.36	64.29	36.00	0.42	11.75	13.45	0.87
11.8.01	207.00	38.60	5.60	27.00	35.00	31.00	69.17	58.36	63.77	36.00	0.42	11.50	13.43	0.86
12.8.01	208.00	52.00	0.90	24.00	27.00	25.50	92.41	85.43	88.92	12.00	0.14	1.50	13.42	0.11
13.8.01	209.00	29.40	0.50	24.00	27.00	25.50	92.30	80.94	86.62	32.00	0.37	-	13.41	-
14.8.01	210.00	16.20	0.90	23.50	27.00	25.25	92.41	92.27	92.34	15.00	0.17	-	13.40	-
15.8.01	211.00	-	1.70	25.00	34.00	29.50	79.10	63.53	71.32	10.00	0.12	11.50	13.38	0.86
16.8.01	212.00	16.00	4.50	24.00	34.00	29.00	73.73	66.80	70.27	18.00	0.21	11.00	13.37	0.82
17.8.01	213.00	-	3.00	25.50	34.00	29.75	76.46	68.73	72.60	12.00	0.14	7.00	13.35	0.52
18.8.01	214.00	-	2.80	27.00	34.00	30.50	85.78	57.75	71.77	27.00	0.31	9.00	13.34	0.67
19.8.01	215.00	-	2.00	26.50	34.50	30.50	70.00	60.94	65.47	11.00	0.13	9.50	13.33	0.71
20.8.01	216.00	-	4.10	26.50	35.00	30.75	70.54	53.20	61.87	19.00	0.22	11.00	13.31	0.83
21.8.01	217.00	-	2.50	27.00	33.00	30.00	73.73	68.00	70.87	14.00	0.16	6.00	13.30	0.45
22.8.01	218.00	3.80	1.00	27.00	29.50	28.25	85.78	85.45	85.62	29.00	0.34	3.00	13.28	0.23
23.8.01	219.00	0.80	2.20	25.00	33.50	29.25	73.41	71.21	72.31	14.00	0.16	6.00	13.26	0.45
24.8.01	220.00	-	2.70	25.50	33.50	29.50	85.44	68.86	77.15	12.00	0.14	10.00	13.25	0.75
25.8.01	221.00	-	2.40	24.50	34.00	29.25	72.67	71.23	71.95	17.00	0.20	10.00	13.23	0.76
26.8.01	222.00	-	4.00	26.50	34.00	30.25	86.34	68.73	77.54	32.00	0.37	11.50	13.22	0.87
27.8.01	223.00	-	3.60	26.50	35.00	30.75	65.70	60.94	63.32	25.00	0.29	9.50	13.20	0.72
28.8.01	224.00	-	2.90	27.00	35.00	31.00	72.67	63.20	67.94	23.00	0.27	9.00	13.18	0.68
29.8.01	225.00	-	3.40	26.50	34.50	30.50	64.26	63.20	63.73	26.00	0.30	10.00	13.16	0.76
30.8.01	226.00	-	2.90	25.50	34.50	30.00	69.26	63.53	66.40	17.00	0.20	9.50	13.15	0.72
31.8.01	227.00	-	3.20	26.00	35.00	30.50	79.10	69.20	74.15	14.00	0.16	10.00	13.13	0.76

Aug. 2001.

ea	ed	ea-ed	Ra	Rs	f(T)	f(ed)	f(n/N)	Rnl	Rn	f(U)	w	(1-w)	c	Eto
mbar	mbar	mbar	mm/day	mm/day										
42.29	31.26	11.03	15.73	9.74	17.00	0.09	0.76	1.22	6.08	0.34	0.78	0.22	1.09	6.03
42.95	29.46	13.50	15.70	10.59	17.05	0.10	0.86	1.49	6.45	0.36	0.78	0.22	1.08	6.60
42.95	28.64	14.32	15.67	9.13	17.05	0.10	0.70	1.25	5.60	0.39	0.78	0.22	1.03	5.78
37.91	29.86	8.06	15.64	9.41	16.65	0.10	0.73	1.21	5.84	0.31	0.76	0.24	1.09	5.49
42.95	29.66	13.30	15.62	10.26	17.05	0.10	0.83	1.43	6.27	0.32	0.78	0.22	1.10	6.42
44.32	26.32	17.99	15.59	10.54	17.15	0.11	0.87	1.70	6.20	0.37	0.78	0.22	1.04	6.57
40.36	29.17	11.19	15.55	10.52	16.85	0.10	0.87	1.50	6.40	0.36	0.77	0.23	1.10	6.41
43.63	28.48	15.15	15.52	10.65	17.10	0.11	0.89	1.59	6.40	0.43	0.78	0.22	1.06	6.81
42.29	26.63	15.66	15.49	10.78	17.00	0.11	0.90	1.73	6.35	0.40	0.78	0.22	1.06	6.73
45.01	28.94	16.08	15.46	10.62	17.20	0.10	0.89	1.58	6.39	0.37	0.79	0.21	1.07	6.74
45.01	28.70	16.31	15.43	10.46	17.20	0.10	0.87	1.56	6.28	0.37	0.79	0.21	1.07	6.64
31.94	28.40	3.54	15.39	4.71	16.10	0.11	0.20	0.34	3.19	0.30	0.73	0.27	1.03	2.69
31.94	27.66	4.27	15.36	3.84	16.10	0.11	0.10	0.17	2.71	0.36	0.73	0.27	1.01	2.39
31.44	29.03	2.41	15.32	3.83	16.05	0.10	0.10	0.17	2.71	0.31	0.72	0.28	1.01	2.20
40.99	29.23	11.76	15.29	10.39	16.90	0.10	0.87	1.51	6.29	0.30	0.77	0.23	1.11	6.24
39.73	27.92	11.81	15.25	10.09	16.80	0.11	0.84	1.52	6.05	0.32	0.76	0.24	1.08	5.96
41.63	30.22	11.41	15.22	7.79	16.95	0.10	0.57	0.95	4.89	0.30	0.77	0.23	1.05	4.79
43.63	31.31	12.32	15.18	8.92	17.10	0.09	0.71	1.13	5.55	0.34	0.78	0.22	1.09	5.72
43.63	28.56	15.07	15.14	9.18	17.10	0.10	0.74	1.33	5.56	0.30	0.78	0.22	1.06	5.64
44.32	27.42	16.90	15.10	10.02	17.15	0.11	0.84	1.59	5.93	0.32	0.78	0.22	1.07	6.23
42.29	29.97	12.32	15.06	7.16	17.00	0.10	0.51	0.85	4.52	0.31	0.78	0.22	1.03	4.48
37.91	32.46	5.45	15.02	5.45	16.65	0.09	0.30	0.45	3.64	0.35	0.76	0.24	1.02	3.28
40.36	29.18	11.17	14.98	7.13	16.85	0.10	0.51	0.87	4.48	0.31	0.77	0.23	1.03	4.35
40.99	31.62	9.37	14.94	9.38	16.90	0.09	0.78	1.22	5.81	0.30	0.77	0.23	1.10	5.65
40.36	29.04	11.32	14.90	9.36	16.85	0.10	0.78	1.35	5.66	0.32	0.77	0.23	1.07	5.52
42.95	33.30	9.65	14.86	10.18	17.05	0.09	0.88	1.30	6.34	0.36	0.78	0.22	1.11	6.32
44.32	28.06	16.26	14.82	9.04	17.15	0.11	0.75	1.37	5.41	0.34	0.78	0.22	1.04	5.62
45.01	30.58	14.43	14.77	8.74	17.20	0.10	0.71	1.19	5.36	0.33	0.79	0.21	1.05	5.51
43.63	27.81	15.82	14.73	9.28	17.10	0.11	0.78	1.45	5.51	0.34	0.78	0.22	1.04	5.68
42.29	28.08	14.21	14.68	8.98	17.00	0.11	0.75	1.36	5.37	0.32	0.78	0.22	1.05	5.42
43.63	32.35	11.28	14.64	9.23	17.10	0.09	0.79	1.21	5.72	0.31	0.78	0.22	1.08	5.66

WEATHER DATA AND DAILY REFERENCE EVAPOTRANSPIRATION FC SEP-01

Date	Jub-Day	Rain fall	Evap	T min	Tmax	Tmean	Rh max	Rh min	Rh mean	Wind-spead	U	Sun-shine	N	n/N
		mm	mm	°c	°c	°c	%	%	%	km/day(U)	m/sec	hrs (n)	hrs	
1.9.01	228	0	2.9	25	34	29.5	63.53	62.18	62.86	18.00	0.21	11.00	13.11	0.84
2.9.01	229	0	3.1	24.5	34.5	29.5	73.62	63.53	68.58	29.00	0.34	10.00	13.09	0.76
3.9.01	230	0	2.8	25	34.5	29.75	82	60.94	71.47	21.00	0.24	9.00	13.07	0.69
4.9.01	231	0	2	25	31.5	28.25	72.87	66.86	69.87	15.00	0.17	4.00	13.06	0.31
5.9.01	232	0	3.1	26	35	30.5	79.95	63.53	71.74	23.00	0.27	8.00	13.04	0.61
6.9.01	233	0	3.2	22.5	34	28.25	66.86	52.48	59.67	18.00	0.21	8.50	13.02	0.65
7.9.01	234	0	3.3	24	34.5	29.25	69.7	52.48	61.09	16.00	0.19	11.00	13.00	0.85
8.9.01	235	0	3.6	25	35	30	72.87	55.12	64.00	18.00	0.21	11.00	12.98	0.85
9.9.01	236	0	3.2	25	34	29.5	70.54	52.48	61.51	29.00	0.34	11.00	12.96	0.85
10.9.01	237	0	3	24	35	29.5	67.23	53.2	60.22	26.00	0.30	11.00	12.94	0.85
11.9.01	238	0	3.3	24	34.5	29.25	64.26	55.12	59.69	20.00	0.23	10.00	12.92	0.77
12.9.01	239	0	2.6	24	33.5	28.75	72.87	68	70.44	28.00	0.32	9.00	12.89	0.70
13.9.01	240	0	2.5	23.5	34	28.75	66.27	60.34	63.31	33.00	0.38	8.00	12.87	0.62
14.9.01	241	0	2.7	24.5	32.5	28.5	72.87	62.18	67.53	26.00	0.30	5.00	12.85	0.39
15.9.01	242	0	3.8	20.5	32	26.25	71.42	61.7	66.56	22.00	0.25	10.00	12.83	0.78
16.9.01	243	0	2.9	21.5	32.5	27	71.95	61.95	66.95	23.00	0.27	10.00	12.81	0.78
17.9.01	244	0	3.7	20.5	33	26.75	65.6	56.82	61.21	25.00	0.29	9.45	12.79	0.74
18.9.01	245	0	2.9	23	34	28.5	66.86	52.85	59.86	17.00	0.20	10.00	12.76	0.78
19.9.01	246	0	3.3	22.5	34.5	28.5	66.27	52.48	59.38	16.00	0.19	10.00	12.74	0.78
20.9.01	247	0	3	21.5	34.5	28	68.78	52.85	60.82	17.00	0.20	10.25	12.72	0.81
21.9.01	248	0	3.1	21.5	34	27.75	60.85	52.48	56.67	15.00	0.17	10.00	12.69	0.79
22.9.01	249	0	3.2	21.5	34	27.75	66.27	52.48	59.38	15.00	0.17	10.50	12.67	0.83
23.9.01	250	0	3	22	34	28	66.27	52.48	59.38	30.00	0.35	10.50	12.65	0.83
24.9.01	251	0	3.3	22.5	34.5	28.5	66.27	51.3	58.79	23.00	0.27	10.25	12.62	0.81
25.9.01	252	0	3.2	23	34.5	28.75	63.18	50.79	56.99	30.00	0.35	10.50	12.60	0.83
26.9.01	253	0	3	21.5	34	27.75	63.18	51.3	57.24	26.00	0.30	10.50	12.58	0.83
27.9.01	254	0	2.7	21.5	34	27.75	63.18	53.2	58.19	23.00	0.27	10.50	12.55	0.84
28.9.01	255	0	3.4	21.5	34.5	28	66.27	50.79	58.53	27.00	0.31	10.50	12.53	0.84
29.9.01	256	0	2.9	23.5	34	28.75	66.86	52.85	59.86	40.00	0.46	10.00	12.50	0.80
30.9.01	257	0	3	23.5	34	28.75	61.7	53.2	57.45	12.00	0.14	10.00	12.47	0.80

Sept. 2001.

ea	ed	ea-ed	Ra	Rs	f(T)	f(ed)	f(n/N)	Rnl	Rn	f(U)	w	(1-w)	c	Eto
mbar	mbar	mbar	mm/day	mm/day										
40.99	25.76	15.23	14.59	9.77	16.90	0.12	0.86	1.69	5.64	0.32	0.77	0.23	1.05	5.72
40.99	28.11	12.88	14.55	9.19	16.90	0.11	0.79	1.42	5.47	0.35	0.77	0.23	1.06	5.55
41.63	29.76	11.88	14.50	8.62	16.95	0.10	0.72	1.22	5.24	0.33	0.77	0.23	1.07	5.30
37.91	26.49	11.43	14.45	5.83	16.65	0.11	0.38	0.71	3.66	0.31	0.76	0.24	1.00	3.63
43.63	31.30	12.33	14.40	8.02	17.10	0.09	0.65	1.05	4.97	0.33	0.78	0.22	1.06	5.05
37.91	22.62	15.29	14.36	8.28	16.65	0.13	0.69	1.50	4.71	0.32	0.76	0.24	1.03	4.88
40.36	24.65	15.70	14.31	9.63	16.85	0.12	0.86	1.76	5.46	0.31	0.77	0.23	1.06	5.67
42.29	27.06	15.23	14.26	9.61	17.00	0.11	0.86	1.63	5.58	0.32	0.78	0.22	1.07	5.79
40.99	25.21	15.78	14.21	9.58	16.90	0.12	0.86	1.74	5.45	0.35	0.77	0.23	1.06	5.77
40.99	24.68	16.31	14.16	9.56	16.90	0.12	0.87	1.78	5.39	0.34	0.77	0.23	1.05	5.70
40.36	24.09	16.27	14.10	8.99	16.85	0.12	0.80	1.67	5.07	0.32	0.77	0.23	1.03	5.29
39.12	27.55	11.56	14.05	8.42	16.75	0.11	0.73	1.33	4.98	0.35	0.76	0.24	1.04	4.95
39.12	24.76	14.35	14.00	7.85	16.75	0.12	0.66	1.34	4.55	0.36	0.76	0.24	1.01	4.75
38.51	26.00	12.51	13.95	6.20	16.70	0.12	0.45	0.87	3.78	0.34	0.76	0.24	1.00	3.90
33.47	22.28	11.19	13.89	8.89	16.25	0.13	0.80	1.72	4.94	0.33	0.73	0.27	1.05	4.84
35.07	23.48	11.59	13.84	8.86	16.40	0.13	0.80	1.67	4.98	0.33	0.74	0.26	1.05	4.92
34.53	21.13	13.39	13.78	8.54	16.35	0.14	0.77	1.72	4.68	0.34	0.74	0.26	1.03	4.76
38.51	23.05	15.46	13.73	8.81	16.70	0.13	0.81	1.73	4.88	0.32	0.76	0.24	1.04	5.07
38.51	22.87	15.65	13.67	8.78	16.70	0.13	0.81	1.75	4.84	0.31	0.76	0.24	1.04	5.04
37.33	22.70	14.63	13.61	8.89	16.60	0.13	0.83	1.79	4.88	0.32	0.75	0.25	1.05	5.04
36.75	20.82	15.93	13.56	8.73	16.55	0.14	0.81	1.86	4.68	0.31	0.75	0.25	1.02	4.85
36.75	21.82	14.93	13.50	8.97	16.55	0.13	0.85	1.88	4.84	0.31	0.75	0.25	1.04	4.99
37.33	22.16	15.16	13.44	8.94	16.60	0.13	0.85	1.87	4.84	0.35	0.75	0.25	1.03	5.12
38.51	22.64	15.87	13.38	8.78	16.70	0.13	0.83	1.81	4.77	0.33	0.76	0.24	1.03	5.06
39.12	22.29	16.83	13.32	8.88	16.75	0.13	0.85	1.88	4.78	0.35	0.76	0.24	1.02	5.17
36.75	21.04	15.71	13.26	8.85	16.55	0.14	0.85	1.95	4.69	0.34	0.75	0.25	1.03	4.98
36.75	21.38	15.37	13.20	8.82	16.55	0.14	0.85	1.93	4.69	0.33	0.75	0.25	1.03	4.92
37.33	21.85	15.48	13.14	8.79	16.60	0.13	0.85	1.91	4.69	0.34	0.75	0.25	1.03	5.00
39.12	23.41	15.70	13.08	8.50	16.75	0.13	0.82	1.75	4.63	0.38	0.76	0.24	1.02	5.05
39.12	22.47	16.64	13.02	8.47	16.75	0.13	0.82	1.81	4.55	0.30	0.76	0.24	1.02	4.76

WEATHER DATA AND DAILY REFERENCE EVAPOTRANSPIRATION FOR T Oct-01

Date	Jub-Day	Rain fall	Evap	T min	Tmax	Tmean	Rh max	Rh min	Rh mean	Wind-spead	U	Sun-shine	N	n/N
		mm	mm	° c	°c	°c	%	%	%	km/day(U)	m/sec	hrs (n)	hrs	
1.10.01	258	2.6	0.8	23.5	32	27.75	65.7	60.85	63.28	18.00	0.21	5.00	12.45	0.40
2.10.01	259	0	0.9	23	31	27	72.2	66.86	69.53	39.00	0.45	4.00	12.42	0.32
3.10.01	260	0	2.4	23	32	27.5	78.29	64.26	71.28	19	0.22	5	12.40	0.40
4.10.01	261	0	2.2	23.5	33	28.25	73.73	66.27	70.00	22	0.25	5.5	12.37	0.44
5.10.01	262	0	2	23.5	32.5	28	85.01	80.04	82.53	14	0.16	5	12.34	0.41
6.10.01	263	0	2.1	21	32.5	26.75	80.05	78.29	79.17	16	0.19	9.5	12.32	0.77
7.10.01	264	0	2.4	21	33	27	73.74	71.95	72.85	10	0.12	10	12.29	0.81
8.10.01	265	0	2.5	21.5	34	27.75	69.07	52.48	60.78	11	0.13	9.5	12.26	0.77
9.10.01	266	0	2.6	22	33.5	27.75	69.07	52.48	60.78	13	0.15	9.25	12.23	0.76
10.10.01	267	0	2.6	22	33.5	27.75	71.43	57.75	64.59	14	0.16	9.25	12.21	0.76
11.10.01	268	0	2.6	20	33.5	26.75	74.33	62.18	68.26	18	0.21	9.25	12.18	0.76
12.10.01	269	0	2.6	18	34	26	61.76	52.48	57.12	13	0.15	9.5	12.15	0.78
13.10.01	270	0	3	20.5	33.5	27	65.07	59.26	62.17	7	0.08	9.5	12.12	0.78
14.10.01	271	0	3	18	33	25.5	66.83	62.18	64.51	10	0.12	9	12.09	0.74
15.10.01	272	0	1.8	16.5	30	23.25	56.78	46.66	51.72	10	0.12	9	12.06	0.75

oct. 2001.

ea	ed	ea-ed	Ra	Rs	f(T)	f(ed)	f(n/N)	Rnl	Rn	f(U)	w	(1-w)	c	Eto
mbar	mbar	mbar	mm/day	mm/day										
36.75	23.25	13.50	12.96	5.84	16.55	0.13	0.46	0.98	3.40	0.32	0.75	0.25	0.98	3.55
35.07	24.38	10.69	12.89	5.30	16.40	0.12	0.39	0.78	3.19	0.38	0.74	0.26	0.98	3.32
36.18	25.79	10.39	12.83	5.79	16.50	0.12	0.46	0.89	3.46	0.32	0.75	0.25	1.01	3.47
37.91	26.54	11.37	12.76	6.03	16.65	0.11	0.50	0.94	3.58	0.33	0.76	0.24	1.00	3.63
37.33	30.80	6.52	12.70	5.75	16.60	0.10	0.46	0.74	3.57	0.31	0.75	0.25	1.03	3.29
34.53	27.33	7.19	12.63	8.03	16.35	0.11	0.79	1.43	4.60	0.31	0.74	0.26	1.06	4.23
35.07	25.55	9.52	12.57	8.26	16.40	0.12	0.83	1.61	4.59	0.30	0.74	0.26	1.05	4.34
36.75	22.33	14.42	12.50	7.97	16.55	0.13	0.80	1.74	4.23	0.30	0.75	0.25	1.03	4.39
36.75	22.33	14.42	12.44	7.81	16.55	0.13	0.78	1.71	4.15	0.31	0.75	0.25	1.03	4.33
36.75	23.74	13.01	12.37	7.78	16.55	0.13	0.78	1.63	4.21	0.31	0.75	0.25	1.03	4.30
34.53	23.57	10.96	12.30	7.75	16.35	0.13	0.78	1.62	4.19	0.32	0.74	0.26	1.04	4.16
32.95	18.82	14.13	12.23	7.84	16.20	0.15	0.80	1.94	3.94	0.31	0.73	0.27	1.01	4.07
35.07	21.80	13.27	12.16	7.81	16.40	0.13	0.81	1.78	4.08	0.29	0.74	0.26	1.02	4.10
31.94	20.60	11.34	12.09	7.52	16.10	0.14	0.77	1.74	3.90	0.30	0.73	0.27	1.02	3.82
27.75	14.35	13.40	12.02	7.49	15.65	0.17	0.77	2.09	3.53	0.30	0.70	0.30	0.99	3.63

Anova Table

Plant Populatin 20 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab
Irrigation x Nitrogen	2.00	1.94	0.72	0.15	
Error	12.00	58.66	4.88		
Total					

Tiller 20 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	10.11	5.05	3.34	3.88	6.95
Nitrogen	1.00	1.12	1.12	0.74	4.75	9.33
Irrigation x Nitrogen	2.00	2.33	1.16	0.77		
Error	12.00	18.16	1.52	-		
Total						

Dry Weight 20 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	0.09	0.04	0.37	3.88	6.95
Nitrogen	1.00	0.10	0.10	0.77	4.75	9.33
Irrigation x Nitrogen	2.00	0.19	0.05	0.74		
Error	12.00	1.57	0.13	-		
Total						

Plant Height 20 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	61.00	30.50	0.71	3.88	6.95
Nitrogen	1.00	9.38	9.38	0.22	4.75	9.33
Irrigation x Nitrogen	2.00	21.44	10.72	0.25		
Error	12.00	514.66	42.88	-		
Total						

Rooting Depth 20 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	6.33	3.16	1.12	3.88	6.95
Nitrogen	1.00	2.72	2.72	0.96	4.75	9.33
Irrigation x Nitrogen	2.00	1.44	0.72	0.25		
Error	12.00	34.00	2.83	-		
Total						

Anova Table

Leaf Area Index 20 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	1%
Replication						
Irrigation	2.00	0.06	0.03	0.42	3.88	6.95
Nitrogen	1.00	0.30	0.30	3.97	4.75	9.33
Irrigation x Nitrogen	2.00	0.11	0.05	0.73		
Error	12.00	0.93	0.07	-		
Total						

Leaf Length 20 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	1%
Replication						
Irrigation	2.00	3.00	1.55	0.16	3.88	6.95
Nitrogen	1.00	0.05	0.05	0.01	4.75	9.33
Irrigation x Nitrogen	2.00	1.44	0.72	0.08		
Error	12.00	114.00	9.50	-		
Total						

Number of Leaf 20 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	1%
Replication						
Irrigation	2.00	40.33	22.16	3.78	3.88	6.95
Nitrogen	1.00	37.35	37.55	7.04	4.75	9.33
Irrigation x Nitrogen	2.00	10.11	5.05	0.95		
Error	12.00	64.00	5.33	-		
Total						

Width of Leaf 20 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	1%
Replication						
Irrigation	2.00	0.00	0.00	0.00	3.88	6.95
Nitrogen	1.00	0.01	0.01	1.09	4.75	9.33
Irrigation x Nitrogen	2.00	0.01	0.01	0.70		
Error	12.00	0.15	0.01	-		
Total						

Anova Table

Plant Populatin 40 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	3.94	1.72	0.35	3.88	6.95
Nitrogen	1.00	5.35	5.55	1.14	4.75	9.33
Irrigation x Nitrogen	2.00	1.94	0.72	0.15		
Error	12.00	58.66	4.88	-		
Total						

Tiller 40 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	13.52	6.76	0.98	3.88	6.95
Nitrogen	1.00	8.68	8.68	1.26	4.75	9.33
Irrigation x Nitrogen	2.00	2.52	1.26	0.18		
Error	12.00	82.66	6.88	-		
Total						

Dry Weight 40 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	0.78	0.39	0.75	3.88	6.95
Nitrogen	1.00	26.42	26.42	50.60	4.75	9.33
Irrigation x Nitrogen	2.00	0.71	0.30	-		
Error	12.00	6.26	0.52	-		
Total						

Plant Height 40 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	12.44	6.12	0.22	3.88	6.95
Nitrogen	1.00	12.50	12.50	0.44	4.75	9.33
Irrigation x Nitrogen	2.00	12.00	6.00	0.21		
Error	12.00	346.60	28.72	-		
Total						

Rooting Depth 40 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	24.71	12.05	10.33	3.88	6.95
Nitrogen	1.00	14.12	14.12	12.19	4.75	9.33
Irrigation x Nitrogen	2.00	5.44	2.72	2.33		
Error	12.00	14.00	1.16	-		
Total						

Anova Table

Leaf Area Index 40 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	0.02	0.01	0.01	3.88	6.95
Nitrogen	1.00	0.90	0.40	0.44	4.75	9.33
Irrigation x Nitrogen	2.00	1.35	0.67	0.33		
Error	12.00	24.50	2.04	-		
Total						

Leaf Length 40 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	8.11	4.05	0.50	3.88	6.95
Nitrogen	1.00	26.86	26.88	3.34	4.75	9.33
Irrigation x Nitrogen	2.00	1.44	0.72	0.09		
Error	12.00	96.66	8.05	-		
Total						

Number of Leaf 40 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	52.63	26.34	0.14	3.88	6.95
Nitrogen	1.00	58.68	58.68	0.31	4.75	9.33
Irrigation x Nitrogen	2.00	44.36	22.18	0.12		
Error	12.00	2278.00	189.83	-		
Total						

Width of Leaf 40 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	0.003	0.001	0.60	3.88	6.95
Nitrogen	1.00	0.002	0.002	0.80	4.75	9.33
Irrigation x Nitrogen	2.00	0.001	0.001	0.20		
Error	12.00	0.030	0.002	-		
Total						

Anova Tablo

Plant Populatin 60 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	F. Tab 1%
Replication						
Irrigation	2.00	3.94	1.72	0.35	3.88	6.95
Nitrogen	1.00	5.35	5.55	1.14	4.75	9.33
Irrigation x Nitrogen	2.00	1.94	0.72	0.15		
Error	12.00	58.66	4.88	-		
Total						

Tiller 60 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	F. Tab 1%
Replication						
Irrigation	2.00	4.86	2.43	0.39	3.88	6.95
Nitrogen	1.00	7.39	7.34	1.17	4.75	9.33
Irrigation x Nitrogen	2.00	5.38	2.68	0.43		
Error	12.00	75.33	6.27	-		
Total						

Dry Weight 60 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	F. Tab 1%
Replication						
Irrigation	2.00	1.30	0.65	0.05	3.88	6.95
Nitrogen	1.00	210.86	210.80	17.50	4.75	9.33
Irrigation x Nitrogen	2.00	65.85	32.90	2.73		
Error	12.00	141.57	12.04	-		
Total						

Plant Height 60 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	F. Tab 1%
Replication						
Irrigation	2.00	61.44	30.72	6.58	3.88	6.95
Nitrogen	1.00	40.50	40.50	8.68	4.75	9.33
Irrigation x Nitrogen	2.00	0.33	0.16	0.04		
Error	12.00	56.00	4.66	-		
Total						

Rooting Depth 60 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	F. Tab 1%
Replication						
Irrigation	2.00	12.33	6.16	9.25	3.88	6.95
Nitrogen	1.00	14.72	14.22	21.33	4.75	9.33
Irrigation x Nitrogen	2.00	3.44	1.72	2.58		
Error	12.00	8.00	0.66	-		
Total						

Anova Table

Leaf Area Index 60 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	1.58	0.79	0.43	3.88	6.95
Nitrogen	1.00	3.19	3.19	1.72	4.75	9.33
Irrigation x Nitrogen	2.00	0.44	0.22	0.12		
Error	12.00	22.26	1.89	-		
Total						

Leaf Length 60 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	4.44	20.22	2.85	3.88	6.95
Nitrogen	1.00	0.88	0.88	0.13	4.75	9.33
Irrigation x Nitrogen	2.00	13.77	6.88	0.98		
Error	12.00	84.00	7.50	-		
Total						

Number of Leaf 60 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	73.36	36.93	0.28	3.88	6.95
Nitrogen	1.00	8.68	8.68	0.07	4.75	9.33
Irrigation x Nitrogen	2.00	12.02	60.51	0.46		
Error	12.00	1570.87	130.92	-		
Total						

Width of Leaf 60 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	0.010	0.005	2.29	3.88	6.95
Nitrogen	1.00	0.060	0.060	25.95	4.75	9.33
Irrigation x Nitrogen	2.00	0.008	0.004	0.80		
Error	12.00	0.820	0.002	-		
Total						

Anova Table

Plant Populatin 80 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	3.94	1.72	0.35	3.88	6.95
Nitrogen	1.00	5.35	5.55	1.14	4.75	9.33
Irrigation x Nitrogen	2.00	1.94	0.72	0.15		
Error	12.00	58.66	4.88	-		
Total						

Tiller 80 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	0.11	0.05	0.10	3.88	6.95
Nitrogen	1.00	23.34	23.34	45.10	4.75	9.33
Irrigation x Nitrogen	2.00	0.77	0.38	0.72		
Error	12.00	6.50	0.54	-		
Total						

Dry Weight 80 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	59.29	29.64	1.61	3.88	6.95
Nitrogen	1.00	371.64	371.64	20.12	4.75	9.33
Irrigation x Nitrogen	2.00	28.95	14.47	0.78		
Error	12.00	221.67	18.47	-		
Total						

Plant Height 80 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	6.33	3.16	1.97	3.88	6.95
Nitrogen	1.00	32.00	32.00	19.86	4.75	9.33
Irrigation x Nitrogen	2.00	0.33	0.16	0.10		
Error	12.00	19.33	1.61	-		
Total						

Rooting Depth 80 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	6.33	3.16	4.75	3.88	6.95
Nitrogen	1.00	10.88	10.88	16.33	4.75	9.33
Irrigation x Nitrogen	2.00	0.77	0.38	0.58		
Error	12.00	8.00	0.66	-		
Total						

Anova Tablo

Leaf Area Index 80 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	F. Tab 1%
Replication						
Irrigation	2.00	1.06	0.50	1.26	3.88	6.95
Nitrogen	1.00	7.96	7.85	19.73	4.75	9.33
Irrigation x Nitrogen	2.00	0.67	0.33	0.84		
Error	12.00	4.77	0.39	-		
Total						

Leaf Length 80 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	F. Tab 1%
Replication						
Irrigation	2.00	24.33	12.16	0.99	3.88	6.95
Nitrogen	1.00	72.00	72.00	5.86	4.75	9.33
Irrigation x Nitrogen	2.00	12.30	6.16	0.50		
Error	12.00	147.33	12.77			
Total						

Number of Leaf 80 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	F. Tab 1%
Replication						
Irrigation	2.00	8.11	4.05	0.83	3.88	6.95
Nitrogen	1.00	227.55	227.55	46.68	4.75	9.33
Irrigation x Nitrogen	2.00	18.11	9.05	1.86		
Error	12.00	58.50	4.87			
Total						

Width of Leaf 80 DAT

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	F. Tab 1%
Replication						
Irrigation	2.00	0.003	0.001	0.60	3.88	6.95
Nitrogen	1.00	0.045	0.045	16.20	4.75	9.33
Irrigation x Nitrogen	2.00	0.003	0.001	0.60		
Error	12.00	0.030	0.002			
Total						

Anova Table

GRAIN YIELD

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	1.58	0.79	0.03		
Nitrogen	1.00	382.20	382.72	12.13	3.88	6.95
Irrigation x Nitrogen	2.00	60.52	30.26	0.96	4.75	9.33
Error	12.00	378.66	31.55			
Total						

STRAW YIELD

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	25.60	12.80	0.01	3.88	6.95
Nitrogen	1.00	813.40	813.40	6.27	4.75	9.33
Irrigation x Nitrogen	2.00	119.70	59.80	0.46		
Error	12.00	1557.30	129.80	-		
Total						

EARHEAD DENSITY

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	201.00	100.50	6.26	3.88	6.95
Nitrogen	1.00	3528.00	3528.00	219.76	4.75	9.33
Irrigation x Nitrogen	2.00	674.35	337.16	21.00		
Error	12.00	192.66	16.05	-		
Total						

Filled Grains

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	340.70	170.30	0.30	3.88	6.95
Nitrogen	1.00	4140.50	4140.50	7.25	4.75	9.33
Irrigation x Nitrogen	2.00	439.00	219.50	0.38		
Error	12.00	6856.60	571.30			
Total						

Unfilled Grains

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab	
					5%	1%
Replication						
Irrigation	2.00	20.11	10.05	0.06	3.88	6.95
Nitrogen	1.00	522.72	522.72	3.34	4.75	9.33
Irrigation x Nitrogen	2.00	116.77	58.58	0.37		
Error	12.00	1876.00	156.53	-		
Total						

Anova Table

Grain Test Weight

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	1%
Replication						
Irrigation	2.00	1.30	0.65	0.53	3.88	6.95
Nitrogen	1.00	1.46	1.46	1.20	4.75	9.33
Irrigation x Nitrogen	2.00	0.49	0.23	0.19		
Error	12.00	14.72	1.22	-		
Total						

Kernel Test Weight

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	1%
Replication						
Irrigation	2.00	7.20	3.60	1.83	3.88	6.95
Nitrogen	1.00	0.60	0.60	0.31	4.75	9.33
Irrigation x Nitrogen	2.00	1.56	0.78	0.40		
Error	12.00	23.60	1.96			
Total						

Grain Length

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	1%
Replication						
Irrigation	2.00	0.01	0.00	0.14	3.88	6.95
Nitrogen	1.00	0.01	0.00	0.14	4.75	9.33
Irrigation x Nitrogen	2.00	0.05	0.02	0.50		
Error	12.00	0.71	0.05			
Total						

Grain Width

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	1%
Replication						
Irrigation	2.00	0.040	0.020	0.57	3.88	6.95
Nitrogen	1.00	0.004	0.004	0.11	4.75	9.33
Irrigation x Nitrogen	2.00	0.040	0.020	0.53		
Error	12.00	0.450	0.030			
Total						

Kernel Length

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	1%
Replication						
Irrigation	2.00	0.04	0.02	0.58	3.88	6.95
Nitrogen	1.00	0.44	0.04	1.21	4.75	9.33
Irrigation x Nitrogen	2.00	0.01	0.01	0.14		
Error	12.00	0.48	0.04			
Total						

Kernel Width

Source of Varience	d.f	Sum of square	MSS	F.Cal	F. Tab 5%	1%
Replication						
Irrigation	2.00	0.005	0.002	0.04	3.88	6.95
Nitrogen	1.00	0.002	0.002	0.03	4.75	9.33
Irrigation x Nitrogen	2.00	0.040	0.020	0.31		
Error	12.00	0.890	0.070			
Total						