RESPONSE OF UPLAND RICE TO MOISTURE REGIMES, NITROGEN LEVELS AND WEED CONTROL

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By

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THESIS ADVISOR : Dr. D. LENKA

IN MEMORY

OF

MY FATHER

RESPONSE OF UPLAND RICE TO MOISTURE REGIMES, NITROGEN LEVELS AND WEED CONTROL

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Basudev Behera

A thesis

submitted to Orissa University of Agriculture and Technology , Bhubaneswar, in partial fulfilment of the requirements for the Degree of MASTER OF SCIENCE of Agriculture (Agronomy)

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C E R T I F I C A T E

This is to certify that the thesis entitled " Response of Upland Rice to Moisture Regimes, Levels of Nitrogen and Weed Control " submitted in partial fulfilment for the award of the degree of Master of Science in Agriculture (Agronomy) of Orissa University of Agriculture & Technology, Bhubaneswar, is a record of bonafide research work carried out by Sri Basudev Behera under my supervision and guidance. No part of this thesis has been submitted for any degree or diploma. It is further certified that such help or source of information, as has been availed of during the course of investigation, has been acknowledged by him.

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B h u b a n e s w a r,

Dated the 30th June, 1985.

Basudev Behera
30.6.84
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INTRODUCTION

I N T R O D U C T I O N

Of the total rice area of 143.5 million hectares in the globe about 14 million hectares (10%) is under upland rice and South-East Asia accounts for 7%. In Orissa, about 18% of the total of 4.4 million hectares under rice is upland rice. In inland districts covering 70 % of the State upland rice is cultivated from jhumed hill tops to the hill slopes and hill bottoms including plains and as such is responsible for very low yield of rice (1126 Kg/ha) in the state as compared to that in neighbouring eastern states. Very low yields of rice in Eastern India, particularly in Orissa, remains a great concern to the scientists and special projects are in operation to increase the yield.

Though Orissa's <u>Kharif</u> season rainfall is not low (1332^{mm}) upland rice suffers from occasional dryspells of varying duration (3 to 21 days) at certain critical stages of life cycle due to erratic and uncertain monsoon, and mal distribution and succumbs to failure. Analysis of time series data for several years indicate that probability of occurence of dryspells (55 to 90 %) increases from 2nd week of September and rice varieties, particularly, medium and long duration ones suffer. To escape from the hazards of dryspells, it becomes necessary to grow short duration rice varieties to mature before mid-September (Lenka, 1978). Provision of irrigation, particularly after flowering has been found very rewarding and in drought years, response even to one irrigation after flowering has been found to be 70-80 % more than the rainfed crop. Since many years attempts are being made to divert such drought prone lands to non-rice crops and or to adopt mixed/intercropping. Success in this direction has not been very encouraging for rice is the staple food and the poor farmers to whem such highlands belong want to have some rice anyhow for their domestic use. This urges improvement in cultural practices in addition to adoption of high yielding variety to increase the yield of upland rice.

The upland soils in Orissa are red and lateritic, residual in nature, sandy to loamysand in texure, highly eroded, low in organic matter and nitrogen with pH 4.5 to 6.5. In such poor soils high nitrogen application increases drought succeptibility due to rapid vegetative growth exhausting the limited available moisture and very low dose, on the other hand, keeps the crop submarginal.

Upland rainfed rice is infested heavily by weeds and if not weeded intime, the weeds overtake the crop and the crop fails. Weed problem in rice field increases with increased fertiliser and moisture and the effieiency of these factors of crop production decreases. Loss due to weed infestation under upland condition has been estimated to be 45-48%. Cost of cultivation goes very high only due to weed control. Non-availability of labour during a very short span of 15-30 days after sowing is a great constraint for weed control too. High labour cost is the next important consideration. It is now felt essential to adopt chemical methods wholly or partly to control weeds in time and to reduce labour cost. Nevertheless, timely weed control increases moisture availability to the crop and the overall efficiency of the system.

Keeping these problems of upland rice in view, an experiment was conducted in Kharif 1984 at the Central Research Station, Bhubaneswar, with the following objectives:

1. To study the response of upland rice to irrigation particularly, after flowering and to calculate water requirement of the crop,

ii. To study the profile soil moisture variation throughout the cropping season,

iii. To find out the response of nitrogen under irrigated and rainfed conditions,

iv. To find out the optimum dose of nitrogen and to calculate the uptake of nutrients and

v. To find out a suitable weed control method.

CHAPTER—II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Upland rice is raised as direct seeded crop under rainfed conditions in highlying lands during *kharif* season. The varieties are mostly photoinsensitive with maturity duration ranging from 70-110 days. The upland is variously known in different parts of the country such as Beali, Dungar and Taila in Orissa and 'Aus' in West Bengal and Assam. The crop is also known as autumn rice, as it is ready for harvest during the period from early September to mid-October.

Environment of upland rice differs from that of medium and lowland rice in its soil moisture maintenance and consequently with the nutrient and temprature regimes. The upland rice is generally grown in a moisture regime the upper limit of which does not exceed generally the saturation (= 0) and seldom remains under standing water. The root zone is always aerated and reductive condition does not occur. The lower limit of soil moisture may reduce upto wilting point if dry spells occur and it is the relative variation of moisture in these precincts of saturation and willing points that determines the success of an upland rice crop. Since greater portion of crop life is spent in the dry regime rainfall in small quantities much below the evaporative demand of the atmosphere very freqeuntly results in failure of the crop. The situation is aggravated when the soil is poor with respect to its WHC and nutrient status. The crop suffers from deficiency of nutrients availability gives only a measure of water lost through transpiration and does not provide any account of other losses. In practice, a considerable quantity of water is lost by evaporation from the soil surface of the cropped area in addition to transpiration losses. Loss due to evaporation and transpiration combinedly represent the quantity of water used by a crop and is designated as "Evapo-transpiration". Some quantity of water, though much less in comparision to evapo-transpiration , is used for metabolic purposes, by the plant and the total quantity these three is known as the consumptive use. This does not include losses due to deep percolation, seepage and run-off. Water requirement as used by irrigation specialists includes consumptive use (Evapo-transpiration) and other economically unavoidabl losses such as seepage, deep percolation, water required for land preparation and for spacial purposes.

1. Transpiration Ratio and Evapo-transpiration from rice field:

Excessive depth of water in the field didn't influence the ratio of weight of water transpired by a rice crop to the weight of dry matter produced. Transpiration ratio remained same irrespective of degree of saturation of the soil (Grist 1959). Peak periods of transpiration were observed at near maximum tillering stage and just after heading, the second peak being greater than the first. It was considered that second transpiration peak was caused due to panicle transpiration. Transpiration rate increases with increase in LAI, but the transpiration ratio per unit leaf area decreases with increase in LAI. Daily transpiration need increases with increase in dry weight during early and middle stages of growth. Total transpiration was correlated with total drymatter production and transpiration rate at each growth stage was correlated with net assimilation rate (Sugimoto, 1975). The ratio decreases with application of manures and fertilisers since they produced larger amount of DM in proportion to quantity of water transpired, which, of course, was greater than that required by plants grown under control (no manuring) treatments(Chaudhury and Pandey, 1968)

Evapo-transpiration and transpiration values for new _indica_ varieties like Jinheung, Yushin, Milyang-23 and Suweon- 264 were 548 and 315, 611 and 399, 623.2 and 408 mm, respectively. ET was more dependent on transpiration from leaf surface than evaporation from soil surface. Maximum ET occured at the end of July and was 8.2mm/day for variety Jinbeung and 8.9 to 9.0 mm/day in other varieties(Ham,Jung, Kim, 1980). Tomar and Ol Tode (1979) made an extensive study of ET from rice crop in south and South-East Asia. Crop growth co-efficient factor (ET-EP) was approx 1.2 at flowering. According to Badchelor and Robert (1983) transpiration from panicles accounted for 2% of total canopy transpiration.

2. Water Requirement of rice

Water requirement of rice has been found to vary with the duration of the crop, the season and the prevailing weather condition, topography, the soil type and the cultural practices followed. Various workers have reported varying figures of water requirement of rice depending on various conditions prevailing at different places. Studies on water management and water requirement of upland rice are very meagre.

Water requirement of dwarf indica varieties is comparatively lower than that of tall *indicas* because of their shorter duration. The water requirement of TN-1 at Bhubaneswar was 1131 mm of which 40 mm accounted for nursery raising, 280mm for puddling and 811mm from transplanting to maturity (Lenka and Bhol, 1972). During dry season, the water requirements of TN-1 were 729,1314 and 1071 mm under saturated, submerged (6.0-7.5 cm) and alternate wetting and drying conditions, respectively (Lenka 1971).

At Chakuli water requirement of 'Bala' (104 days) in wet season was 296mm under continuous saturation and 620mm under continuous submergence (Lenka, 1976). Excluding 200 mm for nursery and puddling, water requirements for cauvery (96 days), Bala (104 days), TN-1 (113 days), Padma (108 days)

Ratna (111 days) IR-8 (135 days), Jaya (125 days) and Jagannath (152 days) were 410, 430, 450, 530 , 490, 930, 840 and 1150 mm respectively, during Kharif season. Due to high evaporative demand and low water table, the water reqüirements were higher in rabi season which were 730, 1020, 960, 900, 1160 and 1360 mm for Bala (118 days) TN-1 (138 days), Padma (119 days), Ratna (124 days), IR-8 (148 days) and Hema (146 days), respectively, (Lenka, 1976). Water requirements from transplanting to tillering tillering to flowering and flowering to ripening were 237, 300 and 293 mm for T N-1 and 245, 250 and 395 mm for IR-8, respedtively

3. Manuring and Water requirement

Manuring increases water requirement and water use efficiency. Total water requirement of rice T_{1242} (tall *indica*) increased with increasing levels of manuring which also increased the water use efficiency per unit dry matter produced (Rout, 1966). Water use efficiency in terms of Grain production per ha. mm water was also more in well fertilised plots.(Chaudhury and Pandey, 1968).

Jalha, Aziz & Mishriki (1980) found daily monthly and seasonal, ET increased with increasing irrigation and/or N rates reaching maximum value in August. The efficiency of water use not significantly affected by nitrogen doses varying from 0-100 kg/ha.

4. Critical Period of Water Requirement.

A particular crop variety requires varying quantity of water at various stages of its life-cycle. Any reduction in water supply at such growth stages adversely affects the crop growth and yield. The period when water deficiency affects crop growth is known as the critical period.

Welmarked periods of high water requirement observed in the life cycle of rice plant are (i) Pre-flowering and flowering periods covering 15 days, (ii) grain formation period covering 5-7 days (Singh et al- 1935);Lenka 1971. The water requirement just prior to flowering was 2-3 times more than the quantity required during the time 15 days before flowering or just after flowering (Narasingarao, 1951). First 20 days period of tillering and 40 days to 66 days coinciding with primordia growth and flowering were very critical for both dwarf *indica* TN-1 and tall *indica* NP 130 (Dastane et al, 1967). Reproductive phase was considered most critical stage in the life cycle of rice crop (Sahu and Rout, 1969).

Studies at IRRI (1970) revealed that moisture stress in the vegetative growth stages reduced grain yield through a reduction in tiller number and hence in panicle number per hill. Stress in reproductive and ripening period decreased the grain yield by reducing the number of filled grains and grain weight (Lenka, 1971). The most critical time for moisture stress is period immediately around panicle initiation. For improved varie--ties, the stage, duration and intensity of the stress period is more important in determining the amount of yield reduction.

5. Crop Weed Association

Much diversity is marked with regard to the distribution of weeds in rice. The major weeds in Kharif season in ppland condition in Eastern India are Cyperus rotundus, Digitaria Sanguinalis, Echinochloa Crusgalli, Commelina, bengalensis, Amaranathus spinosus, Fimbristilis tenera, Eclipta alba (Patro et al 1973; Bhagat et al 1977; Singh et al., 1977).

In upland red lateritic soils of Orissa the common weeds are Coleome viscosa, Phyllanthus niruri, Abutilon indicum, Celosia argentia, Sida rhombifolia, Xanthium Strumanium (Patro and Naik, 1973, Pillai and Rao, 1974). Workers at CRRI, Cuttack, reported Cynodon dactylon Echinochloa colonum, Fimbristilis Spp, and Phyllanthus niruri to be common weeds at CRRI, Cuttack (Manna et al 1972, Dubey, 1972).

Problematic weeds in upland soils of Western India are panicum colonum, Echinochloa crusgalli, Cyperus iria, Eclipta alba (Patel et al 1980).

Upland rice soils of Central India experiences heavy infestation by Echinochloa Colonum, Setaria glauca, Panicum spp Bracharia ramosa, Malluga Cervinia Commelina forske, Cynodon dactylon, Cyperus Spp and Corchorus Spp and Corchorus Spp (Khan, 1971, Dutta et al 1977).

The major problematic upland weeds that needed control measure in South India were perennial weeds like Cyperus rotundus, Cynodon dactylon and annual weeds such as Celosia argentia, Eleusine indica , Portulaca oleracea , Ageratum Conyzoides, Brachiaria platyphylla and Echinochloa colonum (Singh et al, 1970, Pillai et al 1976, Singlachar et al 1978) Under upland condition of Bhubaneswar, grasses and sedges formed about 80-90% of the total weed growth associated with early rice (Misra and Roy, 1971)

6. Losses caused by weeds in rice field

According to estimates made by different foreign and Indian workers, crop losses ranged from 30 to 88 % under varying degrees of weed infestation. Under Indian condition, the yield losses varies from 43% from a 3 yr trial at 13 locations (Rao & Pillai, 1974), to 36% (Nonjappa and Krishnamurty, 1978), and 69% in direct sown upland conditions (Tosh, 1977). The crop losses reported are 36% in Indonesia (Seerjani, 1969), 11% to 65% in Taiwan (Chang, 1973) and 40-85 % under Nigerian upland condition (Moody, 1975).

7. Weed Infestation and nutrient remoral

Rainfed upland rice utilises as high as 77 Kg. N, 8.6 Kg. P_2O_5 and 83.4 Kg. K20/ha when grown under weed free conditions whereas under weed infested condition the crop could remove only 30 kg N, 4.8 kg.P_2O_5 and 40.6 kg.K20/ha (Rainreddy and Hukkeri, 1980 . Associated weeds could remove nutrients in order of 93/kg N, 24.9 kg P_2O_5 and 90.5 kg K_{20}/ha. under direct sown rainfed upland condition(Pillai and Rao-1976).

Fertiliser application was only justified under weed free condition .(Henrich, 1981). He concluded this from the study of interaction of fertiliser and weed conentration on yield and nutrient uptake of rice.

8. Methods of weed control

Provision of weed free condition by timely and efficient weed control methods can bring a spectacular increase in rice yield under upland condition, particularly, in rainfed situations (Misra et al, 1970, Pacro et al 1973).

8.1. Mechanical and cultural method

Upland rice crop needed effective weeding for first 3-4 weeks after sowing(Bhan et al, 1971, Shetty et al 1974, Rao et al, 1974). Two handweedings were adequate for controlling weeds in upland situation (Ram Murthy et al 1974; Rethinam et al 1974; Pillai et al, 1976; Shridhar et al, 1976). These 2 hand weedings were to be given at 3 and 6 weeks after sowing. Three hand weedings to be taken at 10, 20, and 40 DAS were advocatedly Padmanabhan (1977). Hoeing followed by hand weedings at 15 and 30 DAS controlled weeds efficiently under upland condition in Orissa and gave higher grain yield (Singh and Khan, 1972, Patro and Tosh, 1973).

Limitations of mechanical and cultural methods of weed control

Timely weed control was absolutely necessary for effective weed management in upland condition irrespective of the method adopted for weeding and number of weedings performed (Pillai, 1976). Unworkable soil condition i.e. low moisture content of soil that did not permit quick working of holing imple--ments was a great barrier to timely and effective weeding (Manna et al 1972, Patro et al, 1972). Hoeing followed by 60 hand weeding though controlled weed efficiently, it was a costly proposition, time consuming, tedius and greatly dependent on labour free at peak period of cropping season(Mitra, 1970). Hoeing and harrowing though controlled weeds, resulted in mortality of 10-15% of rice seedlings due to severe root prunning. Heavy downpour in early cropping season made fields unworkable for timely interculture(Thakur, 1969; Tosh, 1975). Adoption of mechanical method of weed control was costly & time consuming and hence required use of alternative methods of weed control (Rao and Agrawal, 1976; Rathi and Tiwari; 1976).

8.2 Chemical method of weed control

Use of selective herebicides in upland condition showed promising results within and outside India. Phenoxy-herbicides like 2,4 -D showed their competence for efficient weed control. But they did not control monocot weed population successfully under upland conditions (Mukhopadhyaya 1962). Recently herbicides like nitrofen, Benathicocarb and propanil (Stam-F 34) could control grasses, sedges and broad leaved weeds effectively. (Patro et al., 1972).Rao et al 1976; Tosh, 1977; Ali et al., 1979). Choice herbicides at present in upland condition is limited only to Butachlor, USB 3584, Oxadiazon and Propanil.

The rate of application of propanil has been reported by many workers to be 5-6 L/ha. (Sankar 1973; Jhiagarajan, 1974); 3 to 4 kg/ha (Raghavalu et al 1973, Rethinam et al., 1974, Ray et al., 1974); 2L/ha (Kakati et al). 2 kg/ha alongwith 3% urea (Patro et al 1974 , Pillai et al,1976; Dubey et al., 1977). Application of 1.5 kg propanil a.i/ha at 2-3 leaf stage of weeds gave best control Pillai and Nair, 1978).

The selective and contact herbicide,propanil,gave good control of grasses, sedges and broad leaved weeds (Scopadya et al., 1971). Propanil applied @ 3.36 kg/ha gave good control of Panicum maximum, Cassia tora, Corchorus Spp, Cynodon dactylon, Cyperus rotundus, Eclipta alba and Sesbanna Spp.

8.3 Post emergence application of herbicide + Mechanical Weed control

Dwarf indica rice cultivars under upland conditions need weed free environment upto 40-45 days DAS because of its slow canopy development (Bhan et al., 1971, Pillai et al., 1976, Rao et al., 1977). However propanil application as post - emergence spray @ 3.0 L/ha could not control Commelina bengalensis, and Acanthospermum hispidum effectively. These weeds came in large number and posed serious competition to the crop at later stages of growth. These resistant weeds were well controlled by supplementing an interculture with hand operated weeder or one handweeding (Patro et al., 1973; Mukhopadhyaya and Sen, 1977). Post-emergence application of 2TU Propanil 15 DAS followed by hand weeding 35 DAS could control weeds efficiently and gave very good crop yield (Gurmel Singh et al., 1976, Raiwakar, 1977).

Single application of Propanil was not sufficient for controlling weeds effectively in upland (Takematsu and Konnal, 1977). Two applications of Propanil @ 1.5 kg/ha each at 15 DAS and 30 DAS could not control weeds in upland rice effectively (Ramoorthy et al., 1974). Tosh et al 1977). Propanil and Butachlor application followed by one handweeding gave grain yield similar to that obtained under weedfree condition (Dash and Singh, 1984).

9. Effect of soil moisture regime, nitrogen and weed control on growth characters

9.1 Height

Moisture below saturation had a stunting effect (Sahu and Rout, 1969). Tall indica, Japonica indica and dwarf indica were reduced by 42,39.3 and 45.8%, respectively, in and Singh, 1971). Number of tillers was found to be positively correlated with increasing rate of nitrogen application (Ramanujam and Rao,1971). Basal and additional nitrogen fertilisation at tillering increased the number of tillers/m^2(Dhyama, 1977). Nitrogen fertilisation significantly affected the number of tillers/^{2} (Chow, 1980).

Under weedfree condition, there was higher yield of rice due to profuse tillering (Scopadya 1971; Chiu, 1977). Two Applications of propanil as post-emergence spray, one at 15 DAS and another at 30 DAS could maintain a weed free condition for first 45-60 days of crop and this resulted in good initial start to induce greater and synchronous tillering (Singh *et al*., 1979). Decrease in number of tillers/m^2 by unrestricted weed growth was reported by Ghobrial (1983).

9.3 Leaf area and number

Increasing water level increased leaf area (Ghosh 1954). Submergence of 4 cm(Enyi,1963), 8.75 cm (Rath,1965) and 15 cms (Raut,1966) increased leaf area more than other water management treatments and that at field capacity.

Rate of increase in LAI was dependent on climatic elements like light, temperature and application of Nitrogen (William *et al*., 1962 and 1968, Rukridge and Ratkowsky,1971; Rishen and uilsen,1975, Dasgupta,1969). There was significant increase in leaf number with increasing levels of N upto 160 kg/ha. The same finding were obtained under Bhubaneswar condition by Tosh and Mishra (1972), Tripathy and Mishra (1973) and Sahoo and Mishra (1977). Dry matter production was proportional to increase in LAI until an optimum point was reached. Increased rate of N increased leaf area, but lowered the photosynthetic activity due to mutual shading. LAI was dependent on tillers/ unit area, number of leaves/tiller and leaf size (Singh & Pande, 1974) Stone and Steinmetz (1979) while studying the effect of N on development of LAI of rice - CV IAC 47 and CICA-4, under upland conditions found that N increased LAI due to increase in number of tillers/m^2 and size of leaves. CICA-4 had a higher LAI due to its higher tillering capacity.

Flag leaf area was also reported to increase with increase in N levels (Raju and Mishra, 1976). Similar increase in flag leaf area was noticed by Sahoo and Mishra (1977) upto 90 kg N/ha. There was a positive correlation between leafarea and yield when nitrogen rate was increased from 90 to 120 kg N/ha.

9.4 Dry matter production

Dry matter production increased consistently with lengthening the period of nitrogen nutrition (Singh et al., 1963; Tanaka et al, 1964; Murrata, 1965). There was linear increase in dry matter accumulation per unit area with increasing N levels (Khuspe and Joshi, 1971; Patil et al., 1976). Under rainfed upland condition dry matter production/m^2 increased at all stages of growth with increasing level of N from 30 to 120 kg/ha (Singh and Modgal, 1979). Dry matter production/m^2 was proportional to LAI until an optimum point. (Singh and Pande, 1974, Sahu and Murty, 1975, Koregane and Jawalkar, 1976).

Application of propanil @ 1.5 kg/ha each 15 DAS and 30 DAS not only controlled weed growth but also provided ideal conditions for development of rice crop. The propanil-treatedplots recorded 27.% increase in dry matter production as compared to untreated (controlled) plots (Ram Moorthi et al., 1974). N, and P. contents of weed population were more and weeds removed 30.4 kg N, 18.2 kg P_2O_5/ha. and markedly decreased in dry season than in wet season.

Panicle length increased only upto application of 60 kg N/ha.

Mahatim Singh (1979) reported increase in panicle length and weight of the panicles due to application of propanil @ 3 kg/ha.

10.3 <u>Total number of spikelets/panicle</u>

There was significant increase in number of grains/panicle with increasing the levels of nitrogen (Katyan Kutti <u>et al</u> 1968; Basu Ray Chaudhury 1968, Koyama <u>et al</u> ,1972; Singh <u>et al</u>., 1978). At CRRI, Cuttack, increasing trend in number of spikelets per panicle was observed upto 90 kg N/ha. (Rao and Prasad, 1973). But Koyama and Niam Srichand (1973) found that total number of spikelets/panicle increased upto 94 kg N/ha. At Bhubaneswar Sahoo and Mishra (1977) reported increase in number of grains per panicle upto 90 kg/ha. No of spikelets/panicle increased with increasing the level of N to give 4×10^4 grains/m^2.

Ghobrial (1983) reported significant increase in number of grains/panicle under good weed management.

10.4 <u>Fertile grains/Panicle</u>

Very high percentage of sterility was found under unflooded condition (Chaudhry and Mc.Lean 1963). Highest sterility was observed in plants subjected to stress during the vegetative phase followed by that during grain filling stage (Rao, 1971).

Increase in levels of N increased the fertile grains/panicle (HSU and Teng, 1974, Dasgupta et al., 1970; Eunus and Sadeque 1974, Verma 1973., Singh et al., 1977). But Kumura (1957), Hasgawa et al.,(1958), Yamangata (1950) reported increase in no of fertile grains per panicle with increasing levels of N upto certain limit. Under Bhubaneswar condition Sahoo and Mishra (1976), got increased weight of fertile grains/panicle upto 90 kg N/ha.

Application of propanil twice @ 3.5 kg/ha produced 108.1 grains/panicle whereas unweeded control gave only 92.4 grains/Panicle (Rammoorthy et al 1974, Kakati et al 1977, Mahatim Singh et al 1979). Unrestricted weed growth decreased number of filled spikelets/panicle (Ghobrial, 1983).

10.5 1000-grain weight

Significant increase in thousand x grain weight over no nitrogen (control) was reported by Tripathy & Mishra (1973). Test weight increased upto a 90 kg N/ha as reported by Rao and Prasad (1973) from CRRI, Cuttack.

On an average, application of propanil @ 2.0 kg/ha as a post-emergence spray showed increased test weight over other promising herbicidal treatments (Kakati et al 1977, Mahatim Singh et al 1979). On the contrary, Rammoorthi et al (1974) did not find significant increase in weight of 1000-grains due to herbicidal treatment in upland rice over no herbicidal treatments.

11.1 Grain yield

Increasing the stress period during the vegetative phase and/or the reproductive phase decreased the grain yield (IRRI, 1969). The duration of the time the plant was subjected to moisture stress was more important in determining the amount grains/panicle (HSU and Teng, 1974, Dasgupta et al., 1970; Eunus and Sadeque 1974, Verma 1973., Singh et al., 1977). But Kumura (1957), Hasgawa et al.,(1958), Yamangata (1950) reported increase in no of fertile grains per panicle with increasing levels of N upto certain limit. Under Bhubaneswar condition Sahoo and Mishra (1976), got increased weight of fertile grains/panicle upto 90 kg N/ha.

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On an average, application of propanil @ 2.0 kg/ha as a post-emergence spray showed increased test weight over other promising herbicidal treatments (Kakati et al 1977, Mahatim Singh et al 1979). On the contrary, Rammoorthi et al (1974) did not find significant increase in weight of 1000-grains due to herbicidal treatment in upland rice over no herbicidal treatments.

11.1 Grain yield

Increasing the stress period during the vegetative phase and/or the reproductive phase decreased the grain yield (IRRI, 1969). The duration of the time the plant was subjected to moisture stress was more important in determining the amount of yield reduction that the particular growth stage at which the stress occured. Soil moisture below the saturation level for more than 3 days at a stretch reduced the grain yield of rice (Dastane et al 1970). Irrespective varieties and and seasons, the length of internodes and grain yield/plant were minimum under deficient water supply. There existed a positive correlation between the relative rates of stem growth and grain yield; it was possible to predict grain yield on the basis of stems growth much ahead of harvest (Sen and Datta, 1970; Kwang and Ghi, 1978). Grain and straw yields were increased from 393 and 732 kg/ha under completely upland rainfed conditions to 462 and 754 kg/ha with irrigation to maintain soil moisture content at F.C. Kwang (1978).

Unpublished work of Lenka (1973-78) showed that the upland rice variety OR34-16 (Parijat) responded to irrigation during 3 Kharif seasons out of five. Irrigation at 0.5 bar as and when necessary and irrigation after flowering increased yield by 90% in drought years and 35-40% in moderate rainfall years. Only in one normal year the differences in yield were not significant.

Choi, and Choi (1980) reported that yield under upland condition is lower than that obtained from low land condition. They inferred this after conducting one experiment with 6 low land rice varieties and 7 upland rice varieties under both lowland and upland situations.

/ There was increase in grain yield of dwarf indica rice varieties with increase in nitrogenous fertiliser variations CV. Saket, Ratna and CR 44-1 gave highest yields at 60 kg N/ha. The response to applied N upto (60 kg/ha) was quadratic in nature. The most profitable N rates for 3 varieties were 52.2, 68.5 and 37.6 kg/ha, respectively.

Singh and Modgal (1979) did not find any response of rainfed upland rice above 60 kg N/ha. Whereas Fagade (1979) under rainfed upland condition got increased yield upto 30 kg/ha in 1976 and upto 60 kg/ha in 1977. The average of 3.06 t/ha with no nitrogen increased to 3.72 t due to application of 60 kg N.

By and large response of upland rice grain-yield to nitrogen is less than that of medium and low land varieties due to longer duration and operative moisture regimes of the latter groups. From all the trials on response of short duration upland rice (115 days)varieties to N levels it is concluded that maximum response is at 25-30 kg and the optimum lies at 40 kg and the yield declines beyond 60 kgN.

<u>Weed & Yield</u>

Substantial increase in grain yield under upland rainfed condition was obtained by maintaining weed free environment upto 45 days from the commencement of the crop (Bhan *et al*; 1971). Weed free condition for 45 days can be maintained by spraying nitrogen as pre-emergence spray, Benthiocarb as early post-emergence spray or Propanil as post-emergence spray (Pillai *et al* 1976; Rao *et al* 1976).

Repeated application of propanil @ 1.5 a.i/ha with 3 % urea was as efficient as handweeding in terms of reduction of weed growth and higher grain yield (Rammoorthi *et al*; 1974; Dubey *et al*; 1977; Tosh, 1977).

Mair Pillai and George(1979) under semidry condition got 2.73 t/ha, 2.45 - 2.65, 2.31 - 2.35, 1.74 t/ha. grain yield from 2 handweedings, Propanil + 1 handweeding, MCPA + 1 handweeding and without any weed control measure, respectively. Fagade (1979) under upland condition got 2.5 t/ha. with 3 kg propanil/ha. which was similar to 2 handweedings. But he got the highest grain yield of 3.95 t/ha. from propanil + 1 handweeding.

10.2 Straw yield

Straw yield increased with increasing N levels (Srinivasan et al 1968, Bathkal and Patil 1968; Pandey 1969 Singh *et al* 1977; Singh and Singh 1976).

11.3 Grain straw ratio

In years of well distributed rainfall, short duration rice varieties maturing before middle of October could be grown successfully by keeping soil saturated throughout. Soil moisture stress after peak tillering produced ineffective tillers and that from peak tillering to flowering reduced panicle length and other yield attributing characters. Stress during flowering to ripening reduced grain filling and yield and the reduction in yield was found to be in the order of 2 to 3.9 ha as compared to that under continuous 3-5 cm submergence in dry season if water table remained above 40 cm. Under situations of low water table (below 40 cm), the decrease was in order of 3-5 q/ha (Lenka,1976).

Harvest index decreased with increase in N levels (Venkateswarlu *et al*, 1975 . Singh and Stokopf 1971) while working with rice varieties Kanchi, Karuna, Cauvery, Muthuswamy *et al*. 1972 reported significant influence of N levels on grain-straw ratio. Pande (1973) noticed decrease in grain straw ratio with increase in N levels. About (1961) marked a significant effect of early stage application of N and P on grain straw ratio. Wabhab and Hussain (1957) got higher grain:straw ratio by nitrogen application during early reproductive stage.

12.1 Uptake of nutrient elements

Stress at vegetative and maturity periods reduced protein content of grain while that at reproductive phase enhanced it (Rao, 1971). Kumbhar and Sonar (1978) found that N, K, Fe and Mg contents were higher in upland varieties than in lowland ones.

Uptake of N increased with increasing N-levels. (Verma-1971, Singh et al, 1977). Increase in N levels increased uptake of N but decreased the uptake of P. Lokanathan (1968) noticed a positive correlation between total uptake of N and K. Saddayapan and Kolandai Swamy (1974) observed increased P&K content in grain due to increasing N levels.

N-content in grain and straw increased with increase in N-rate upto 75 ppm but decreased at 150 ppm (Sahu and Murty, 1976). Padmaja (1977) reported sharp increase of N concentration in grain than that in straw and at still higher levels the trend was reverse. Concentration of P and K in grain increased upto 60 PPM N in soil and remained more or less constant at still higher levels.

Recovery of fertiliser N by grain and straw raaged from 33 to 81% (Reddy and Patrick 1976). Wang and Peng (1981) found that fertiliser N usage by rice was 6.76 % from greening to tillering, 24.17 % from greening to maximum ear emergence stage, and 40.06 % from greening to ripening. Plant took 70 % from soil and 30 % from fertiliser source. Singh and Modgal (1979) found concentration and uptake of N to increase with increasing N levels from 30 K to 120 K N/ha, in rainfed upland condition at all stages of growth. Plant accumulated 15 % N upto tillering, 50 % upto PI, and 85-90 % upto heading. Thus proportionately less N uptake (10-15 %) at post-heading stage was the major constraint for production efficiency in rainfed upland rice. Upland rainfed rice Pereria removed 61 Kg N/ha. Mascarenhas, and Camargo (1979) found that under rainfed upland condition the N content in above ground portions were 1,2, 1.5, 1.53, 1.82 and 2.1 % respectively, with the application of 0, 20, 40, 60, 80 Kg N/ha. Ohyama (1977) calculated that N contents from heading to 20 days after heading were 0.7 to 1.1 % in straw and 1.0 to 1.3% in ear. Vaughan, Womack and Smith (1980) reported increased grain protein content when N increased from 0 to 36 Kg N/ha. Sing and Modgal (1979) found increase in concentration and uptake of N due to increase in levels of Nitrogen application at all stages of crop growth but the difference was the highest at PI stage, in subsequent stages these differences became narrower.

CHAPTER—III

MATERIALS AND METHODS

MATERIALS AND METHODS

1. EXPERIMENTAL SITE

The experimental site was located in the A-block of the Central Research Station of the Orissa University of Agriculture and Technology, Bhubaneswar, during Kharif season, 1984.

2. SOIL CHARACTERISTICS

The experiment under report was conducted in a well-drained site with pH 4.8. A composite sample from twenty randomly collected samples from different portions of the plots was sieved through 2 mm sieve and analysed for mechanical constituents and chemical composition. Different physical constants were also determined (Table-1(a):

TABLE-1(a) Mechanical Composition

Soil Separates	Composition(%) Dry wt.	Method addopted
Sand	83.1	
Silt	10.2	Bouyoucos
Clay	6.7	Hydrometer method (Piper-1950)

Table -1(b)

Soil constituents	Composition/ content	Method adopted
pH	4.8	Beckman electronic pH-meter.
Organic Carbon	0.359 kg/ha	Walkley Black Rapid titration.
Total Nitrogen	540 kg/ha	Kjeldahl digestion and distillation method.
Available P_2O_5	29.6 kg/ha	Olsen method (Jackson, 1967)
Available K_2O	158.5 kg/ha	Flame Photometer method

TABLE-1(c) Physical Constants

Particulars.	Depth (cm)				Method employed.
	0-15	15-30	30-45	45-60	
Apparent specific gravity (g.cm^{-3})	1.75	1.60	1.63	1.55	Field method.
Specific gravity.	2.66	2.52	2.57	2.50	Picnometer method.
Field capacity(%) (Gravimetric)	11.2	12.2	11.5	13.4	Field determination method.
Permanent wilting point.	3.5	3.7	3.4	5.8	Sunflower method (Piper-1950)

3. CROPPING HISTORY OF THE EXPERIMENTAL PLOT

The sequence of cropping adopted at experimental site during last 4 years prior to commencement of the present experiment are presented in (Table-2).

TABLE-2 Cropping history.

Year	Kharif.	Rabi	Summer.
1980-81		Sugarcane.	Sugarcane.
1981-82	Sugar cane.	Sugarcane.	Ratoon.
1982-83	Ratoon.	-	-
1983-84	Rice	Horsegram.	Se Samum.
1984-85	Experimental	-	-

4. SEASON AND CLIMATE

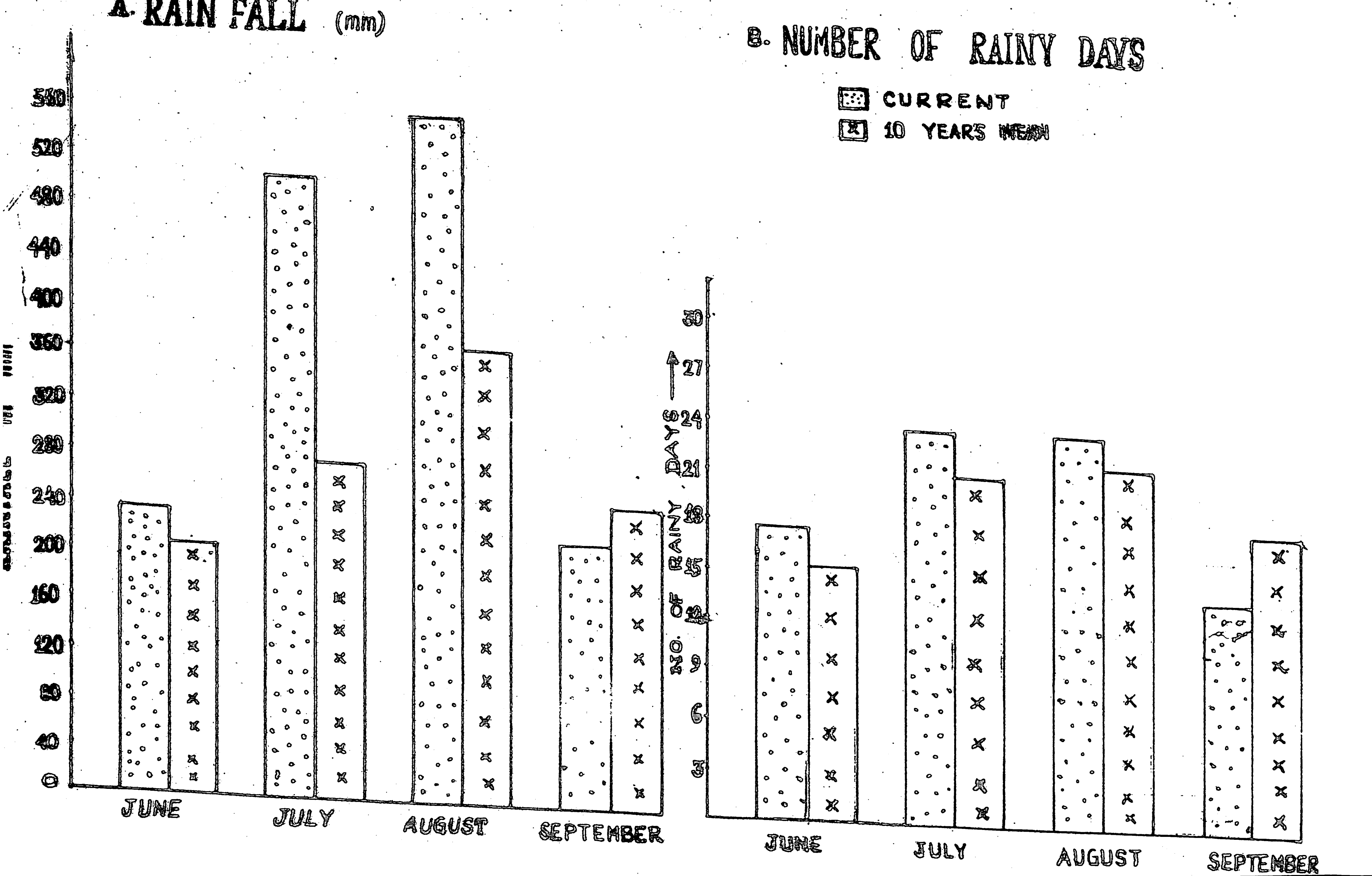
The Central Research Station, Bhubaneswar, is situated at 20° 15' N Latitude, and 80° 52' E long at an elevation of 25.9m above M.S.L. It has a warm and moist climate characterised by humid Summer and mild winter. The climate of Bhubaneswar is moist and hot (Lenka, 1974).

4.1. Rainfall

The mean annual rainfall is 1508 mm. The monsoon sets in by about 10th June and recedes by 15th October. The distribution of rainfall is uneven and nearly 90% of the total annual rainfall is received during months of June (185.7mm), July (360.5mm), August (333.6mm), September (273.6mm) and October (183.2mm). A rainfall of 166.7mm is generally received from November to May. April and May are relatively dry months. The average rainfall Code is D_1E_3 $(B_1\ A_2\ B_1)C_1\ D_1\ E_2$ (Lenka, 1975).

Rainfall received during different months of the cropping seasons are June-234mm, July 507.6/mm, August 557.4 mm and September 215.8 mm. Last 10 years mean rainfall for corresponding months were 207.2 mm, 275.1 mm, 371.4 mm, 247.1 mm respectively. The crop experienced dry spells from 20.6.84 to 26.6.84 (Seedling stage) and from 17.8.84 to 21.8.84 (Flowering stage).

Fig. 1. RAINFALL AND NUMBER OF RAINYDAYS (CURRENT AND 10 YRS. MEAN) DURING CROP GROWTH PERIOD



4.2. Evaporation

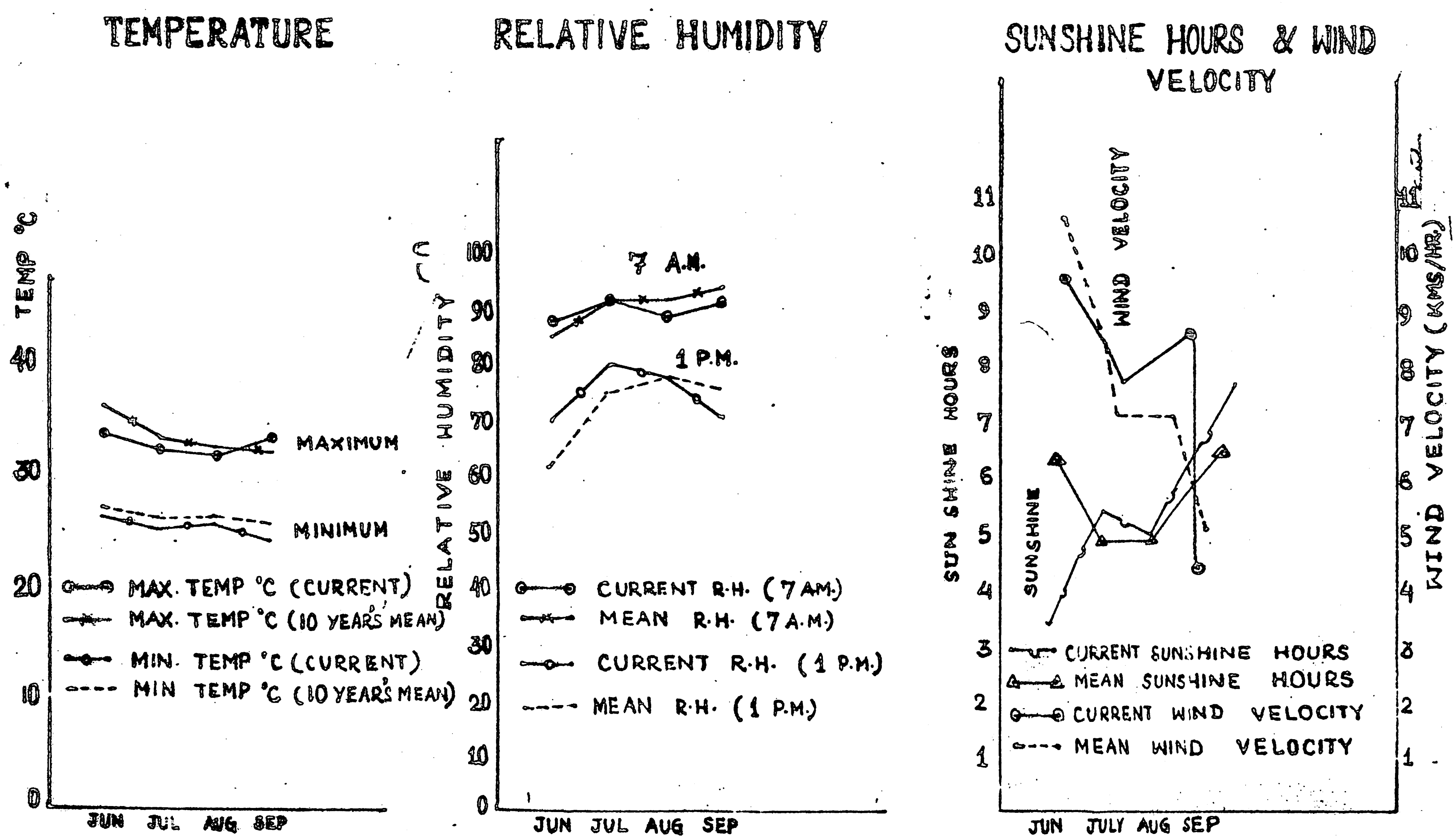
Evaporation loss from U.S.W.B. class 1 open pan evaporimeter increases gradually with increasing tempera-ture reaching the maximum of 8.5 mm/day in the month of May and decreases abruptly in subsequent months due to monsoon rains. It reduces to 4.3 mm/day in Kharif season (June to October) and 4.1 mm/day during rabi season (November to February). The mean evaporation during the cropping season was 4.14 mm/day. The total evaporation from 8.6.84 to 16.9.84 was 405.7 mm.

4.3. Air temperature

The mean annual temperature varies from 20.1°C to 32.6°C. The month of May is the hottest, maximum temperature during this month touching 44°C. The last week of the month of December is the coldest and the temperature drops down to 11°C. The mean maximum temperature in the month of May is 37.6°C and falls to 30°C in June. From July to October, the maximum temperature remains constant at about 32°C. The range of variation of minimum temperature remains almost constant around 25°C during June to October and gradually falls to 14.1°C in December, to 14.6°C in January and to 18.1°C in February.

The mean maximum and minimum temperatures were 33.4°C and 26.1°C and 26.1°C, 32.2°C and 25.2°C, 31.6°C and 25.4°C, 32.5°C and 24.7°C, respectively, during the months of June, July, August and September. Last 10 years average maximum and minimum temperatures for the correspond-ing months were 35.8°C and 26.5°C, 32.5°C and 25.9°C, 31.7°C and 25.8°C, 32.1°C and 25.3°C respectively.

Fig.2. TEMPERATURE (MAX. AND MIN.), RELATIVE HUMIDITY (7AM AND 1 PM), SUNSHINE HOURS AND WIND VELOCITY (CURRENT AND 10 YRS MEAN) DURING CROP GROWTH PERIOD



4.4. Wind Velocity

The average wind velocity figures reported during the cropping season were 9.5, 7.6, 8.3 and 4.2 Km/h, respectively, during June, July , August and September. Whereas last 10 years average figures for corresponding months were 10.3, 7.8, 7.58 and 5.93 Km/h.

4.5. Bright Sunshine Hours (BSH)

During last 10 years, the average bright Sunshine periods during June, July, August and September were 6.3, 4.9, 4.9 and 6.5 hour/day, respectively. During the cropping season the corresponding figures were 6.3, 4.9, 4.9 and 6.5 hours/day. The total bright sunshine hours during the year 1984 was 2790.3 . The daily average bright sunshine was 7.62 h/day.

4.6. Relative Humidity

The mean relative humidity varies from 64-85%. April is the most arid month and August the most humid. In the morning relative humidity is maintained at about 86-90% throughout the year. In the afternoon, relative humidity varies from 39 % in the month of April to 81 % in the month of August.

The mean relative humidity percentage values during morning and afternoon were 87 and 69, 91 and 79, 88 and 77, 91 and 70 during the month of June , July, August and September respectively. The last 10 years average figures for corresponding months were 85 % and 61 % , 91 % and 74% , 91 and 77%, 92 and 75 % , respectively.

TABLE 3. Weather Data of the Central Research Station, Bhubaneswar for the period from June to September, 1984 and the mean data for preceding 10 years (1974-1983) (Normal)

Month	Year	Rainfall mm.	rainy days	Mean maximum temperature (°C)	Mean min. temperature (°C)	Relative Humidity Morning	Relative Humidity After noon.	Wind velocity km/ha	Mean bright sunshine/ (h/day)
June	Current	234.0	18.0	33.4	26.1	87.0	69.0	9.50	3.4
	Mean	207.2	15.6	35.8	26.5	85.0	61.0	10.30	6.3
	D.N	+ 26.8	+ 2.4	- 1.4	- 0.4	+ 2.0	- 8.0	- 0.6	-2.9
July	Current	507.6	24.0	32.2	25.2	91.0	79.0	7.60	5.4
	Mean	275.1	21.3	32.5	25.9	91.0	74.0	7.80	4.9
	D.N.	+232.5	+2.7	-0.3	-0.7	0.0	-15.0	-0.20	-10.5
August	Current	557.4	24.0	31.6	25.4	88.0	77.0	8.30	5.0
	Mean	371.4	22.2	31.7	25.8	91.0	77.0	7.58	4.0
	D.N	+186.0	+ 1.8	-0.1	-0.4	-3.0	0.0	+ 0.72	+ 0.1
September	Current	215.8	14.0	32.5	24.7	91.0	70.0	4.20	7.7
	Mean	247.1	18.4	32.1	25.3	92.0	75.0	5.93	6.5
	D.N.	- 31.3	-4.4	+0.4	-0.6	-1.0	-5.0	-1.73	+1.2

D.N- Deviation from normal.

5. EXPERIMENT

The details of the treatments employed are presented in the table-4.

TABLE 4

	Treatments.	Symbols used.
1.	<u>Moisture Regime</u>	
	Rain fed....	I_1
	Irrigation at 0.5 bar	I_2
	Irrigation (0.5 bar) from flowering to maturity....	I_3
2.	<u>Levels of nitrogen-</u>	3
	25.50 and 75 kg/ha.	N_1, N_2, N_3 respectively.
3.	<u>Methods of weed control</u>	
	Chemical. Stam F-34 16 DAS- weedamin:34DAS	W1
	Chemical + Mechanical (Stam F34)	W2
	Mechanical only..	W3
	Extra-treatment Control (unfertilized, Rainfed but mechanically weeded)	C

5.1. The experiment was laid out in a 3^3 partially confounded design. Each replication had 3 blocks containing one extra plot (9+1) per block. The extra treatment control was randomised in each block alongwith the treatments per block N and W components were confounded. Lay out plan is presented in Fig. 3.

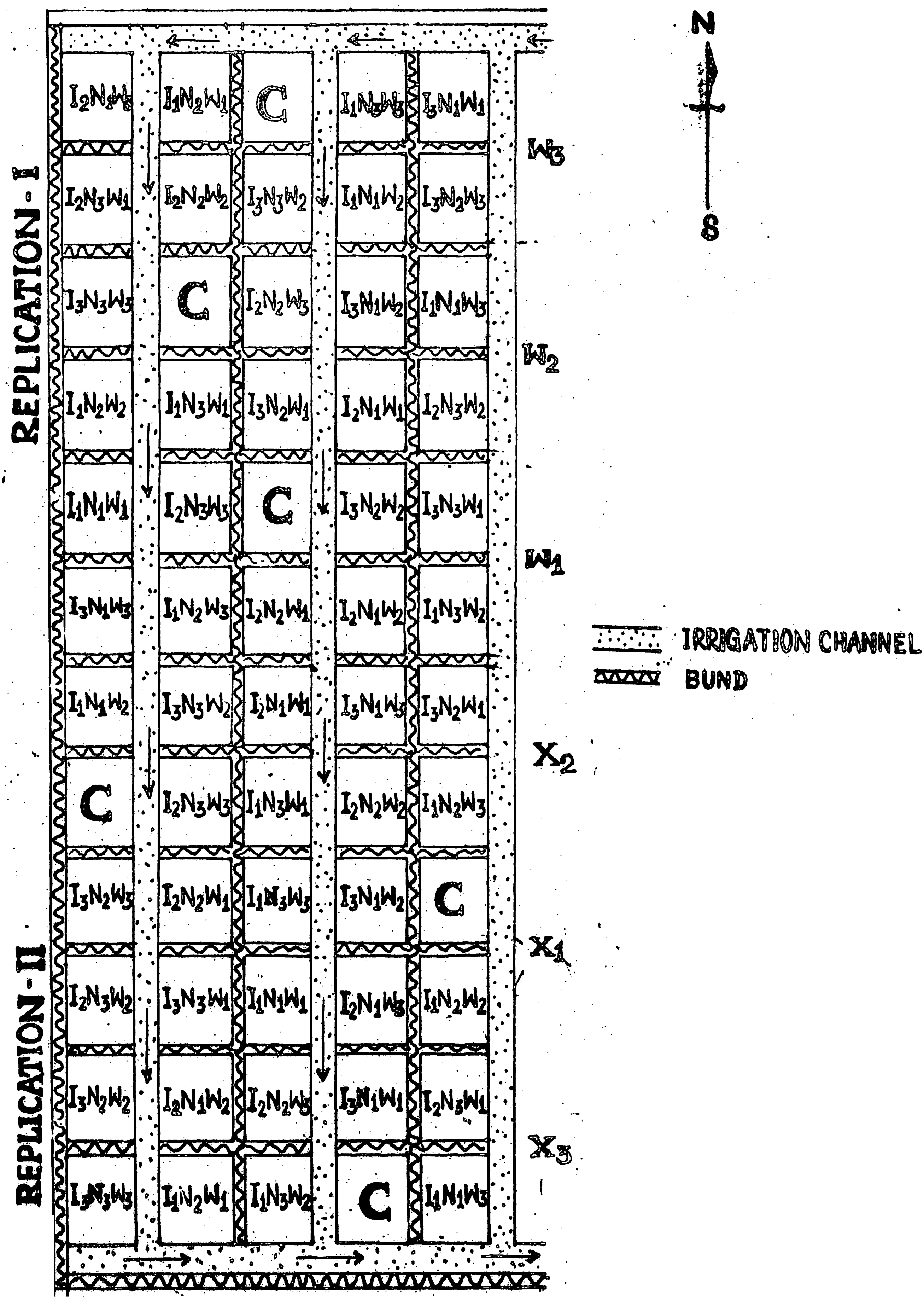
5.2. Plot Size

a) Gross Plot Size: 8.0 m x 3.9m = 31.2 Sq.m

b) Net Plot size: 7.00m x 2.70m = 18.9 Sq.m

Net plot was taken eliminating 4 rows from either side along the length and 0.5 m from either side across the breadth.

Fig.-3 PLAN OF LAY OUT



6. VARIETY

Keshari (OR-63-252), this dwarf indica variety developed from a cross between Pankaj/Jagannath, is adaptable to high and medium uplands. The variety matures in about 90 days in Kharif and in 100 days in dry season. The variety has moderate degree of resistance to brown plant hopper, green leaf hopper, bacterial leaf bilight and suffers less from grain discolouration; grains are medium-slender with golden (dull)hull; Kernelwhite, average length of grain 5-23 mm, average breadth of grain 2.20 mm, length to breadth ratio 2.38 thousand kernel weight is 14.51 g.

7. GENERAL CHARACTERISTICS OF HERBICIDES USED

a) Propanil (Stam-F-34)-3,4 -Dichloropropionanilide.

It is a selective contact herbicide belonging to the anilides group usually used @ 3-8 g/ha. It is a post - emergence herbicide treated when grasses are in 2-3 leaf stage. A higher dose is needed to control grasses at 4 leaf stage.

It is aways applied as post-emergence contact-spray. Absorption through faliage takes place within a period of 4-8 h after treatment. Rainfall, if occurs, washes the chemicals down to the soil. The absorption of the chemical depends on

(1) Moisture- There should be sufficient moisture in the soil.

(2) Heat - There should Not be excessively high heat, spraying should be done in the morning or evening in shinning weather.

The herbicide action is generally seen in 3-4 days, spread to maximum of 4-7 days.

b) Weedanin (Knock-weed)

Weedanin is a selective dranslocated herbicide containing 72% dimethyl amine salt of 2_{1} 4-D (720 g. of 2,4-D per litre) in aqueolls form, soluble in all proportions in water and recommended for control of broad leaved weeds in cereals, sugarcane and other monocot-crops.

Pre-emergence and Post-emergence application

Weedanin can be recommended for application both as pre-emergence and post-emergence to crops and weeds . Post-emergence applications in crops like sugarcane, wheat and maize are more effective. It is preferrable to spray weedanin at the susceptible stage of weed growth even with the treat of rain than delay spraying and allow weeds to grow beyond the recommended stage for treatment. Weed control measures should be taken to keep the crop weed free during critical period of growth.

Details of herbicides used have been given in table 5.

TABLE-5. Details of herbicides used

Common name Herbicide.	a.i. of herbicide.	% a.i.	Dose (Kg/ha.)	Quantity of water used (l/ha)	Quantity of herbi-cide used(l/ha or (Kg/ha)	Time of application
Stam F-34	Propa-nil.	35%	1.5	1125	4.30	Post emergence to crop weeds 16 DAS.
Knock-weed.	2,4-D amine.	72%	1.0	1125	1.39	Post emergence to crop and weeds 34 DAS.

8. GENERAL INFORMATION ON EQUIPMENT/INSTRUMENTS USED IN THE EXPERIMENT.

(a) Tensiometers

Soil moisture tension within 1 bar range was recorded by installing porous cap type water filled tensiometers at 15 and 30 cm depths. All necessary pre--cautions were taken before installing the tensiometers. Soil moisture contents were determined by gravimetrically by sampling before, after irrigation/rainfall and intermitt--ently from all the plots in res. II. Tensiometers were inserted to know the timing of irrigation. Plots scheduled for irrigation at -0.5 bar were given irrigation when the soil moisture tension dropped to -0.5 bar.

(b) Parshall flume

Quantity of water irrigated per plot was measured by installing 7.5 cm throat width parshall fl flume, and mainta--ining free flow.

9. CULTURAL OPERATIONS

9.1. Land Preparation:

The land was thoroughly prepared by iron plough and disc harrow and repeated ladderings.

9.2. Fertiliser application

Phosphate and Potash @ 30 Kg/ha in form of rock phosphate and muriate of potash respectively were applied to the plots at the time of sowing. Fifty percent of the scheduled dose of N was applied at the time of sowing and then rest in 2 equal splits at 16 and 34 DAS.

9.3. Sowing

The crops sown on 8th June, 1984 in 15cms apart rows formed by wooden marker.

9.4. Water management

No irrigation was given to the rainfed treatments. Treatments "irrigated as and when needed at 0.5 bar received 2 irrigations (25.6.84, seedling stage and 19.8.84 flowering stage). Plots irrigated at 0.5 bar after flowering received only one irrigation on 19.8.84 (flowering stage 73 DAS.

9.5. Weed management

Post emergence application of propanil (Stam F-34) was made on 24.6.1984 (16 DAS) to the scheduled treatments. Weedanin (mock-weed) was again sprayed to chem + chemical plots on 12.7.84.(34 DAS). Mechanically weeded plots were weeded on 15 and 35 DAS. Plots scheduled to be weeded both chemically and mechanically were hand weeded once at 35 DAS. Control plots were hand weeded twice .

9.6. Plant Protection

To prevent the crop from attack of insects and BLB Demecron @ 250cc/ha at 37 DAS and Hitox @ 3.7 kg/ha in 500cc water at 46 DAS were sprayed as prophylactic measures.

9.7. Harvesting and threshing

The crop matured in 98 days. After eliminating boarder from both the sides the plots were hausted, bundled separately, sundried and threshed. Weight of grains and straw was recorded plot wise 6 days after sundrying. To know the moisture content samples of grains and straw were oven dried for 18 hours at 80°C and final yields were adjusted to 14% moisture content.

10. MOISTURE STUDIES

Soil samples were collected from each plot of replication-1 by a soil auger from different soil depths viz: 015 cm, 15-30 cm, and 30-45 cm. The soil samples were collected from these depths before and after each rainfall and/or irrigation. Soil samples were collected in the aluminium cans and weighed, Oven dried at 105°C for 24 hours and reweighed to determine the moisture content.

$$\text{Soil moisture content (Gravimetric)} = \frac{\text{Weight of moist sample} - \text{weight of Ovendried sample}}{\text{Weight of ovendried sample}} \times 100$$

$$\text{Moisture content } (cm^3/cm^3) = \text{Moisture \% (Weight basis)} \times \text{B.D.}$$

From these data, periodic and seasonal ET, water requirement, WUE and Crop-co-efficients were calculated.

10.1. Moisture used in an interval of time.

$$\frac{(Ma-Mb)}{100} \times Bdi \times Di \text{ where}$$

Ma- Moisture content at the beginning of the internal

Mb- Moisture content at the end of the interval.

Bdi = Bulk density of ith layer (gcm^{-3})

Di = Depth of ith layer (cm)

= Summation.

U = Water user during the interval (cm)

Water Requirement

$$W.R. = \sum_{i=1}^{n} \frac{(Ma-Mb)}{100} \times Bdi \times Di + ER + I$$

Where Ma- Moisture in the beginning of crop season.

Mb- Moisture at the end of crop season.

ER= Effective Rainfall

I = Irrigation.

Ground water contribution was considered nil as water level remained 60 cm below and roots were confined upper 22 cms.

10.3. Consumptive Use

$$U = \sum_{j=1}^{n} u_j + 0.6 \sum_{i=1}^{n} E_k$$

Where U = Consumptive use.

u_j= Water used during J th interval

E_k= Actual evaporation from USDA open pan evaperimeter for the number of days between irrigation and sampling.

Effective Rainfall

Quantity of rainfall satisfying the moisture deficit to FC or in excess of pan evaporation was considered effective. This was calculated by taking daily evaporation and rainfall data and soil moisture content into consideration.

10.4. Water Use efficiency (WUE)

$$WUE = \frac{\text{Total drymatter produced (Kg/ha/cm)}}{\text{Water use.}}$$

$$WUE_g = \frac{\text{Grain yield}}{\text{Water use.}} \text{(Kg/ha/cm).}$$

11. WEED STUDIES

Sampling techniques :- From randomly selected 3 places each (50 cm)^2/ plot, weed bnumber and biomas were recorded on 15,45 and 75 DAS.

11(a) Crop weed association

Association of different types of weeds with crop was carefully observed from 15DAS to maturity. Weeds so obta observed were put under taxonomic classification (Tadulingam and Venkatanarayan- A Handbook of South Indian Weeds).

11.(b) Weed Count

Weed population was recorded from 3 sampling units each 50cm x 50cm, selected at randum per plot at 15,45 and 75 DAS.

11.(c) Weeds from each sampling unit including roots were washed and sundried for 50-60 hours to record the weight.

12. Biometric studies (Crop)

Sampling technique:-

Two sampling units each 1 meter long in crop rows, were selected at randum in each plot and were marked by bamboo pegs. Observations on height and tillers were recorded from the plants or the units commencing from 20 DAS to 80 DAS.

12.1. Plant height:-

The height of the main shoot of each plant was measured from ground level upto the last auricle. At the time of harvest, the plant height was measured upto the tip of the panicle. From each linear meter sampling unit 10 such plants were measured and average plant height was calculated.

12.2. No. of tillers/m^2

Total number of tillers from 2 sampling units each 1 linear meter long were counted, averaged out and converted to tiller/m^2 .

12.3. Leaf Area Index:

Plants from 25cm running strips were uprooted carefully. All the leaves were clipped off and used for determination of leaf area. Area was worked out graphically by sorting the leaves into different size-groups and tracing out one from each group on the graph paper. Area per leaf was multiplied by the number of leaves in its group to find out the area of that particular group and were summed up over size groups to find out the total leaf area.

From the total leaf area of all plants, leaf area index was calculated:

$$LAI = \frac{\text{Total leaf area of all the plants } (Cm^2)}{\text{Land area occupied by the plants.}}$$

12.4. Dry matter production/m^2

Dry weight of above ground plant parts from 0.50 area/plot was determined by overing drying the sun dried samples at 80°C for 18 hours . This was multiplied by appropriate factor to convert it into dry matter production/m^2.

From dry matter production/m^2, crop growth rate (C.G.R.) was calculated.

$$C.G.R. = \frac{1}{L} \cdot \frac{dw}{dt} \quad (g/m^2 \text{ day})$$

Where dW :- Change in dry weight.

dt = Change in time i.e. time interval between successive samplings

L = Leaf area.

The CGR was calculated by taking data on DMP. recorded at 30 days interval commencing from 30 to 90 DAS.

12. POST -HARVEST STUDIES

12.1. No. of Panicles/m^2

At the time of harvest, total number of panicles from 2 fixed sampling units were counted and averaged out. It was converted to number of panicles/m^2.

12.2. Length of Panicles

Average Panicle length was determined by measuring 20 randumly selected panicles per plot.

12.3. Fertile and Sterile grains/Panicle

The above 20 Panicles were threshed separately and sterile and fertile grains were counted. Average no. of fertile and sterile grains/Panicle were calculated. The weight of these grains was added to the grain weight of respective plots.

12.4. 1000 grain weight

From threshed grains of each plot small samples were drawn and 1000 grain weight was determined.

13. Yield Studies

13.1. Yield of grain and Straw

Grain and straw yields of each plot were weighed after thorough sundrying.

13.2. Grain Straw ratio. $\frac{\text{Yield of grain (Kg)}}{\text{Yield of straw (Kg)}}$

13.3. Harvest Index (H.I)

$$\text{H.I.} = \frac{\text{Economic yield (Grain)} \times 100}{\text{Biological Yield (Grain + Straw)}}$$

14. Chemical analysis:

14.1. Final Soil Fertility Status:-

Composite soil samples were collected from each plot immediately after the harvest of the crop. The samples were air-dried, powdered and sieved through 2 mm sieve. Contents of total N, Available P_2O_5 and available K_2O were determined.

14.2. Nutrient uptake studies:

Grain and straw samples were oven dried, ground and analysed for N.P.K. as per methods.

Nutrient	Method employed.
Nitrogen :	Modified kjeldahl method (Jackson 1958)
Phosphorus:	Triacid digestion and colorimeteric determina-tion.
Potassium:	Triacid digestion and determination by flame Photometer.

15. STATISTICAL ANALYSIS

Data on biometric parameters, yield attributing characters, yield of grain and straw etc. were analysed statistically as per the method appropriate to the design (Snedecor and Cochran, 1967).

15.1. Correlation Studies

The relation between yield attributing characters and yield, nutrient uptake with yield and soil-test values with yield were calculated by using simple co-rrelation co-efficient formula (Snedecor & Cochran, 1967).

$$r = \frac{\text{Cov.}\ (xy)}{V(x)-V(y)} = \frac{xy - \frac{\Sigma x\ \Sigma y}{N}}{x^2 - \left(\frac{\Sigma x}{N}\right)^2 \times\ y - \left(\frac{\Sigma y}{N}\right)^2}$$

Where r = Pearson's Correlation co.efficient.
x = independent variable
y = dependent variable
Cov (xy) = Co. variance xy.
Vx = Variance x
Vy = Variance y
n = number of pairs of observation

16. RESPONSE CURVE:

To know the type of response curve to be fitted, the sum of squares due to nitrogen was partitioned to linear and quadratic components and tested against error sum of square. Since the quadratic component was found significant, the second degree Curve.

($Y = a + bx - Cx^2$) was fitted.

CHAPTER—IV

EXPERIMENTAL FINDINGS

EXPERIMENTAL FINDINGS

The results of the investigation are presented in this chapter. Data on number and biomass of weeds , crop-weed association, crop growth, yield and yield attri--buting characters were statistically analysed and have been presented in this chapter.

1. PRE-HARVEST CROP GROWTH STUDIES:

1.1. Number of tillers/m^2

Data presented in the table.5 indicates that the number of tillers was minimum in rainfed and unfertilised plots. Different irrigation treatments did not affect number of tillers/m^2 significantly at any of the stages of growth .

The number of tillers/m^2 increased with increasing the levels of N upto 75 kg/ha.

Differential effects of weed control could be discerned only 45 DAS . At 80 DAS, the number of tillers/m^2 was maximum in mechanically weeded plots (440/m^2) and significantly more than that in chemically weed controlled ones. Chemical + mechanically and mechanically weed controlled plots always had significantly more number of tillers/m^2 than chemically weed-controlled plots.(Fig.4)

Interaction of levels of N and weed control method was found significant on 60 DAS. (Table-6).These data indicated that at each level of N, particularly at higher level, chemical + mechanical or mechanical method of weed control produced significantly more number of tillers than chemical method of weed control alone. Maximum number of 486 tillers/m^2 was found when the plot was fertilised with 75 kg N/ha and weeds were controlled mechanically.

TABLE-5. Effect of different treatments on number of tillers

Particulars	Days after sowing			
	20	40	60	80
Moisture regimes				
R	248.2	444.5	467.6	426.5
I (0.5 bar)	252.1	442.6	462.8	428.0
R_f + I (0.5 bar)	253.2	445.1	468.4	429.7
F-test	N.S.	N.S.	N.S.	N.S.
Nitrogen levels (kg/ha)				
25	235.6	436.7	459.7	404.3
50	252.7	443.0	466.4	434.3
75	265.3	452.4	472.8	445.6
F-test	Sig.	Sig.	Sig.	Sig.
Weed Control chemical	248.7	430.5	452.3	408.7
Chem. + Mech.	254.2	448.8	477.7	434.7
Mechanical	250.7	452.9	468.9	440.8
F-test	N.S.	Sig.	Sig.	Sig.
S.E.m ±	1.7	2.2	2.5	3.3
C.D.	N.S.	6.4	7.2	9.7
Mean	251.2	444.1	466.3	428.1
Control	213.3	373.7	370.7	336.3
F-test	Sig.	Sig.	Sig.	Sig.
S.E.m ±	3.4	4.0	4.6	6.1
C.D.	9.9	11.6	13.2	17.7

Fig. 4 EFFECT OF MOISTURE REGIME, NITROGEN LEVELS AND WEED CONTROL ON TILLERS/M²

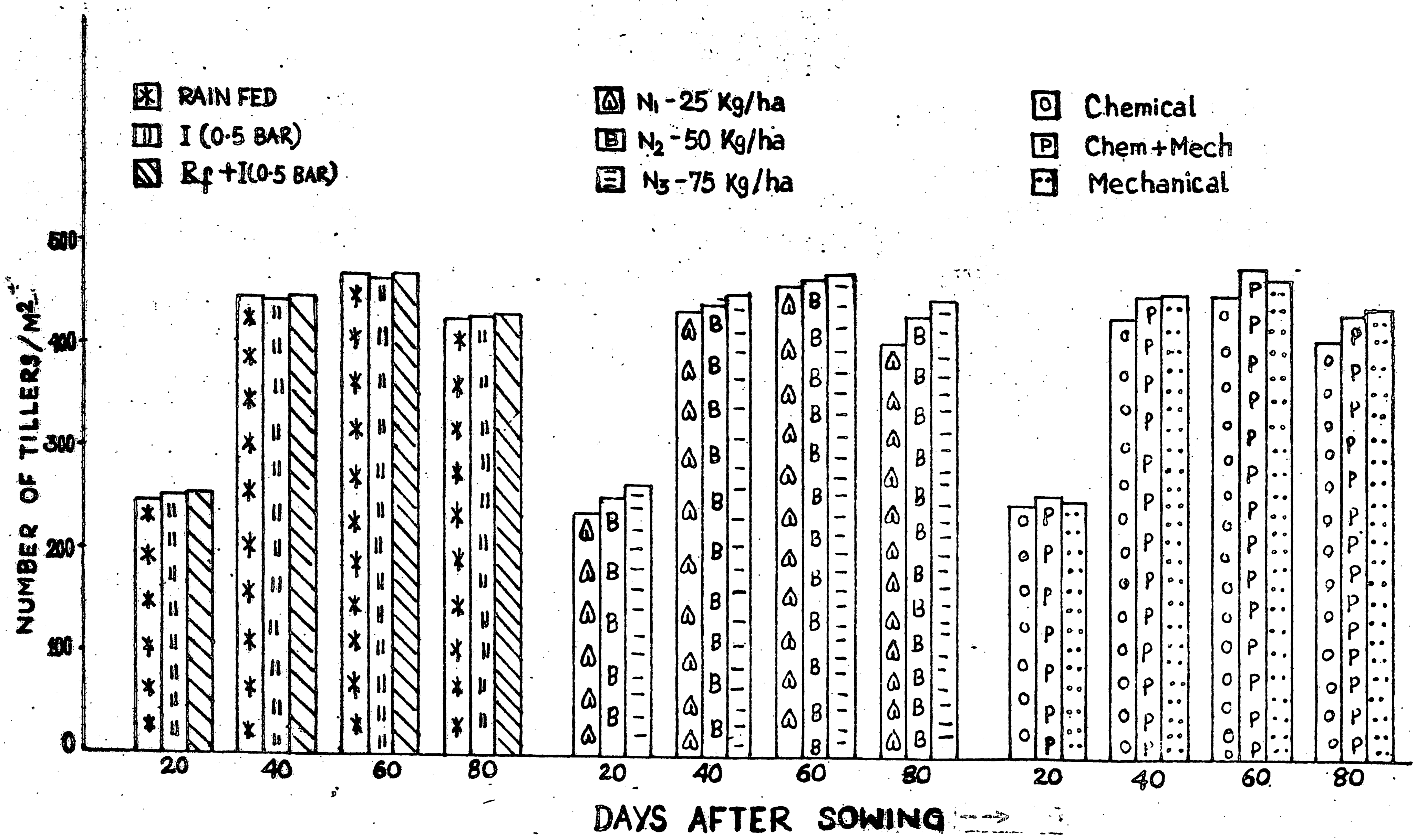


TABLE-6. Effect of nitrogen x weed control on tillers/m^2 60 DAS

Particulars	Weed control practices		
	Chemical	Chemical + Mechanical	Mechanical
Levels at N(kg/ha)			
25	448.0	478.0	453.0
50	457.3	473.6	468.0
75	451.3	481.4	486.0
	SEm ±		CD (0.05)
	4.33		12.55

1.2. Height

Data on height of the main shoot recorded at an interval of 20 days commencing from 20 DAS till harvest are presented in Table 7.

Plants were 8 cm fall on 20 DAS and grew progressively with time and attained maximum height at harvest. Always plants under control were the shortest. Fertilization, weed control and water management schedules increased the plant height significantly. Irrigation treatments had no differential effects on plant height at any stage of plant growth. At all stages of crop growth plant height increased with levels of N and plants fertilised with 75 kg N/ha were the tallest.

At 20 DAS plants in mechanically weed control plots were the tallest. Weed control by chemical and mechanical + mechanical means recorded plant heights of 7.9 and 8.0cm which were at par and significantly shorter to mechanically weed control treatment. At 40 DAS chemical + mechanical method of weed control resulted in the tallest plants followed by mechanical and chemical treatments respectively in order. At 60/80 DAS and at harvest weed control by chemical + mechanical and mechanical means alone were at par but significantly superior to chemical weed control treatments.

TABLE-7 Effect of moisture regimes, nitrogen levels and methods of weed control on heigh at different stages of growth

Particulars	Days after sowing				
	20	40	60	80	Harvest
Moisture regimes					
R	8.2	15.6	24.3	43.5	62.8
I (0.5 bar)	8.3	15.6	24.1	43.4	62.1
R_f + I (0.5 bar)	8.0	15.3	24.5	43.3	62.3
F-test	N.S	N.S	N.S	N.S	N.S.
SEm ±	0.18	0.17	0.39	1.00	0.68
Nitrogen (Kg/ha)					
25	7.1	14.1	22.6	40.5	58.4
50	8.4	15.8	24.8	44.3	63.4
75	9.0	16.6	25.5	25.4	65.4
F-test	Sig.	Sig.	Sig.	Sig.	Sig.
Weed control					
Chemical	7.9	14.4	23.1	41.0	59.8
Chem. + Mech.	8.0	16.3	25.1	44.5	63.7
Mechanical	8.6	15.7	24.7	44.7	63.8
F-test	Sig.	Sig.	Sig.	Sig.	Sig.
SEm ±	0.18	0.17	0.39	0.34	0.24
C.D.(0.05)	0.52	0.50	1.14	1.00	0.68
Mean	8.2	15.5	24.3	43.4	62.4
Control	5.6	12.2	20.1	33.0	50.6
SEm ±	0.32	0.31	0.68	0.63	0.43
C.D.(0.05)	0.94	0.91	0.97	1.82	1.25

1.3. Leaf Area Index:

Leaf area index of the crop at different stages of growth for different treatments was recorded and these data are presented in table-8.

Unfertilised and unweeded plants had the least LAI at all stages of the crop growth. LAI increased significantly due to fertilisation and weed control. In the beginning, the LAI was 0.85 and reached the maximum value (5.02) on 60 DAS and fell to 4.5 harvest.

Irrigation treatments had no differential effects on LAI upto 60 DAS. But at 80 DAS, irrigation at (0.5 bar) from flowering to maturity recorded LAI_s of 4.48 and 4.50 respectively both of which were at par and were significantly more than the rainfed treatments.

LAI increased progressively with increasing levels of nitrogen and was maximum at all stages with 75 kg/ha.

Different weed control practices had no differential effect on LAI upto 20 DAS, but at subsequent stages weed control by propanil followed by hand weedings and by hand weedings alone were equally effective, but more efficient than weed control by chemical methods alone.

Interaction of nitrogen x weed control was found significant at 60 DAS (Table-9). At same method of weed control, LAI increased as the fertiliser dose increased from 25 to 75 Kg N/ha . At a particular dose of nitrogen weed control by propanil followed by hand weedings recorded maximum LAI., but all values were at par with that obtained by application of mechanical method of weed control. Both these were significantly superior to weed control by chemicals alone.

Interaction effect of irrigation x nitrogen was found significant at 80 DAS (Table-10). At all stages of growth irrigation at 0.5 bar and irrigation (0.5 bar) from flowering to maturity recorded LAIs which were at par but significantly more than that with rainfed treatment. With each irrigation schedule, LAI increased with increasing nitrogen dose and was maximum with 75 kg N/ha.

Interaction effect of nitrogen and weed control was also found significant at 80 DAS. Weed control by propanil followed by hand weedings recorded the highest LAI which was at par with weed control by mechanical ways. (table-11)

Interaction of weed control x irrigation was found significant at 80 DAS. Maximum LAI was recorded due to weed control by propanil followed by hand weedings and irrigation at 0.5 bar SMS which was at par with weed control by mechanical means and irrigation at 0.5 bar SMS. Irrespective of the method of weed control, LAI of rainfed treatments was the least. (Table-12).

TABLE-8 Effect of moisture regimes, nitrogen levels and methods of weed control on leaf area index at different stages of crop growth

Particulars	Days after sowing			
	20	40	60	80
Moisture Regimes				
R	0.84	4.35	5.01	4.39
I(0.5 bar)	0.86	4.38	5.04	4.48
Rf + I(0.5 bar)	0.85	4.32	5.02	4.50
F-test	N.S	N.S	N.S	Sig.
Nitrogen (kg/ha)				
25	0.77	3.83	4.49	3.96
50	0.87	4.46	5.20	4.62
75	0.91	4.71	5.38	4.80
F-test	Sig.	Sig.	Sig.	Sig.
Weed Control Practices				
Chemical	0.83	4.06	4.62	4.14
Chem. + Mech.	0.87	4.49	5.24	4.69
Mechanical	0.85	4.45	5.21	4.55
F-test	N.S	Sig.	Sig.	Sig.
S.Em ±	0.03	0.02	0.02	0.02
C.D (0.05)	0.10	0.06	0.06	0.07
Mean	0.85	4.34	5.02	4.46
Control	0.58	3.40	3.73	3.31
F-test	Sig.	Sig.	Sig.	Sig.
S.Em ±	0.06	0.03	0.04	0.04
C.D.(0.05)	0.18	0.10	0.11	0.12

TABLE-9 Effect of Nitrogen x Weed control on leaf Area Index at 60 DAS

Particulars	Weed control methods		
Levels of N(kg/ha)	Chemical	Chem./ Mech.	Mechanical
25	4.02	4.69	4.75
50	4.80	5.43	5.37
75	5.04	5.60	5.52
	S.Em ±	0.04	C.D.0.11 (0.05)

TABLE-10 Effect of Irrigation x Nitrogen levels on LAI at 80 DAS

Particulars	Nitrogen Levels (kg/ha)		
	25	50	75
Moisture Regimes			
R	3.79	4.61	4.78
I(0.5 bar)	4.09	4.59	4.76
Rf + I(0.5 bar)	3.99	4.65	4.86
	S.Em ±	0.04	C.D= 0.12 (0.05)

TABLE-11. Effect of Nitrogen x Weed control on LAI at 80 DAS

Particulars	Weed Control Methods		
	Chemical	Chem. + Mech.	Mechanical
Levels of N(kg/ha)			
25	3.74	4.22	3.91
50	4.32	4.79	4.74
75	4.35	5.06	4.99
S.E.O ±	S.Em ±	0.04	C.D.0.12 (0.05)

TABLE - 12 Effect of Weed Control x Irrigation on LAI at 80 DAS

Particulars	Moisture Regimes		
	R	I(0.5 bar)	Rf+I(0.5 bar)
Weed control methods			
Chemical	4.11	4.69	4.38
Chem. + Mech.	4.13	4.70	4.61
Mechanical	4.17	4.68	4.64
	S.Em ±	0.04	
	C.D(0.05)	0.12	

1.4 Dry matter production

Data on Dry matter production/m^2 as influenced by different treatments are presented in the Table 13 and illustrated in Fig 5. control plots recorded the least dry weight/m^2 and these values were 106.3, 222.5 and 293.3 g/m^2 at 30,60 and 90 DAS respectively. Application of treatments significantly increased the dry matter production.

Differences in dry matter production due to irrigation schedules were found significant only at 90 DAS and irrigation at 0.5 bar recorded the highest DMP/m^2 which was closely followed by irrigation (0.5 bar) after flowering to maturity. Dry matter/m^2 was significantly less in rainfed treatments as compared to irrigation throughout and after flowering.

Similar to effects on plant height and tiller number,dry matter also increased significantly due to application of 50 and 75 kg and at harvest the value was 511 g/m^2 whereas that with 25 kg N/ha it was 401.0 g/m^2.

At all stages of growth, dry matter/m^2 was the least due to weed control by chemical means alone and the difference between this and the weed control either by chemical + mechanical or mechanical alone widened at subsequence stages. At 90 DAS, Chemical + Mechanically weed control treatments recorded maximum of 498 g dm/m^2 which was significantly more than only mechanically weed control treatments.

TABLE 13. Effect of moisture regimes, nitrogen levels and weed control methods on dry matter production at different stages of growth (g/m^2)

Particulars	Days after sowing		
	30	60	90
Moisture Regimes			
R	123.4	279.7	415.4
I (0.5 bar)	123.5	279.8	492.4
R+I(0.5 bar)	124.2	279.5	477.6
F-test	N.S	N.S.	Sig.
Nitrogen (kg/ha)			
25	111.0	256.9	401.0
50	121.0	283.5	472.8
75	139.6	298.5	511.6
F-test	Sig.	Sig.	Sig.
Weed Control			
Chemical	123.8	257.3	400.9
Chem. + Mech.	125.9	291.8	498.8
Mechanical	121.3	289.9	485.6
F-test	Sig.	Sig.	Sig.
S.Em ±	0.50	2.42	3.3
C.D.(0.05)	1.41	7.02	9.6
Mean	123.7	279.7	461.8
Control	106.3	222.5	293.3
F-test	Sig.	Sig.	Sig.
S.Em ±	0.9	4.4	6.1
C.D.(0.05)	2.6	12.8	17.6

Fig.5 EFFECT OF MOISTURE REGIMES, NITROGEN AND WEED CONTROL METHODS ON DRY MATTER PRODUCTION (g/m²) AT DIFFERENT STAGES OF CROP GROWTH

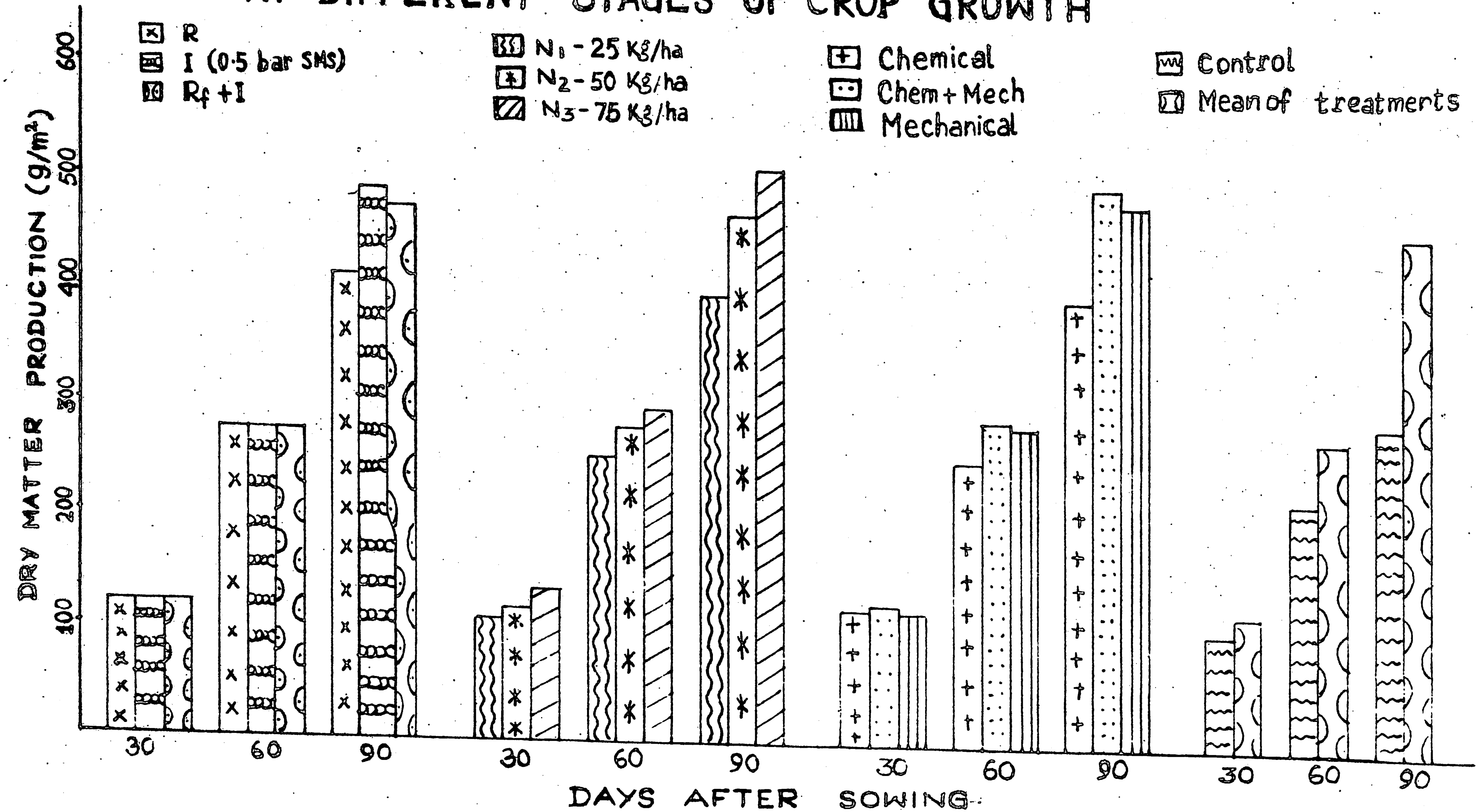


TABLE 14. Effect of nitrogen x weed control on dry matter production at 90 DAS (g/m^2)

Particulars	Methods of weed control		
	Chemical	Chem. + Mech.	Chemical
Nitrogen levels(Kg/ha)			
25	344.2	444.3	414.5
50	416.5	511.5	490.3
75	442.2	540.7	552.0
S.Em ±	5.7		
C.D.(0.05)	16.7		

The interaction of nitrogen x weed control was found significant (table 14). These data indicated that combination of mechanical method of weed control and 75 Kg N/ha gave the maximum dry matter/m^2, but it was at par with that obtained from the combination of 75 Kg N/ha and chemical + mechanical method of weed control. At a particular method of weed control, dry matter production increased with levels of N upto 75 Kg/ha. Similarly at a particular level of nitrogen, weed control by propanil followed by hand weedings gave the maximum dry matter production/m^2.

1.5 Crop Growth Rate (C.G.R)

Crop growth rates at different periods of growth are presented in table 15. Crop growth rates were less under control during 30-60 and 60-90 day intervals. Application of treatments increased CGRs significantly.

Irrigation treatments made no differential effects on CGRs during 30-60 days period. At 60-90 day period irrigation at 0.5 bar recorded the highest CGR and was superior to irrigation from flowering to maturity and rainfed treatments.

During 30-60 days interval, the nitrogen level of 75 Kg N/ha recorded C.G.R. of 5.31 which was at par with 50 Kg and both these were significantly superior to 25 Kg N/ha. During 60-90th day interval the highest level i.e 75 Kg N/ha recorded maximum CGR (7.18 /m^2/day) and was significantly superior to both 25 and 50 Kg.

Weed control by propanil followed by handweeding and hand weeding only were at par in dry matter production but significantly superior to weed control by chemicals only.

Interaction effect of nitrogen x weed control on CGR was found significant (Table 16). Application of 75 Kg N/ha and alongwith weed control by mechanical means recorded the highest CGR (8.07).

TABLE 15. Effect of moisture regimes, nitrogen levels and methods of weed control on crop growth rate (CGR) at different stages of growth ($g/m^2/day$)

Particulars	Period of Crop growth (DAS)	
	30 - 60	60 - 90
Moisture Regimes		
R	5.21	4.52
I (0.5 bar)	5.21	7.08
R_F + I (0.5 bar)	5.17	6.60
F-test	N.S.	Sig.
Nitrogen (N/ha)		
25	4.86	4.80
50	5.42	6.30
75	5.31	7.10
F-test	Sig.	Sig.
Weed control		
Chemical	4.44	4.78
Chem. + Mech.	5.83	6.90
Mechanical	5.62	6.52
F-test	Sig.	Sig.
S.Em ±	0.11	0.13
C.D (0.05)	0.31	0.39
Mean	5.20	6.07
Control	3.87	2.36
S.Em ±	0.20	0.24
C.D(0.05)	0.57	0.70

TABLE 16. Effect of nitrogen x weed control on crop growth rate ($g/m^2/day$) during 60-90th day

Particulars		Weed contrl. practices	
	Chemical	Chem. + Mech.	Mechanical
Nitrogen levels (kg/ha)			
25	3.65	5.80	4.95
50	5.20	7.17	6.54
75	5.50	7.73	8.07
S.Em ±	0.23		
C.D.(0.05)	0.67		

1.6 Duration to Panicle Initiation

Panicle initiation in each treatment was studied by split opening the main tiller at 2 to 3 days interval starting from 35 days after sowing. The initiation date for practical purposes was recorded when the primordia was 2 mm long. These data have been presented in Table 17.

In rainfed and unfertilised plots flower primordia were initiated 41 days after sowing. This duration was delayed by 4 to 5 days due to application of different treatments. Application of graded doses of nitrogen prolonged the duration by 2-3 days and with 75 kg N initiation occurred 45 days after sowing. Other treatments had no appreciable effect and initiation occurred in about 44 days after sowing.

TABLE 17. Effect of different treatments on duration to Panicle initiation and 50 per cent flowering

Particulars	Characters Duration panicle initiation	Duration to 50% flowering
Moisture Regimes		
R	44.0	68.50
I (0.5 bar)	44.6	69.1
R_f + I (0.5 bar)	44.8	69.3
F-test	N.S	
Nitrogen levels (kg/ha)		
25	43.7	68.2
50	44.1	69.1
75	45.0	69.5
F-test	Sig.	Sig.
Weed Control		
Chemical	43.8	68.3
Chem. + Mech.	44.61	69.1
Mechanical	44.9	69.4
F-test	Sig.	Sig.
S.Em ±	0.25	0.21
C.D.(0.05)	0.7	0.60
Mean	44.4	68.9
Control	41.0	66.0
F-test	Sig.	Sig.
S.Em ±	0.46	0.38
C.D.(0.05)	1.35	1.09

1.7 Duration to 50% flowering

Data presented in the table 17 indicated that control plots came to flowering on 66 DAS. Different water management, weed control and/or fertilisation schedules increased the duration by 3 days.

Rainfed treatments averaged over methods of weed control and nitrogen levels come to 50% flowering in 68 days. Irrigation at 0.5 bar sms throughout or after flowering delayed the duration by one day only.

Chemically weed controlled plots came to 50 % flowering in 66 days and mechanical weeding delayed this only by one day. Similarly, application 50 and 75 kg N/ha increased 50 % flowering duration from 68 days under 25 kg N to 69 days.

2. WEED STUDIES

2.1 Crop weed association

The following are the types of weeds observed in the experimental plot from sowing till maturity (table No.18).

TABLE 18. Types of weeds

Type	Botanical name	Family	Nature of occurance
Narrow leaved weeds			
Grasses (Annual)	Echinochloa colonum, linn	Gramineae	x
	Digitaria Sanguinalis, Scop	"	x
	Eleusine indica, Gaertn	"	x
Grasses (Perennial)	Sporobolus diander, Beaur	"	xx
	Cynodon dactylon, Pers	"	XX
Sedges	Cyperus rotundus, Linn	Cyperaceae	xx

Contd...

TABLE 18. (Continued)

Type	Botanical name	Family	Nature of occurance
Broad leaved weeds			
(Annual)	Cleome viscosa, Linn	Capparidaceae	x
	Eupatorium glandulosum,	Compositae	x
	Commelina bengalensis,linn	Commelinaceae	x
	Physalis minima,linn.	Solanaceae	x
	Acanthospermum hispidum DC	Asteraceae	x
	Amaranathus viridis ilinn-	Amaranthaceae	xx
	Leucas aspera,Labiratae		xx
	Boerhaavia hispidum Rubiaceae		xx
	Portulaca oleracea,linn	Portulacaceae	xx
	Heliotropium indicum,	Boraginaceae	xx
Perrenial	Sida acuta	Malvaceae	x
	Mimosa pudica linn,Mimosae		xx

X Occurs in large number during 1st 30 days of crop and poses severe problem.

xx Occurs in small numbers from 45 DAS to harvest and poses moderate degree of infestation.

2.2 Total weed population

Data presented in table No.19 indicated that there was minimum number of weeds under control throughout the cropping season.

Different irrigation treatments had little effect on weed population counted on 15 and 45 DAS. At 75 DAS, rainfed treatment recorded the least weed population.

Nitrogen levels affected weed population greatly. An increasing trend in weed population was associated with increase in nitrogen levels upto 75 N/ha.

Number of weeds was not significantly affected by different methods of wed control till 15 DAS. At 45 and 75 DAS the number of weeds were more under chemically controlled plots.

TABLE 19. Effect on moisture regimes, nitrogen levels and methods of weed control on total weed population at different stages of crop growth.

Particulars	Days after saving		
	15	45	75
Moisture regimes			
R	218.6	41.3	53.4
I (0.5 bar)	219.9	41.6	55.3
Rf+ I(0.5 bar)	218.9	40.7	55.3
F-test	N.S.	N.S.	Sig.
Nitrogen levels (kg/ha)			
25	210.1	36.5	50.7
50	218.1	42.3	55.8
75	229.2	44.8	57.5
F-test	Sig.	Sig.	Sig.
Weed control methods			
Chemical	220.5	45.4	61.0
Chem. + Mech.	219.2	38.3	50.7
Mechanical	217.8	39.9	52.2
F-test	N.S.	Sig.	Sig.
S.Em	1.1	0.5	0.2
C.D.	3.2	1.3	0.7
Mean	219.2	41.2	540.7
Control	208.3	38.7	46.3
S.Em ±	2.0	0.8	0.4
C.D(0.05)	5.9	2.4	1.1

2.3 WEED BIOMASS

Data presented in the Table 20 indicated that dry weight of weeds/ (50 cm)^2 was the lowest in control plots. There was no difference in weed biomass on 15th and 45th day after sowing dure to irrigation. But on 75th day, irrigation from flowering to maturity recorded the highest biomass of weeds.

Weed biomass / (50 m)^2 increased with increasing nitrogen levels from 25 kg to 75 kg/ha. On 15th and 75th day, the weed dry weight/ (50 m)^2 in case of 75 kg N/ha and 50 kg N/ha were significantly more than that at 25 kg N/ha.

Weed control by chemicals alone recorded maximum weed dry weight/ 50 cm x 50 cm units on 45th and 75th day. At 15th day, weed control treatments caused no variation in weed biomass / 50 cm x 50 cm. Weed control by propanil followed by handweeding recorded the least weed dry weight / unit area, though it was at par with mechanical control alone on 45th day.

TABLE 20. Effect of moisture regimes, nitrogen levels and weed control on total weed biomass at different stages of crop growth (8/50 cm x 50 cm areas)

Particulars	Days after sawing		
	15	45	75
Moisture regimes			
R	16.1	47.2	62.0
I (0.5 bar)	16.2	47.5	61.4
R_f + I(0.5 bar)	16.3	46.9	63.7
F-test	N.S.	N.S.	Sig.
Nitrogen (Kg/ha)			
25	14.7	43.9	56.6
50	16.1	47.5	63.9
75	17.9	50.2	66.7
F-test	Sig.	Sig.	Sig.
Weed control			
Chemical	16.2	57.4	73.3
Chem. + Mech.	16.2	39.4	53.5
Mechanical	16.2	40.9	60.3
F-test	N.S.	Sig.	Sig.
S.Em ±	0.1	1.3	0.7
C.D(0.05)	-	3.7	1.9
Mean	16.2	47.2	62.4
Control	13.6	37.9	49.9
F-test	Sig.	Sig.	Sig.
S.Em	0.2	2.3	1.2
C.D(0.05)	0.5	6.7	3.5

3. POST HARVEST OBSERVATIONS

Data on yield attributing characters viz. number of panicles/m^2, number of fertile grains / panicle and weight of 1000-grains etc. are presented in the Table. 21.

3.1 Number of panicles/m^2

Data presented in the table 21 indicated that the number of panicles/m^2 under control was 149 and increased significantly due to application of treatments. Irrigation treatments caused no differential effects on the number of panicles/m^2. There were 197-200 panicles/m^2 due to application of 50-75 Kg N/ha which was significantly more than that with 25 Kg N/ha. Weed control by chemicals followed by handweedings resulted in significantly more number of panicles than by chemical or mechanical methods alone.

3.2 Length of panicle

Data presented in the Table 21 indicated that panicle length under control was 10.92 cm and increased significantly to 16.4 cm due to different treatments.(Fig.6)

There was no significant difference due to irrigation treatments. Panicle length increased significantly with N-levels upto 75 Kg/ha. The length was 15.18 cm with 25 Kg N and increased significantly to 16.5 and 17.48 cm due to application of 50 and 75 Kg N/ha, respectively.

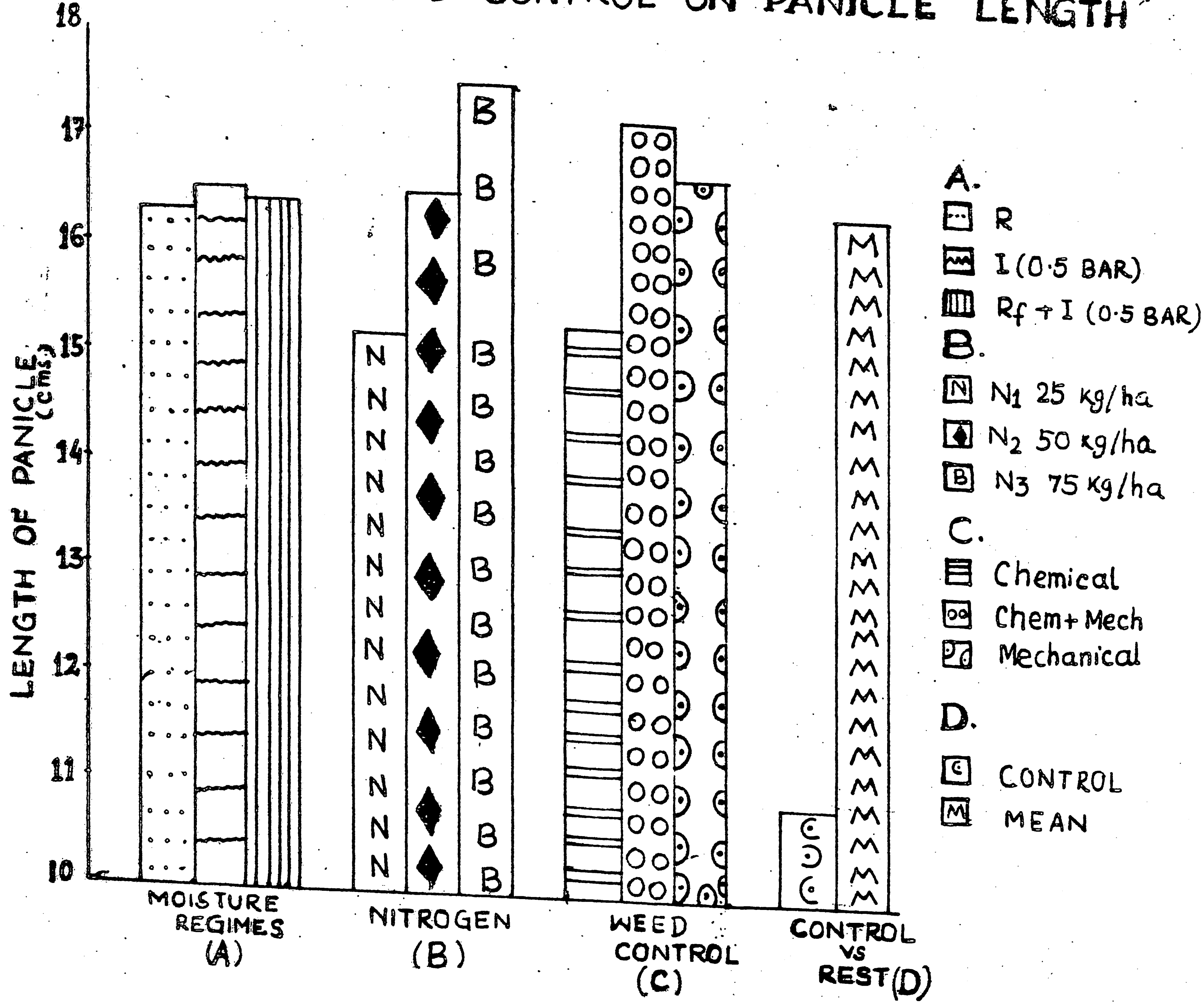
Weed control by propanil followed by handweedings resulted in significantly longer panicles than that by chemical or mechanical methods alone. Weed control by chemicals alone resulted in the shortest panicles of 15.3 cm.

TABLE 21. Effect of moisture regimes, nitrogen levels and weed control on yield attributing characters

Particulars	Yield attributing character					
	Panicle/ m^2	Length of Panicle(cm)	Spike-lets/ panicles.	Fertile grains/ panicle	% of fertile grains	1000 grain weight (g)
Moisture Regimes						
R	191.8	16.3	81.5	55.9	55.7 (68.3)*	17.78
I(0.5 bar)SMS	191.2	16.5	81.7	64.7	63.0 (79.4)*	18.31
Rf+I(0.5 bar)SMS	189.9	16.4	81.2	63.0	61.8 (77.7)*	18.28
F-test	N.S	N.S.	N.S.	Sig.	Sig.	Sig.
Nitrogen levels (Kg/ha)						
25	175.1	15.2	74.8	49.2	54.1 (65.7)*	17.78
50	197.5	16.5	83.9	64.3	61.4 (77.1)*	18.27
75	200.3	17.5	85.7	70.0	65.1 (82.3)*	18.31
F-test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Weed Control						
Chemical	182.2	15.3	77.8	51.7	54.5 (66.3)*	17.76
Chem. + Mech.	199.9	17.2	84.9	68.2	63.9 (80.7)*	18.32
Mechanical	190.8	16.7	81.6	63.6	62.2 (78.3)*	18.29
F-test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.Em ±	2.2	0.1	1.0	0.7	0.3	0.08
C.D(0.05)	6.4	0.3	2.9	2.0	0.8	0.23
Mean	191.0	16.4	81.5	61.2	60.2 (75.3)*	18.12
Control	149.0	10.9	46.5	27.5	50.4 (59.4)*	17.53
F-test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.Em ±	4.0	0.2	1.8	1.3	0.5	0.08
C.D(0.05)	11.7	0.6	5.4	3.6	1.5	0.23

* Original values are given in the parentheses.

AND WEED CONTROL ON PANICLE LENGTH



3.3 Total number of spikelets/Panicle

Data presented in the Table-21 indicated that total number of spikelets/panicle under control was 46.5 and increased significantly to 81.5 due to different treatments.

Number of spikelets/ panicle was not affected by different water management schedules and, on an average, there was 81.1 grains/panicle. Application of graded doses of nitrogen increased the number from 74.8 at 25 kg to 85.7 at 75 kg N/ha and the increase in number of grains at 75 kg N/ha however, was not significant over that at 50 kg N.

Weed control by propanil followed by handweedings gave significantly more number of total spekelets/panicle than chemical or mechanical method alone. Weed control by chemicals alone had the least number of grains/panicle.

3.4 Number of fertile spikelets/panicle

Data presented in Table 21 indicated that the number of filled grains/panicle was 27.5 under control and increased significantly to 61.2 due to different treatments.

Irrigation at 0.5 bar SMS produced the highest number of filled grains/panicle (64.7) which was at par with irrigation (0.5 bar SMS) from flowering to maturity. Both were significantly superior to rainfed treatment that had 55.9 filled spikelets/panicle.

The number of filled spikelets per panicle was 49.0 with 25 kg N/ha and increased significantly to 64 and 70 due to application of 50 and 75 kg/ha, respectively.

Weed control by propanil followed by handweedings recorded minimum of 68.2 filled spikelets/panicle. Weed control either by chemcials alone or mechanical alone was significantly inferior to the former treatment.

Interaction of nitrogen x weed control was found significant (Table 22). These data indicated that 75 kg N/ha and weed control by propanial followed by hand weedings gave maximum number of 77.4 filled grains/panicle which was at par with that of 75 kg/ha and weed control by mechanical means (74.8). These two were significantly superior to all other treatment combinations.

TABLE-22. Nitrogen x weed control on number of filled grains/panicle

Particulars	Methods of weed control		
	Chemical	Chm. + Mech.	Mechanical
N levels (kg/ha)			
25	41.2	56.8	49.6
50	56.0	70.5	66.3
75	57.9	77.4	74.8
SEm ±	1.2		
C.D.(0.05)	3.5		

3.5 Filled grain percentage

Data on filled grain percentage were converted to angular values and the transformed data were analysed statistically. The original values have been given in parentheses. The filled grain percentage under control was 50.4 (59.4) and increased significantly due to different treatments.(Fig.7)

Irrigation as and when needed gave highest percentage of filled grains 63.0 (79.4) which was significantly more than that due to rainfed or irrigation from flowering to maturity.

Percentage of filled grains also increased with increasing the levels at N. With 25 kg N, the value was 54.1% and increased significantly to 61.4 and 65.1 respectively due to application of 50 and 75 kg N/ha.

Weed control by chemicals followed by hand weedings gave 63.9 (80.7) per cent filled grains which was significantly more than chemical or mechanical method of weed control alone.

The interaction of nitrogen x weed control was found significant and these data are presented in Table (c).

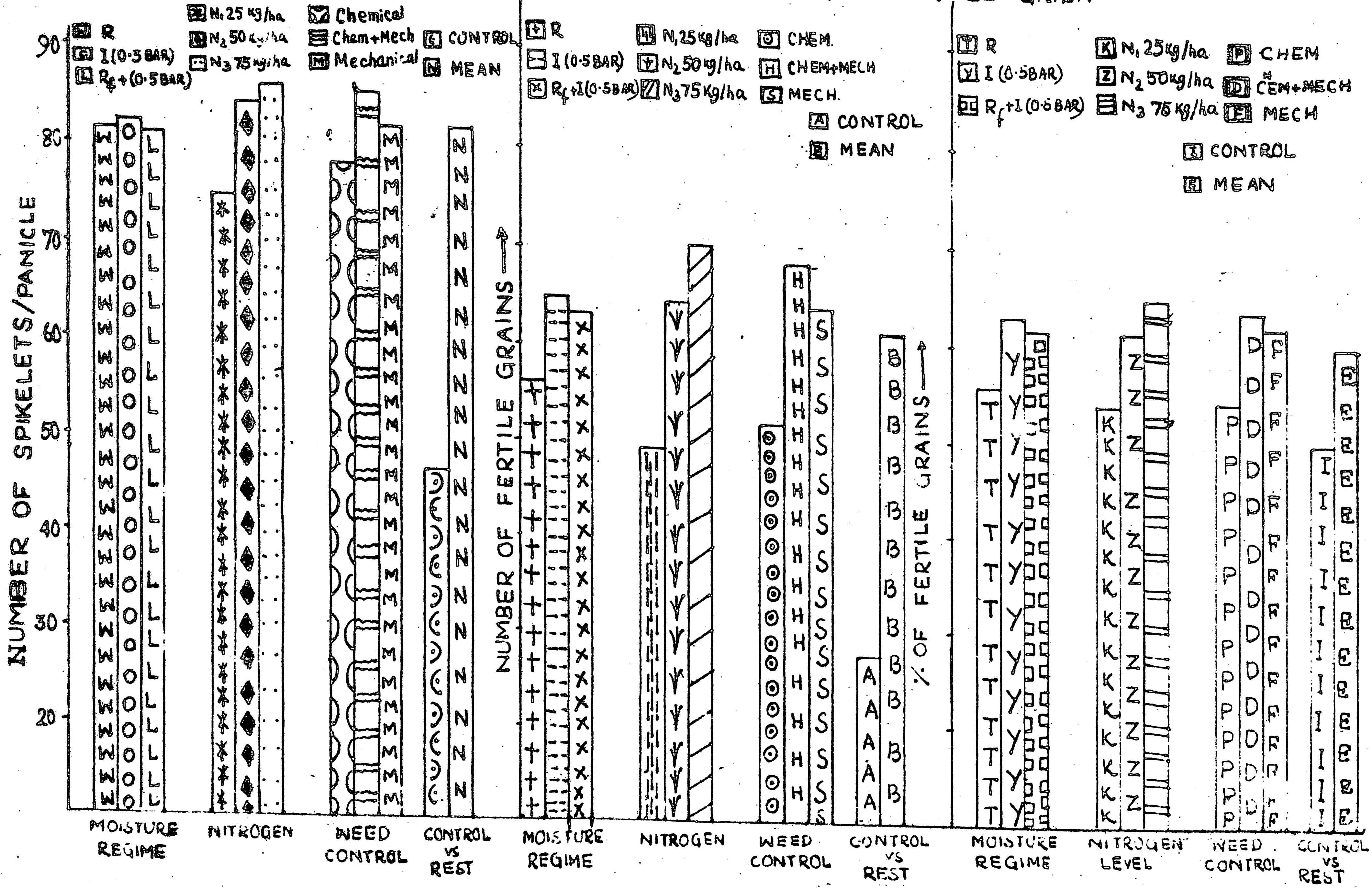
Filled grain percentage increased significantly with increase in N levels at each method of weed control and likewise, at each level of nitrogen chemical weed control followed by handweeding gave maximum percentage of filled grains which significantly superior to other methods of weed control. Application of 75 kg N/ha and mechanical method of weed control gave 69.1 % filled grains which was at par with that from 75 kg N and weed control by propanil followed by handweeding (68.4 %). These two were significantly supeтior to all other combinations.

Table 23. Nitrogen x weed control on percentage of filled grains.

Particulars	Weed control methods		
	Chemical	Chem. + Mech.	Mechanical
Nitrogen levels(kg/ha)			
25	50.02 (58.7)	57.59 (71.3)	54.68 (66.6)*
50	55.52 (68.0)	65.73 (83.1)	62.88 (79.2)
75	57.85 (71.7)	68.40 (86.5)	69.13 (87.3)
S.Em ±	0.48		
C.D(0.05)	1.38		

* Original values are given in the parentheses.

OF SPIKELETS, NUMBER OF FERTILE GRAIN AND % OF FERTILE GRAIN



3.6 1000-grain weight

1000-grain weight under control was 17.5 g. Application of treatments increased this value significantly to 18.12.

Irrigation as and when needed resulted in heaviest grains weighing 18.31 g/1000 which was at par with that under irrigation from flowering to maturity.

Application of nitrogen increased the weight of grains too. The 1000-grain weight due to application of 25 Kg N increased significantly to 18.2 and 18.3 g due to application of 50 and 75 Kg N/ha, though difference between these two values was not significant.

Weed control by propanil followed by handweedings gave the highest 1000-grain weight which was at par with that obtained from mechanical weedcontrol alone. Both these treatments were significantly superior to weed control only by chemicals. (Table 21).

3.7 Grain Yield

Data presented in Table 24 indicated that grain yield under control was 6.76 q/ha and increased to 21.26 quintals due to adoption of different cultural practices. (Fig.8).

The average yield under rainfed conditions was 19 q/ha and increased to 22 quintals due to irrigation at 0.5 bar SMS throughout the growth period or only after flowering. Depending on the rainfall pattern irrigation after flowering and throughout the growth period proved equally effective.

Application of nitrogen at 75 Kg/ha gave the highest yield (23.72 q/ha) which was significantly superior to that from application of 25 and 50 Kg N/ha. The crop responded quadritically upto 75 Kg N/ha.

The yield was affected significantly by weed management practices. Weed control by chemicals only gave the minimum of 18.43 q/ha. Mechanical weed control produced 22.34 q/ha which was more than chemical method. Weed control by propanil followed by handweedings recorded maximum yield 23.03 q/ha which was significantly superior to that obtained from weed control either by chemical or mechanical means.

Of the interactions, only nitrogen x weed control was found significant (Table 25). Irrespective of the method of weed control the yield increased with the levels of nitrogen and maximum yield was obtained from application of 75 Kg N/ha and mechanical weed control which was at par with 75 Kg N and weed control by chemicals followed by handweedings.

Response curve

To findout the nature of response to applied N, the sum of squares was split into linear and quadratic components. Both components were found significant. The second degree response equation was fitted.(Fig.9)

The response equation was =

$$Y = 18.265 + 0.17432\ x - 0.0013056\ x^2$$

$$Y\ max = \frac{-b}{2C}$$

$$\text{Economic optimum dose} = \frac{1}{2c}\ (q/p\ -b)$$

Where : q = Cost of unit fertiliser nutrient (Rs/Kg nutrient

The cost of nitrogen/Kg in terms of urea = Rs.4.95

P = The price of produce in rupees per quintal.

The price of 1 quintal paddy = Rs.137/-

b_1 & C are regression co.efficients.

$$\text{The maximum dose} = \frac{-b}{2C} = \frac{-0.17432}{2x0.0013056} = 66.75\ \text{Kg/ha.}$$

At this level of nitrogen the yield Y = 24.08 q/ha.

$$\text{The optimum dose} = \frac{1}{-(2x0.0013056)}\ (\frac{4.95}{137} - 0.17432)$$

$$= \frac{1}{-0.0026112}\ (0.0361313 - 0.17432)$$

$$= \frac{1}{(-0.0026112)}\ (-\ 0.1381885)$$

$$= 52.921497$$

$$= 52.921\ \text{Kg N/ha.}$$

At this level of N, Y = 23.83 q/ha.

3.8 <u>Straw yield</u>

Data presented in the Table 24 indicated that straw yield under control was 8.94 q/ha. Application of treatments increased this yield to 25.43 q/ha.(Fig.8)

Irrigation at 0.5 bar produced maximum yield of 27 q/ha which was significantly more than rainfed throughout or irrigation from flowering to maturity but 0.5 bar SMS. The completely rainfed treatment produced the least straw yield of 23 q/ha.

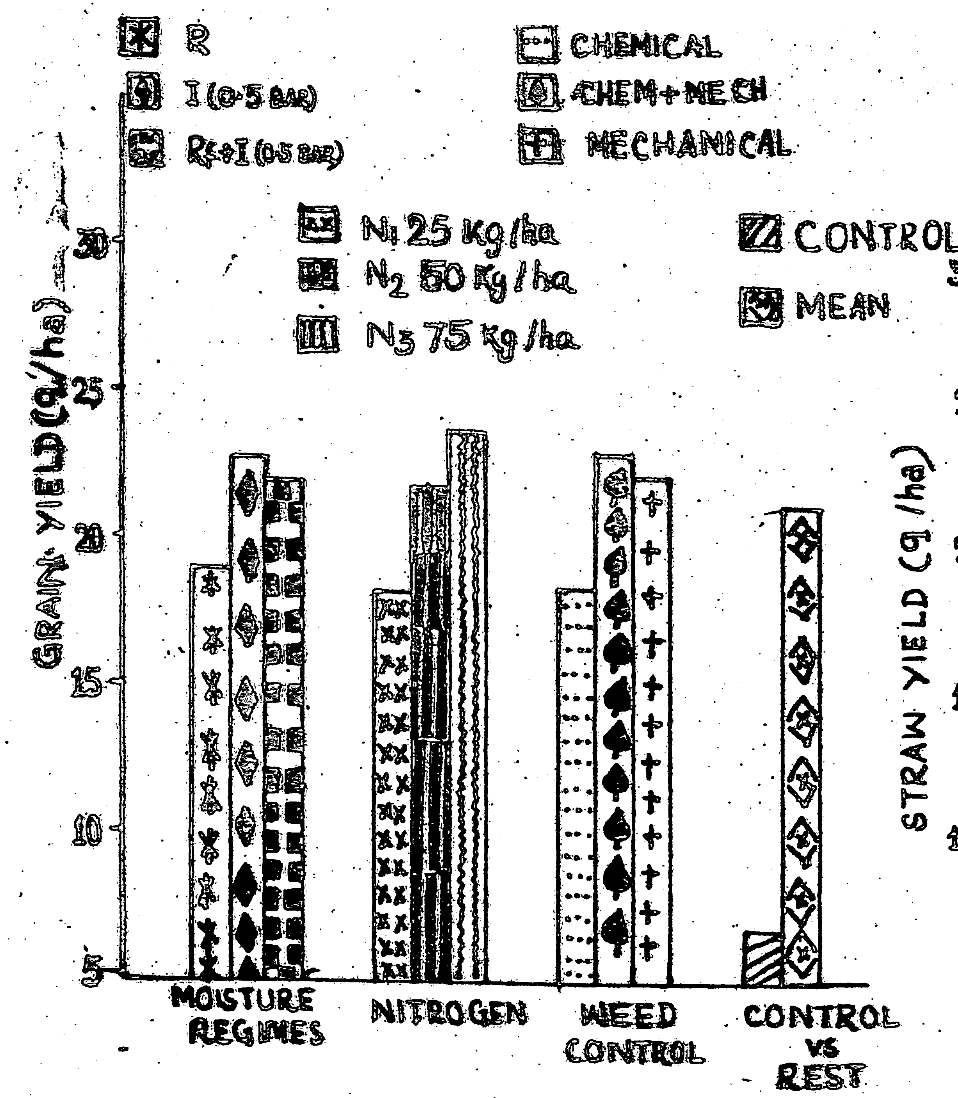
Similar to grain yield, straw yield also increased with increasing levels of N. With 25 kg N/ha, the straw yield was 22.3 and increased to 25.99 and 27.99 q/ha due to application of 50 and 75 kg N respectively. The response was also quadratic.

$$Y = 22.2919 + 0.182012\ x - 0.001356\ x^2$$

<u>Interaction of nitrogen x weed control was found (Table 26)</u>

Significant (table 26). At same method of weed control the straw yield increased with increasing the level of N upto 75 kg N/ha tried. Weed control by propanil followed by hand weedings recorded the maximum straw yield of 27.99 q/h which was significantly more than each of the yields obtained under all other treatment combinations of N and weed control.

Fig. 8: EFFECT OF MOISTURE REGIMES, NITROGEN LEVELS AND WEED CONTROL ON GRAIN AND STRAW YIELD (q/ha)



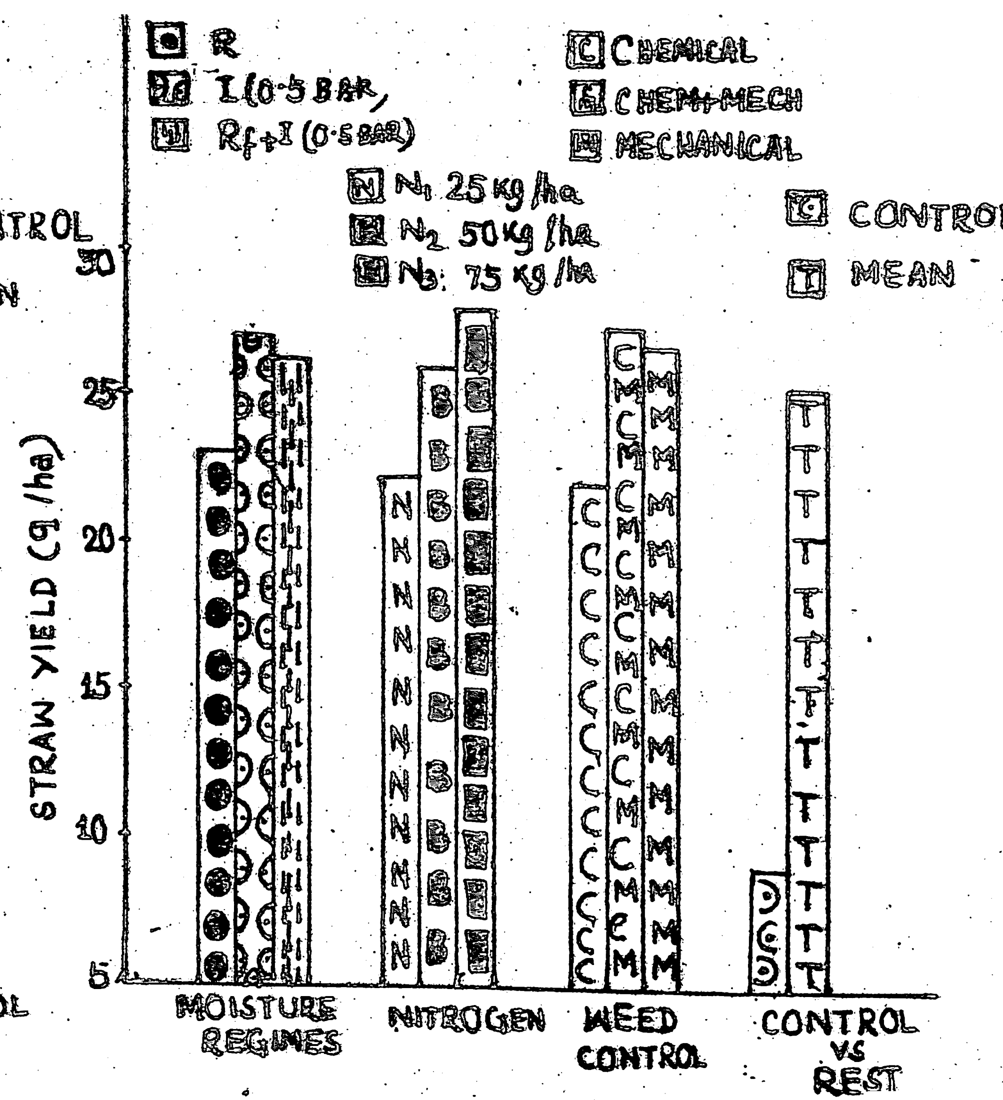


Fig:9- RESPONSE OF THE VARIETY TO NITROGEN LEVELS

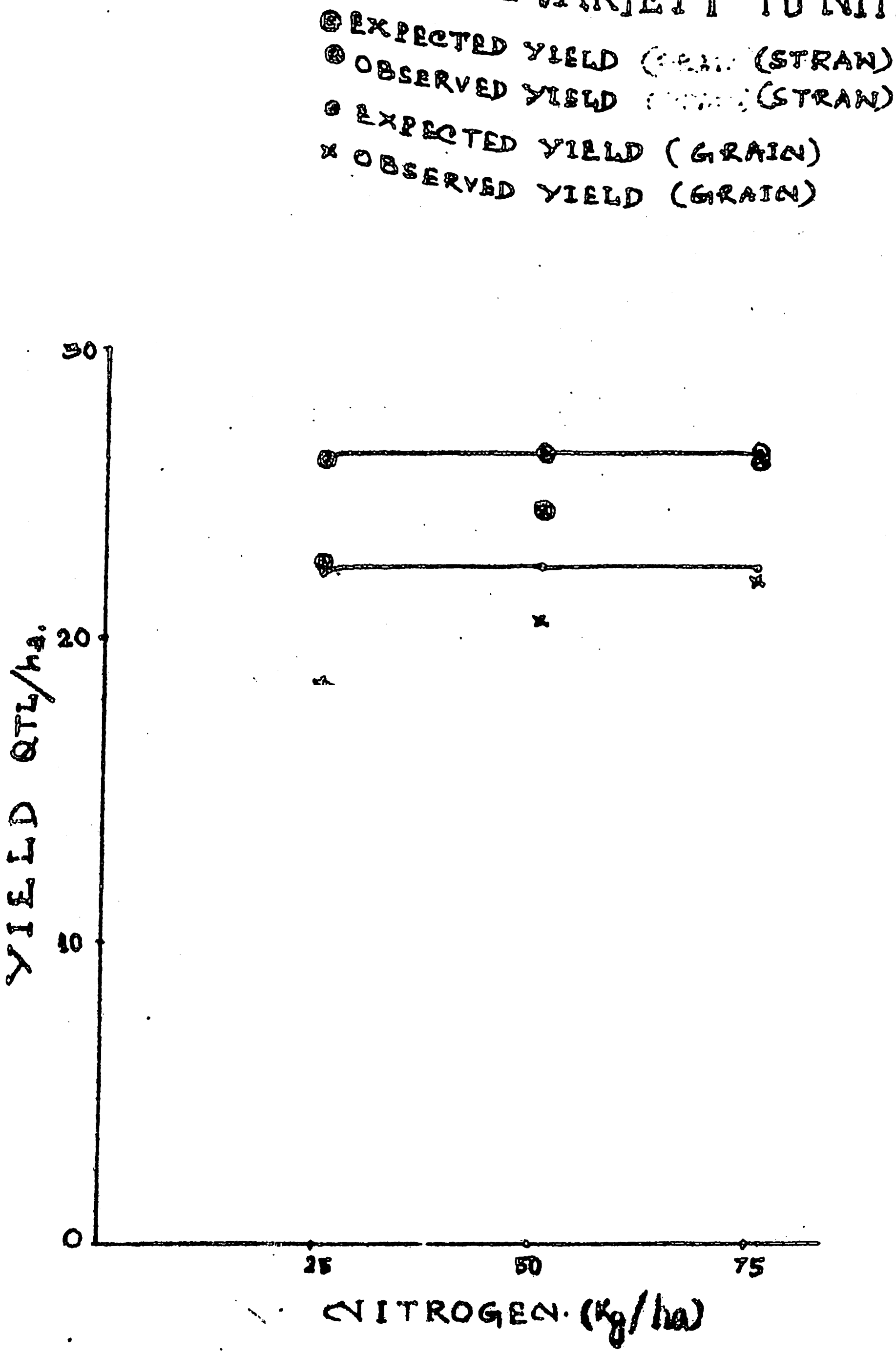


TABLE 24. Grain and Straw yield as affected by treatments

Particulars	Yield q/ha	
	Grain	Straw
Moisture Regimes		
R	19.00	23.07
I(0.5 bar)	22.75	27.01
Rf + I(0.5 bar)	22.04	26.21
F-test	Sig.	Sig.
Nitrogen levels(kg/ha)		
25	18.27	22.31
50	21.81	25.99
75	23.72	27.99
F-test	23.72	27.99
Weed control		
Chemical	18.43	22.19
Chem. + Mech.	23.03	27.35
Mechanical	22.34	26.75
F-test	Sig.	Sig.
S.Em ±	0.16	0.24
C.D.(0.05)	0.46	0.68
Mean	21.26	25.43
Control	6.76	8.94
F-test	Sig.	Sig.
S.E(M)	0.29	0.43
C.D.(0.05)	0.84	1.25

TABLE 25 Effect of nitrogen x weed control on grain yield (q/ha)

Particulars	Weed control methods		
	Chemical	Chem. + Mech.	Mechanical
Nitrogen levels(kg/ha)			
25	15.62	20.29	18.88
50	19.29	23.64	22.54
75	20.43	25.14	25.59
S.Em ±	0.27		
C.D. (0.05)	0.80		

TABLE 26. Interaction of nitrogen and weed control on Straw yield (q/ha)

Particulars	Weed control methods		
	Chemical	Chem. + Mech.	Mechanical
Nitrogen level(kg/ha)			
25	19.28	24.60	22.31
50	22.97	27.96	29.99
75	23.34	29.47	27.99
S.Em ±	0.41		
C.D.(0.05)	1.18		

3.9 Grain straw ratio

Data presented in the Table 27 indicated that the grain: straw ratio was 0.76 under control. Application of treatments increased the grain: straw ratio to 0.835. Irrigation at 0.5 bar recorded maximum grain. Straw ratio which was at par with irrigation from flowering to maturity. The rainfed condition produced the lowest grain: straw ratio, significantly inferior to both irrigation at 0.5 bar through and rainfed before flowering. (Fig.10).

Application of 75 kg N/ha recorded the highest grain: straw ratio of which was at par with 50 kg N/ha and significantly more than the lowest dose of 25 kg N/ha (0.82).

Weed control by propanil followed by handweeding resulted in the highest grain:straw ratio 0.843 which was at par with weed control by mechanical method (0.834). These two methods of weed control were significantly superior to weed control by chemicals alone.

3.10 Harvest Index (HI)

Data presented in the Table 27 indicated that harvest index under control was the least and increased significantly due to treatments of weed control, fertilisation and irrigation. (Fig.10)

Irrigation at 0.5 bar gave the highest harvest index which was at par with irrigation from flowering to maturity. Rainfed condition recorded the lowest HI and was significantly interior to each of the irrigation treatments.

Harvest Index was minimum (44.8) due to application of 25 kg/ha and increased to 45.6 and 45.9 due to application to 50 and 75 kg which were at par.

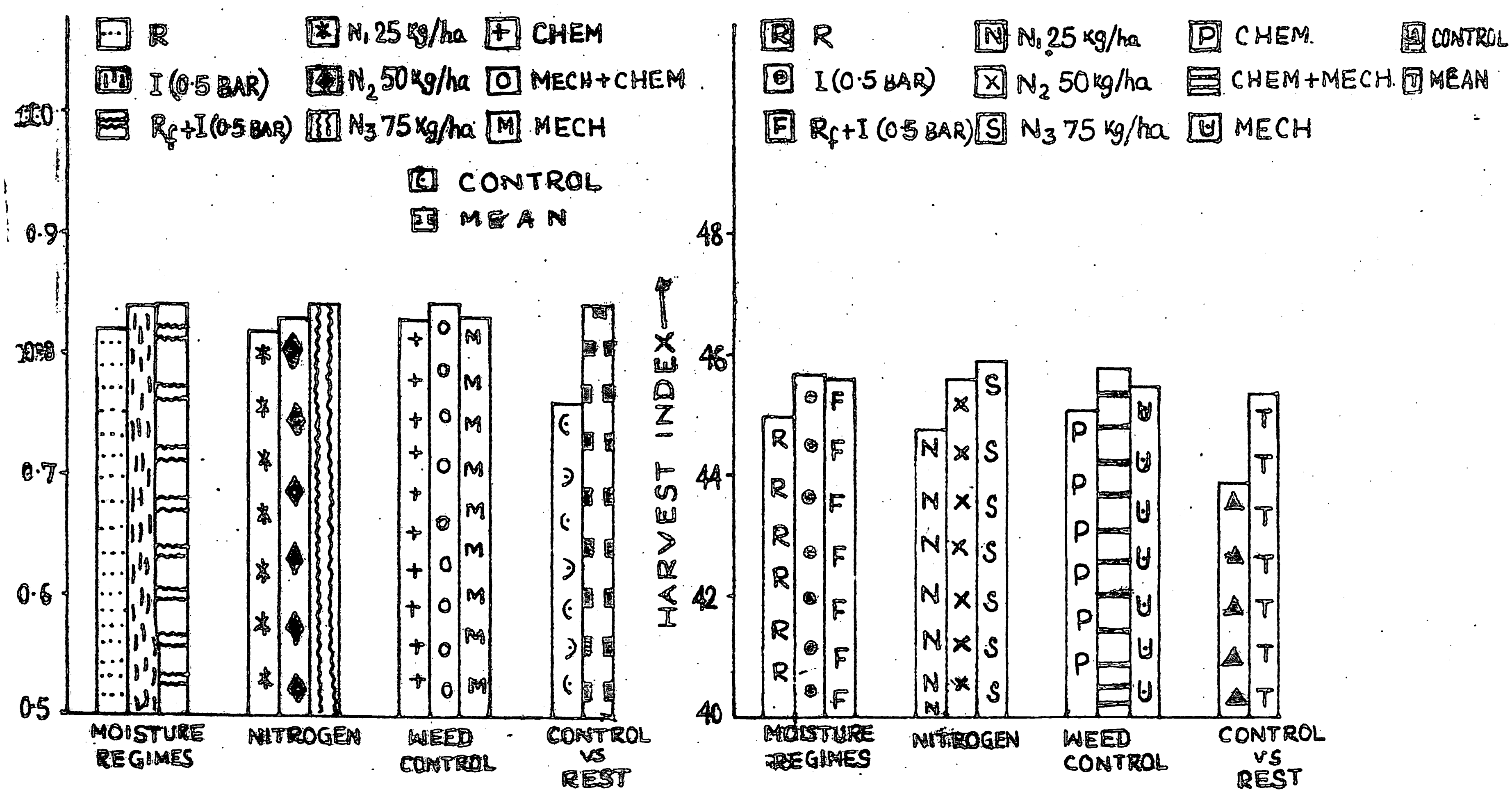
Weed control by propanil followed by hand weedings and mechanical method alone recorded HI values 45.80 and 45.50, respectively, both of which were at par but significantly superior to weed control by only chemicals.

TABLE 27. Effect of Moisture Regimes, Nitrogen levels and weed control methods on grain straw ratio and harvest index

Particulars	Characters	
	Grain:straw ratio	Harvest Index
Moisture Regimes		
R	0.823	42.14 (45.00)*
I(0.5 bar SMS)	0.843	42.54 (45.70)
R_f + I(0.5 bar) sms	0.839	42.48 (45.60)
F-test	Sig.	Sig.
Nitrogen levels(Kg/ha)		
25	0.820	42.03 (44.80)
50	0.838	42.49 (45.60)
75	0.847	42.63 (45.90)
F-test	Sig.	Sig.
Weed control		
Chemical	0.828	42.16 (45.10)
Chem. + Mech.	0.843	42.57 (45.80)
Mechanical	0.834	42.42(45.50)
F-test	Sig.	Sig.
S.Em ±	0.004	0.09
C.D(0.05)	0.011	0.27
Mean	0.835	42.38 (45.4)
Control	0.797	40.93 (43.9)
F-test	Sig.	Sig.
S.Em ±	0.007	0.17
C.D.(0.05)	0.019	0.49

* Original values all given in the parenthesis.

Fig. 10: EFFECT OF MOISTURE REGIMES, NITROGEN LEVELS AND WEED CONTROL ON GRAIN: STRAW RATIO AND HARVEST INDEX



4. NUTRIENT CONTENT AND UPTAKE

4.1 Nutrient content

The contents of N, P_2O_5 and K_2O in grain and 0.28 and under control were 0.95,0.57 increased due to irrigation by about 5.76, 6.45 and 6.45 % respectively. Irrigation after flowering or as and when necessary throughout the crop growth period had no appreciable differential effect. The content of these nutrients also increased in straw due to irrigation (Table 28).

Contents of N, P_2O_5 and K_2O in grain did not vary due to levels of N but their contents increased in the straw, the increase being 10.34, 8.33 and 4.37 % with respect to N, P_2O_5 and K_2O at 75 kg level as compared to those at 25 kg level.

In chemically weed controlled plots, contents of these nutrients were the least. Weed control by chemical + mechanical or mechanical method alone increased the content by about 5.83, 3.17 and 9.68% in grain and 6.89, 13.04 and 3.85 %, respectively, in straw.

4.2 Nutrient uptake

The average yield of control plots was 6.76 quintal grain and 8.94 quintal straw/ha and this crop removed 6.42 kg N, 3.85 kg P_2O_5 and 1.89 kg K_2O through grain and 5.27 kg N, 1.27 kg P_2O_5 and 10.09 kg K_2O through straw amounting to total uptake of 11.69 kg N, 5.12 kg P_2O_5 and 17.98 kg K_2O/ha. When yield due to different treatments increased to 21.26 q grain and 25.43 q straw/ha the respective uptake values increased to 22.75 kg N, 13.82 kg P_2O_5 and 7.02 kg K_2O by grain and 15.26 kg N, 6.32 kg P_2O_5, 47.55 kg K_2O by straw amounting to total uptake of 38.01 kg N, 20.18 kg P_2O_5 and 54.58 kg K_2O/ha. The treatment that produced maximum grain yield of 27.26 q/ha removed 28.9 kg N, 16.4 kg P_2O_5 and 9.0 kg K_2O/ha and the treatment producing maximum yield of q grain and 31.4 q/straw removed 18.2 kg N, 8.2 kg P_2O_5, 59.0 kg K_2O/ha.

TABLE 28. EFFECT OF MOISTURE REGIMES, NITROGEN LEVELS AND WEED CONTROL ON N, P_2O_5, K_2O CONTENT IN GRAIN AND STRAW

Particulars	N Content(%)		P_2O_5 Content(%)		K_2O Content(%)	
	Grain	Straw	Grain	Straw	Grain	Straw
Moisture regimes						
R	1.04	0.59	0.62	0.23	0.31	1.85
I(0.5 bar)	1.10	0.61	0.66	0.26	0.33	1.88
Rf+I(0.5 bar)	1.07	0.61	0.66	0.25	0.34	1.88
Nitrogen level (kg/ha)						
25	1.07	0.58	0.64	0.24	0.32	1.83
50	1.07	0.60	0.65	0.25	0.32	1.86
75	1.07	0.64	0.66	0.26	0.34	1.91
Weed control methods						
Chemical	1.03	0.58	0.63	0.23	0.31	1.82
Chem. + Mech.	1.05	0.61	0.65	0.26	0.33	1.89
Mechanical	1.14	0.62	0.66	0.25	0.34	1.90
Mean	1.07	0.60	0.65	0.25	0.33	1.87
Control	0.95	0.59	0.57	0.20	0.28	1.80

TABLE 29. EFFECT OF MOISTURE REGIMES, NITROGEN LEVELS AND WEED CONTROL ON N, P_2O_5, K_2O UPTAKE BY GRAIN AND STRAW AND TOTAL UPTAKE

Particulars	N uptake(kg/ha)			P_2O_5 uptake(kg/ha)			K_2O Uptake (kg/ha)		
	Grain	Straw	Total	Grain	Straw	Total	Grain	straw	Total
Moisture Regimes(MR)									
R	19.76	13.61	33.37	11.78	5.31	17.09	5.89	42.68	48.57
I(0.5 bar)	25.03	16.48	41.51	15.02	7.02	22.04	7.50	50.78	58.29
Rf+I(0.5bar)	23.58	15.99	39.57	15.55	6.55	22.10	7.49	49.27	56.76
Nitrogen levels(kg/ha)									
25	19.55	12.94	32.49	11.69	5.35	17.04	5.85	40.83	46.68
50	23.34	15.59	38.93	14.18	6.50	20.68	6.98	48.34	55.23
75	25.38	17.91	43.29	15.66	7.28	22.93	8.06	53.46	61.52
Weed control Methods									
Chemical	18.98	12.87	31.85	11.61	5.10	16.71	5.71	40.39	46.10
Chem. + Mech.	24.18	16.68	40.86	14.97	7.11	22.08	7.60	51.69	59.29
Mechanical	25.47	16.59	42.06	14.74	6.69	21.43	7.60	50.83	58.43
Mean	22.75	15.26	38.01	13.82	6.36	20.18	7.02	47.55	54.58
Control	6.42	5.27	11.69	3.85	1.27	5.12	1.89	16.09	17.98

5. Correlation Studies

The values of simple correlation coefficient 'r' are represented in the table (Table 30).

TABLE 30. CORRELATION COEFFICIENTS OF DIFFERENT YIELD ATTRIBUTING CHARACTERS WITH GRAIN YIELD

Sl. No.	Characters x	y	Correlation Coefficient. r
1.	Height	Grain yield	0.82*
2.	LAI	"	0.86*
3.	Number of panicles/m^2	"	0.72*
4.	Panicle length	"	0.92*
5.	Number of spikelets/ panicle	"	0.83*
6.	Percentage of fertile grains.	"	0.89*
7.	Thousand grain wt.	"	0.85*
8.	Nitrogen content in grain	"	0.71*
9.	Nitrogen content in the Straw	"	0.64*
10.	P_2O_5 content in grain	"	0.75*
11.	P_2O_5 content in the straw	"	0.77*
12.	K_2O content in grain	"	0.67*
13.	K_2O content the straw	"	0.75*

* Significant at 5% level of significance

Data on correlation coefficient (Table 30) showed that maximum plant height and LAI had significant positive correlation with grain yield (0.82 and 0.86 respectively). All yield attributing characters, i.e., number of panicles/m^2, panicle length, number of spikelets/panicle, percentage of fertile grains, thousand grain weight were positively correlated with grain yield. Study of correlation between N, P_2O_5, K_2O content of grain and straw showed that there existed a significant positive correlation between these characters and grain yield also.

6. IRRIGATION STUDIES

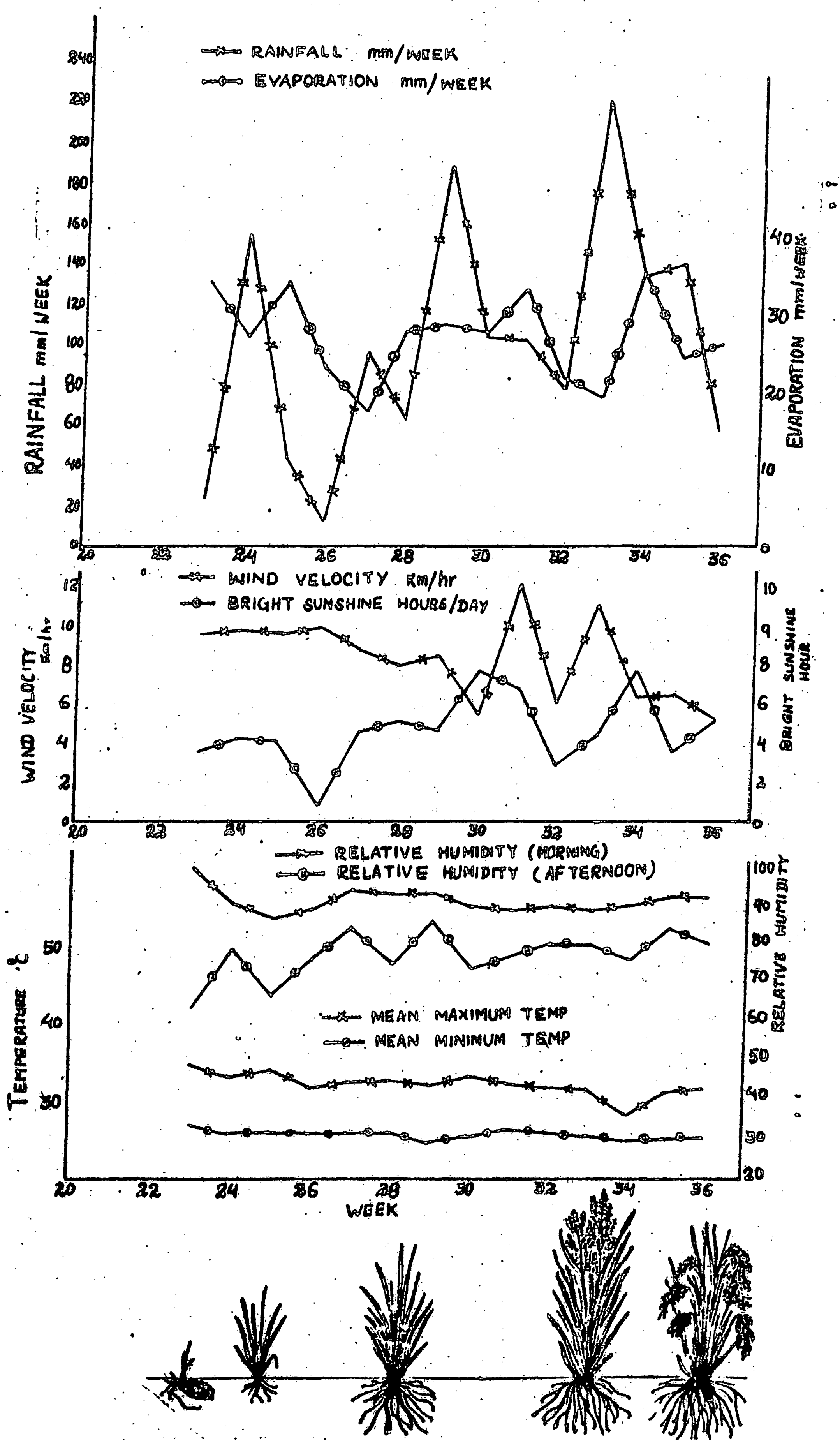
6.1. Weekly Weather Parameters(Table 31).

The crop matured in 98 days (8.6.84 to 13.9.84). The crop experienced narrow variation in temperature (maximum and minimum) and relative humidity during the cropping season. At sowing (23rd meteorological week) the maximum temperature was 34.7°C and dropped to 31.3°C at ripening. The minimum temperature during this period decreased from 27.1°C to 25.0°C. The morning RH was 99% at sowing and 91% at ripening. Data on rainfall and evaporation would indicate that only for 2 weeks rainfall was less than evaporation (Figure-11)

TABLE-31 WEEKLY WEATHER PARAMETERS

Week	Mean Maximum Temp (°C)	Mean Minimum Temp. (°C)	RH Morning (%)	RH After noon (%)	Wind velocity (Kms/ hr.)	Rain fall (mm/ Week)	Evaporation (mm/ week.)	Bright Sunshine hours/ day
23	34.7	27.1	99	63	9.5	22.9	33.0	3.5
24.	32.8	25.8	90	78	9.7	154.8	26.0	4.1
25	33.7	25.9	86	66	9.5	44.2	32.9	3.9
26	31.0	25.1	88	75	9.9	12.1	22.0	0.7
27	32.0	25.4	93	83	8.7	95.9	16.7	4.5
28	32.4	25.6	92	74	7.9	62.7	26.9	5.0
29	31.6	24.5	92	85	8.4	191.4	27.8	4.5
30	32.8	25.3	89	73	5.3	104.5	26.8	7.6
31	31.8	26.0	88	76	12.0	104.1	32.0	6.7
32	31.2	25.7	89	79	5.9	79.4	21.1	2.7
33	31.0	25.2	88	79	11.0	225.7	18.4	4.2
34	32.9	24.8	89	75	6.2	137.1	34.9	7.6
35	30.7	24.9	91	83	6.3	143.6	23.8	3.4
36	31.3	25.0	91	79	5.1	58.6	25.6	4.9

Fig-11 WEEKLY WEATHER PARAMETERS



6.2. Variation in Profile Moisture Content

Data on variation of moisture content as observed in weekly basis are been given in the table-32 . At sowing soil moisture content was below field capacity. The field remained almost saturated throughout the cropping season except during 24th and 25th meteorological weeks coinciding with seedling stage, and 27th week and finally during 31st and 32nd week coinciding with flowering stage of the crop. As such the crop did not suffer from serious moisture stress.

TABLE-32 VARIATION IN MOISTURE CONTENT IN RAINFED PLOTS THROUGHOUT CROPPING SEASON

Particulars	P.C. Moisture (Oven dry basis)		Remarks
	0-15 cm	15-30 cm	
8.6.84	9.5	11.2	Below FC
17.6.84	18.2	20.5	Saturated
24.6.84	9.4	12.5	Below FC
1.7.84	9.0	12.0	Below FC
8.7.84	17.9	19.8	Saturated
15.7.84	11.0	14.5	Below FC
22.7.84	10.6	13.5	Saturated
29.7.84	11.1	14.6	Saturated
5.8.84	10.9	14.8	Below FC
12.8.84	11.0	14.5	Below FC
19.8.84	9.5	12.6	Below FC
26.8.84	18.2	19.8	Saturated
20.9.84	18.0	19.2	Saturated
9[illegible].9.84	18.1	19.3	Saturated
13.9.84	9.3	10.8	Below FC

6.3 Soil Moisture Characteristic Curve

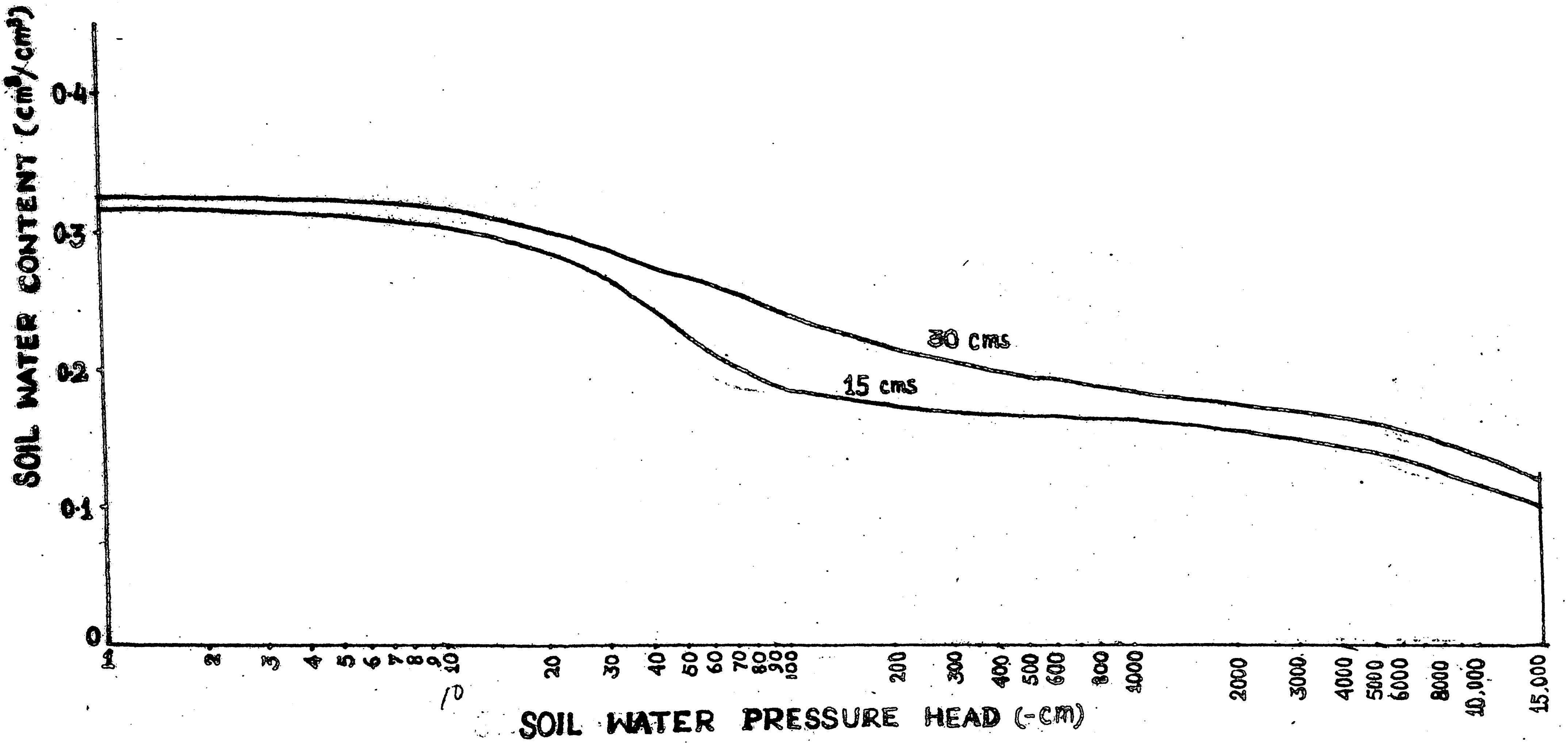
Soil samples were collected from 15 and 30 cm depth. Moisture content was determined by pressure membrane apparatus and the soil moisture characteristic curve was plotted. (Fig. 12). Data are presented in volume (cm^3/cm^3) basis. At 0 bar suction (= 0) moisture contents of 1st and 2nd layers were 31.8 and 32.4 % respectively and the contents at - 15 bar are 11.7 and 13.3 % volume. At field capacity (0.1 bar SMS) the moisture contents were are 24 % and 19% (cm^3/cm^3) for 1st and 2nd layers respectively (Table 33)

TABLE 33. SOIL WATER CHARACTERISTIC CURVE VALUES FOR DIFFERENT SOIL DEPTH (SOIL WATER CONTENT (θ = cm^3)/cm^3)

Particulars (h) in - cm	Soil depth (cm) 15	30
Pressure head(-cm)		
0	0.318	0.324
15	0.298	0.288
30	0.268	0.288
45	0.237	0.273
60	0.216	0.262
75	0.204	0.254
90	0.197	0.249
105	0.189	0.243
120	0.185	0.239
330	0.170	0.205
1000	0.167	0.185
5000	0.139	0.160
10,000	0.117	0.133
15,000	0.105	0.120

Based on three soil cores.

Fig. 12: SOIL WATER CHARACTERISTIC CURVES



6.4 Profile Moisture deficit and Effective Rainfall

These values were calculated as a simple daily book keeping procedure taking soil moisture content from 0-30 cm layer upto field capacity and open pan evaporation into account. Weekly calculations for these components are given in Table 34. Out of total rainfall of 1408 mm during 98 days of crop season 25% was accounted for evaporation. At the start of the crop, the deficit in the profile was 13.6 mm. Adding this to evaporation the value comes to 376.4 mm. Due to intermittent rainfall soil moisture content for same days remained at Saturation. The difference between maximum water holding capacity and field capacity upto 30 cm depth is 3.2 cm. Hence the total effective rainfall comes to 373.9 mm.

During the season for 53 days the moisture content remained below filed capacity and only during end of June moisture deficit fell to 30.5 cm equivalent 65% of available moisture. As such the crop did not suffer from serious moisture defit at any stage of growth.

TABLE 34. PROFILE MOISTURE DEFICIT AND EFFECTIVE RAINFALL

Meteorological week.	Rain fall (mm)	Evaporation (mm)	Deficit at the end of week (mm)	No. of deficit days	Excess (mm)	Effective rainfall (mm)
8-6-84 to 10.6.84	6.3	15.7	23.0	3	-	6.3
23	154.8	26	0	4	105.8	49
24	44.2	32.9	20.6	5	31.9	12.3
25	12.1	22	30.5	7	-	12.1
26	95.9	16.7	0	3	48.7	47.2
27	62.7	26.9	10.2	3	46.0	16.7
28	186.0	27.8	0	2	153.4	38
29	104.5	26.8	4.6	4	82.3	22.2
30	104.1	32.0	14.6	3	82.1	22.0
31	79.4	21.1	7.0	4	50.7	28.7
32	226.2	18.4	6.4	3	207.2	19.0
33	137.1	34.9	0	2	95.8	41.3
34	122.9	23.8	0	3	99.1	23.8
35	38.6	25.6	0	4	33.0	25.6
10.9.84 to 13.9.84	33.2	12.8	3.1	2	23.5	9.7
	1408.0	363.4	-	52	1059.5	373.9

6.5 WATER USE EFFICIENCY

Water Requirement

(WR) = Effective rainfall + irrigation + profile contribution. From data on evaporation, rainfall and moisture upto FC in 0-30 cm layer effective rainfall was estimated (table Plots irrigated at 0.5 bar sms throughout the season received 2 irrigations of 5 cm each (seedling stage and flowering stage). Thus total irrigation requirement was 100 mm. The total water requirement including the profile contribution was 475.4 mm. Plots irrigated from flowering to maturity received only one irrigation at flowering stage. The total water requirement was 425.4 mm.

WUE_g and WUE_{TD} were 51.8 and 113.4, 50.6 and 112.1, 47.9 and 104.7 kg/ha/cm. for irrigation from flowering to maturity, rainfed and irrigation throughout the cropping season, Thus irrigation from flowering to maturity was most efficient whereas irrigation throughout was the least. (Table 35).

TABLE 35 WATER USE EFFICIENCY AS AFFECTED BY MOISTURE REGIMES

Particulars	Effective rain fall(mm)	Irrigation (mm)	Moisture used from profile(mm)	Water requirement (mm)	Grain yield (kg/ha)	Straw yield (kg/ha)	Total (kg/ha)	WUE_g (kg/ha/cm	WUE_{TD} (kg/ha/cm)
Irrigation									
R	373.9	0	1.5	375.4	1900	2307	4207	50.6	112.1
I(0.5 bar)	373.9	100.0	1.5	475.4	2275	2701	4976	47.9	104.7
Rf+I									
(0.5 bar)	373.9	50.0	1.5	425.4	2204	2621	4825	51.8	113.4

CHAPTER—V

DISCUSSION

D I S C U S S I O N

In the preceeding chapter data on effects of irrigation, levels of nitrogen and methods of weed control on growth, yield, water requirement, water use efficiency etc., on the upland rice variety 'Keshari' have been presented. In this Chapter an attempt has been made to establish cause and effect relationship among them and to assign the reasons for the variability, if any.

Growth and Yield

Growth has been defined by Webster as the progressive development of an organism and it represents the aggregate incluence of a large number of attributes determined at different stages of growth that contribute directly or indirectly to yield. The magnitude of each attribute is determined at certain stage of plant growth.

The relationship between grain yield and components of yield can be expressed as

Grain Yield = f (Number of panicles/ m^2, number of spikelets/ panicle, % of filled spikelets. Weight of grains) . The existence of significant positive correlation between yield and different yield attributes substantiated that increase in any one or in all of the characters would increase yield (Hasegawa, et al, 1958) In a determinate plant like rice the vegetative and reproductive growth phases are welldefined. Formation of flower primordia, indicates, the timing of switching over of the vegetative growth to reproductive growth.

In a short duration rice variety of 98 days, the vegetative lag period is hardly 4-5 days and maximum tillering phase coincides with flower Primordia initiation. Within 7-10 days of flower primordia initiation, the length of the panicle, number of grains and their size are fixed. Cultural practices upto flower primordia initiation decide the number of panicles per unit area and at subsequent stages the panicle characters. Each phase has a definite bearing on the next. The earlier phase serves as a source to the later stage- the sink, It is the relative capacity and intensity of each that determines the yield.

Irrigation

In this investigation, the treatment irrigated throughout the cropping season recorded the maximum grain and straw yield. This is followed by irrigation from flowring to maturity and rainfed treatments in order .This can be explained by analysing the variation in growth and developmental characters. There was not much difference between irrigation from flowering to maturity and irrigation treatment the cropping season. Though the seedling stage experienced slight stress, it did not affect any of the yield attributing characters determined at later stages. Yield and path co-efficient analysis for different varieties of rice (Lenka and Mishra, 1973) indicated the relative contribution of tillers length of panicle, number of grains per panicle and gram weight to be 73, 10, 10 and 7 percent respectively.

towards yield. The characters those have increased grain yield due to irrigation are the number of filled grains/ panicle and the test weight which are determined during panicle development phase. Higher yields in case of irrigated plots are due to better pollination and grain filling. Low yield in rainfed plots, was due to less uptake of plant nutrients and less pollination. Response to irrigation was only 3q/ha due to 14% increase in fertile grains/ panicle and 5-6% increase in test weight. Mild stress at flowering stage decreased the number of fertile grains/panicle and low grain weight due to reduction in supply of carbohydrates to grains. Irrigation mitigated this deficiency and helped increased yield. The total uptake of plant nutrients was less under rainfed plots too.

Straw yield is composed of the length of tillers (height), number of leaves, their area and dry matter accumulated in them. These characters were not significantly affected by irrigation. The increase in straw yield might be due to slight increase in tiller number and dry matter mcontent due to irriga--tion. Irrigated plots recorded more grain-straw ratio due to increase in yield attributing characters and maintenance of photosynthetic activity for a longer period. These findings are in close agreement with Fagaria and Wilcox (1977)

The crop did not suffer from serious drought. There were 74 rainy days during the crop season. From the balance sheet (appendix-III) it would be clear that at no time of crop growth, the relatively available moisture content fell below 50% and most of the period was at field capacity or above. Hence, the magnitude of variation due to irrigation was less.

Response to Nitrogen

Unlike the response to irrigation, response to nitrogen was very conspicuous. It is well established that nitrogen is the only element to application of which rice responds remarkably and the crop should be liberally fertilised. This is also quite evident from the yield of the N-unfertilised rainfed treatment in this experiment. The yield in the treatment under control remained the least due to poor fertility status of the soil which resulted in shortest plant of 50 cm with poor growth and yield attributing characters. Application of nitrogen increased the plant growth and development and became maximum at 75 kg N/ha. This level was not significantly more than 50kg N/ha Corresponding significant increase in plant height (29.2%), no of panicles/m^2 (34.2%), leaf area index (44.2%), panicle length (60.5%), number of grains /panicle (84.8%), no. of fertile grains/ panicle (154.5%) amd thousand grain weight (4.4%) accounted for increase in grain and straw yield.

The crop growth rate (CGR) increased progressively due to added dosesof N. The increase in DMP/m^2 might be due to increase in LAI values and hence higher photosynthetic capacity (Chinaswamy and Chandra Shekharan, 1977; Sahoo and Murty, 1975; Koregone and Jawalkar, 1976).

Content of N in grain and straw and total uptake increased progressively with increasing levels of N. (Verma, 1971; Khan and Pathak, 1976). The difference in N-uptake, due to application of 50 and 75 kg N/ha is 3.55 kg/ha, which indicated that at higher levels,more nitrogen was lost due to leaching or the crop was unable to absorb. The soil of the experimental plot was loamy sand with 83.1 % sand. Rapid loss due to leaching in such soils can not be ruled out. Assuming that in such a well drained soil , the crop utilised only from fertiliser source, the recovery calculated to 100, 76 and 57% with the application of 25, 50, and 75 kg N/ha. Recovery was maximum at 25 Kg N level and decreased at higher levels due to greater leaching. At this low level of fertilization depletion of soil N was evident. In wet seasons recovery of 33 to 81% N has been reported by Reddy and Patrick (1976). Recovery of N from fertilizer source was 30% (Wang and Peng, 1981). The economic optimum and maximum doses were calculated to be 53 and 67 Kg/ha. At these levels of N the estimated yields were 23.8 and 24.1 q grain/ha respectively. (Kumar and Sharma, 1980).

Weed Control-

Narrow-leaved weeds were more common and posed a serious problem for obtaining good yield. At early stages, the grassy weeds like Echinochloa Colonum , Digitaria Sanguinalis were common. They were predominat because of their inherent potentiality of early seedling vigour, quick rooting ability and speedy growth. There was severe infestation of nut grass (Cyperus rotundus)too. At 45-75th day interval, the common weeds were commelina beagalensis, and cleome viscosa. But these were not as dominant as grassy weeds due to slow growth habit and less number Manna et al (1972), Patel et al 1980, recorded infestation of such weeds in upland rice.

Propanil which is a contact and selective herbicide effectively controlled weeds when applied at 15 DAS. The weed problem in propanil treated plots was minimum. The pre-harvest growth studies indicated that growth parameters like plant height tillers, LAI, dry matter and crop growth rate were significantly influenced by weed control methods. Killing of weeds just after emergence kept the plots weed-free and allowed the rice crop to grow without competition and the crop as a result, had better growth. Mechanical weed control after propanil application was quite earlier. The weed flush that came later was fewer in number and could be easily contro--lled by hand weedings. Labour requirements was quite low and it was found economic.

Plots weeded by spraying propanil acted as a stale seed bed. As the upper layer was not disturbed, seeds in the lower layer could not come up . The second flush of weeds came much later. Weedamin could not control all weeds. The weeds resistant to propanil and weedamin continued their growth and development and competed with the crop for light , moisture and nutrients and hence the yield in this treatment was less.

Plots weeded by mechanical means alone posed a serious problem. Hand weeding was not easy. Eradication of nutgrass took a lot of time and labour . Weed seeds from lower layers came up and continued to keep the plots weedy. Thus eradication of weeds by mechanical means alone was found costly.

In treatments chemical + chemical, all types of weeds couldn't be controlled and the method became ineffective (Mishra et al 1970, Dutta et al 1972, Patro et al 1973). Second herbicide application retarded crop growth due to yellowing and leaf scortching. The vegetative growth of plants was retarded and the crop absorbed less nutrients.

Yield attributing characters like no. of panicles/m^2 no. of grains/panicle, filled grain % and test weight were significantly influenced by weed control methods. Due to seridus competition of weeds, chemically weeded plots were significantly inferior to other two methods. Low IAI in the treatment is an index of poor growth and hence remained photosynthetically poor and sink requirement could not be met and there was less % of filled grains/panicle. Mechanically weeded plots were at par with propanil followed by hand weedings. Thus propanil fellowed by hand weedings. Thus propanil fallowed by hand weedings recorded the highest grain yield (22.3 q/ha and Straw yield (26.75 q/ha), whereas chemically weeded plots recorded 18.4 q grain and 22.2 q straw/ha. The difference is attributed to difference in growth and developmental characters of plants.

Water Requirement:

The rice crop cv 'Keshari' matured in 98 days (8.6.84 to 13.9.84). Plants irrigated at 0.5 bar theough out required 4 75.9 mm water, plots irrigated from flowering to maturity required 425.9 mm and water requirement for rainfed plots was 375.9mm. These values of WR for Kharif season appears to be low. Water requirement depends on soil, plant and atmospheric factors.

During the season, atmospheric demand remained low due to very high humidity even though temperature remained moderately high. Soil component appears to be more important during this season too. Since the soil remained mostly saturated and the rooting depth seldom exceeded 22cm, absorption from layers below 30cm did not appear to be very high except during the periods of dryspell. Drum culture experiments preventing deep percolation losses during Kharif season lent support to this finding that a short duration rice can be grown sucess--fully with 420 mm water (Lenka. 1974).

Response to irrigation particularly after flowering has been remarkable water use efficiency of rainfed rice was only 47.9 Kg grain and 104.7 Kg total dry matter which increased to 51.8 kg grain and 113.4 Kg total drymatter/ha/cm. Due to 5cms irrigation only after flowering. Similar response to irrigation of OR, 34-16 in this soil has been recorded earlier (Lenka 1976). Depending on rainfall condition supplementary irrigation is necessary to ensure at good upland rice crop.

CHAPTER—VI

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

To study the response of upland rice variety "Keshari" to irrigation, levels of nitrogen and methods of weed control during Kharif season, an experiment was conducted at the Central Research Station , OUAT, Bhubaneswar. Salient findings of this experiment are summarised hereunder:

1. During the crop season from 8.6.84 to 13.9.84, the short duration rice variety "Keshari" experienced 1408 mm rainfall in 74 days. The crop suffered from mild stress after flowering and responded to irrigation. One irrigation (5cm) at 0.5 bar SMS after flowering provéd as good as irrigation throughout the growth period as and when necessary and increased the grain yield by 3 q/ha as compared to 19q obtained under rainfed conditions. Only 27% of total rainfall was considered effective.

2. The rainfed and no-nitrogen fertilizer crop yielded 6.76 q grain per ha. This yield increased 23.72 q due to application of nitrogen. The optimum dose was calculated to be 53 Kg/ha.

3. The crop with an average yield of 21.26 grains and 25.43 q straw removed 38.01Kg N, 20.18 Kg P_2O_5 and 54.58 Kg k K_2O_5per ha.

4. Mechanical weed control can be supplemented by chemicals to content the weeds effectives. Post emergence spray of Stam F 34 followed by hand weeding is as good as mechanical weeds control. Weed control by chemicals alone is no substitute to mechanical weed control.

5. The maximum yield of 24.3 q grain and 27.2 q straw was obtained due to application of 75 Kg N, irrigated ance after flowering and with mechanical weed control.

6. Nitrogen and weed control interacted favourably to increase the grain yield. Application of 75 Kg N and weed control by mechanical means produced the highest grain yield. But it was par with 75 Kg N + weed control by propanil followed by handweedings. This intraction was also significant in case of x filled grain % .

7. The study of correlation co-efficients of different yield and growth attributing characters showed that there existed a significant positive correlation between grain yield on the one hand and LAI, maximum plant height, no. of spikelets/panicle, filled grain %, test weight and nutrient content on the other.

C O N C L U S I O N

Even during Kharif season, the short duration rice variety "Keshari" responded to irrigation, particularly, after flowering. It responds well to nitrogen and its optimum dose is about 53 Kg per ha.xx Mechanical weed control can be supplemented by post-emergence herbicide application.

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BIBLIOGRAPHY

B I B L I O G R A P H Y

Anderson, M.S.; Jones, J.W; Armiglra, W.H,(1964) Relative efficiency in various nitrogen fertilizers on production of rice. J.Amer. Soc. Agro.38:743-753.

Batchelor, C.H; Roberts, J. Evaporation from the irrigation water , foliage and panicles of paddy in North-east SriLanka. Agricultural meteorology 1983 29 (1) 11-26 (En 21 ref.)

Bhan,V.M & Maurya, R.A(1971 weed control in field crops at Pantnagar India. Research report (1968-69) Pans 16(4): 690-696

Galello, R(1979) Investigative of effect of weed competition on rice crops, Cultivar, Tropicals 1(3)-75-85

Chahal, R.S; Tulla P.S and Khanna, S.S.(1980) Nutrient uptake by rice crop under submerged and upland conditions. The Journal of the Indian Society of soil schence 28(2) 254-255 (En,7 ref)

Chakraborty, T.(1981)The competition between rice and weed under upland lateritic soil for nitrogen and phosphate. Indian Agriculturist25(4) 249-254 (En, 10 ref) College of Agriculture, Biswa Bharati, Sriniketan 731235, West Bengal India.

Chaudhmy, M.S. and Mclean, E.O(1963)-Comperative effects of flooded and unflooded soil conditions and nitrogen applicatio on growth and nutrient uptake by rice plants. Agron.J. 55(6); 565-567-&Pande RG (168) Rice responds to good water management.Indian Fmg.18(10:31)

________ &________1968. Water requirement and evapo-tranpiration rat in rice. Proc. Symp.water management, Udaipur, Indian Soc Agron.pp.95-100

________ and ______________ 1969. New water management practices in rice. Indian Fmg. 19(1) 23-24 .

Dash, B and Singh, B (1984) Effect of weed control methods on growth and yield of unpuddled rice Indian J of weed science.

Dastane, N.G.; Nelliat,EV 1970 Effect of different water regimes on rice. Ann Rep Agron Divn, IARI, New Delhi.

Deuse, P.L, Hernandez,S, Diallo, S(1974) Trials of Chemical weed control in upland rice in Senegal.

Devi,G.D, Vijayagopal, P.D, Sasidhar,V.K.(1980) Studies on the fractional application of nitrogen on the yield of rice. Agricultural Research Journal of Kerala 18(I) 23-26 (En,Malayalam,4 ref).Kerala Agric. Univ, Vellanikkara, Trichuma Kerala India.

Ghobrial, G.I(1983) Effect of nitrogen fertilizer and weed management on performance of four rice varieties in Sudan Gezera. International Rice Research news letter 8(2) 16(EN), Kenana Research Sta. Abu Mamma,Sudan.

Gopalkrishnan,R,Nair, R.R. Upland rice in Keral needs more attention. Indian farming (1978) 98(5) 17-18(En).

Hoque, M.Z, Akanda,R. Fertilizer of weed mgt. of aus rice in Bangaladesh. International Research news letter (1979) 4(6) 21(En) Bangaladesh Rice Res. Inst. Joydebpur, Dacca, Bangaladesh.

Huh,B.L, Ahn, Y.S, Hong, C.W., Study on the timing of nitrogen top dressing for the panicle of new rice cultivars. Research Reports of the office of rural development, Soil Science, Fertilizer,Plant Protection & Micrology (1979) 21, 19-24 (ko, En,23 ref) Inst. of Agric. Sci, S.Korea.

Kadrekar, S.B, Power,S.L;Chavan, A.S. Application of nitrogen to rice under high rainfall condn. Ind. J.of Agron. (1981) 26(I) 12-14 (En & ref) Dept of Agric. Chem. of Soil Sc. Konkan Krishi Vidyapeetha,Dapoli 415712 Maharashra,India.

Kakati,N.H. & Mani, V.S.(1977) Chemical weed control, in rice in relation to fertilizer use. Abstra papers weed cont. conf. Hyd. PP:7,1977.

Khan, R.A.(1971) Control of weeds by Stam F-34 in upland paddy fields.Rise 20(1) 65-70,1971, Fide Fld.crop Abstr. 25(3): 467, Abstr. No.3388,

Khuspe,V.S.and Joshi, K.S.(1971) Effect of N and yield of paddy variety TN-1.Res.J.of Mahatma phule Agric.Univ.2 (1): 1-8.

Koyama, T.and Niamorichand, N.(1973): Soil plant nutrition status on tropical rice Soil.Sci.and plant Nutrin.18(6): 233-245.

Kumar, S.D, Sharma, H.C.(1980) Response of direct-sown rice to levels of nitrogen under rainfed condition.India J.of Agron.(1980) 25(4) 717-718.

Kwang Ha; GHI (1978) Evapotranspiration of irrigation effect on upland rice, International Rice Commission News letter 27(I) 24-25 (En) Agri.Dev. Corp, Anyang-S.Korea.

__________(1978) Evapotranspiration of irrigation effect on upland rice, International Rice Commission News letter (1978) 27(2) 36-39 (En) Agric, Dev. Corp. Anyang, S.Korea.

Lenka, D.1969. Response of indica and ponlai varieties of rice to high levels of nitrogen in wet and dry season. Indian J. agric.Sci. 39 (7):642-651.

__________;Bhol,B.; Panda,C.; Misra,A.1971 water management for tall and dwarf indica varieties of rice in wet season.IRC. News letter: 20(4):16-19.

__________1971. Response of TN-1 rice to water management practices and nitrogen

__________and Bhol, B. 1972.Water requirement and management practices for T.N-1 rice in wet season.Proc.Symp. Soil Water Management, Hissar, I.C.A.R., PP-326-327.

__________ and Padhi, U.C.1972.Rotational canal closure in Hirakud Ayacut areas.Central Board of Irrigation and Power. Govt.of India, 1 : 1-6.

__________ and Mishra,B.1973.Path coefficient analysis of yield in rice varieties. Indian. J.agric. Sci. 43 (4):376-379.

__________ 1976.Classification of rainfall zones and drought prone areas. Water requirement of crops in Orissa.pp-4-5.

__________ 1976. Water management of rice.Food Farming and Agriculture 7.(11) 22-24.

__________ ;Mishra,B.; Sahu,S.K.and Reddy,D.S.1976.Effect of water management and nitrogen application on rice. Indian J.Agron. 21 (4):420-424

Manna,G.B.Dubey,A.N.& Rao,M.V.(1972) New Chemicals for the control of rice weeds.FAO, Int.Rice Com.Working party of Rice Production & protection Fourteenth session act,30 to Nov.15,Bangnok

Misra, A. & Roy, N.C. (1970) Herbicidal cum cultural studies in high land rice. Indian J weed Sci. 2(1): 56-62, 1970.

Mishra, G. and Samantaray, B. (1955): Effect of various levels of N on vegetative growth and ear emergence of rice plant. J. Ind. Bot. Soc. 34: 454-457.

Modgal, S.C; Singh, M.P. (1980) Weed control through herbicides in direct seaded rice. Indian J. of weed Sci 12(I) 80-86 (En-3. ref.) Dep. of Agron. Himanchal Pradesh Krishi Vishva Vidyalya, Palampur 176062, H.P. India.

Moody, K (1975) Weed control systems for upland rice production. In report on the export consultation meeting on the mechanization of Rice production, Nigeria IITA pp: 71-78.

Moorthy, B.T.S; Dubey, A.N. Relative Efficiency of different herbicides for control of weeds in rainfed upland rice. Indian J. of weed Sci. (1981) 13(I) 56-62 (En. 10 ref.) (RRI Cuttack) 753006, Orissa, India:

Munroe, C.E. Samiano, A.R; 'O'Brien; D.T; Trinidad. E.C.O. Evaluation of traditional and integrated weed control approaches in upland rice in the Philippines. In proceedings of the 8th Asian-Pacific weed science society Conference Bangalore, India. November 22 to 29. 1981 Vol. II. Edited by Rao B.V.V. 113-116, (En. 3 ref) National Crop protection Cent. Los Banos, Philippines.

Muthuswamy, P. Raaj, D. and Krishnamoorthy, K.K. (1972): Studies on the relationship between nutrient uptake and yield of certain high yielding rice varieties. Mad. Agric. J 60 (3): 173-175.

Naidu, N.G; Bhan, V.M. Effect of different Groups of Weeds and periods of weed Free maintainance on the grain yields of drilled rice Int. J. of Weed Sc. (1980) 12 (2) 151-157 (En. 3 ref) Dep. of Agron. G.B. Pant. Univ. of Agric. of Tech. Pantanagar 263145. U.P. India.

Narasinghrao, M.B.V. (1951) Water requirement of crops with special reference to rice Madras Agric. J. 38: 539-548.

Pandey; J. Singh, R.P (1982) Weed Control in upland direct sown rise in Calcareous Soil. In abstracts of papers. annual conference of Indian Soc. of Weed Sci. (undated) 8 (En) Dep. of Agron. Rajendra Agric. Univ. Pusa 848125, Bihar, India.

Patro, G.K. & Tosh, G.C. (1973) Relative efficiency of propanil MCPA & 2,4-D on control of weeds in upland rice. Ind. J Weed Sci. 5(2): 98-104, 1973.

Patro,G.K. & Nayak,B.C. (1973) Reàtive efficiency of stam F-34 & Stam LV-10 alone and in combination with MCPA on cotrol of weeds in upland Rice.Pesticides. 7(5): 11-13,1973.

Pereria,J.C. V.W.A., Mascarenhas,H.A.A.Hiroces R; Pamargo,O.B.A. Effect of nitrogen & rotation with soybean on the yield of upland rice.

Pillai, P.B; Nair, T.R.; George, C.M(1979) Chemical weed control in Rice under semidry conditions. Agril.Res. J.of Keral 17(1) 108-110.

Pillai, K.G. (1981) Land preparation,methods of crop establishment and weed management practices in upland ri ce.Int.Rice com News lett.(1981) 30(1) 43-45.

Rajan,M.S.S; Mahapatra,I.C.(1978) relative efficiency of slow release and split application of nitrogenous fertilizer and weed control methods on yield of direct seeded upland rice. Oryza 15(2) 117-128(En 14 ref) Indian Agric. Res. institute New Delhi 110012 India.

Raghavulu,P. & Sreeramamurty,V.(1973); Weed control indireet sown upland rice.Andhra Agric. J.20(½)47-49,

Raju, R.A. and Misra, G.L.(1976): Effect of levels and source of Nitrogen on high yielding dwarf paddy varieties. Andhra Agric.J.22 (5& 6):183-187.

Ramiah, P.K.(1966): Rice Research and Production in India. Ind.Fmg. 16(6):6.

Ramireddy, S. & Hukkeri,S.B.(1980): Increasing effectiveness of fertiliser through weed control in direct seeded irrigated rice.Fert.news 25(11): 30-33.

Rao, M.S.S.& Agarwal, P.G.(1976) Investigation on chemical weed control in upland and low land rice.

Rao, M.V.; Prasad,M.(162) Response of short duration high yielding rice varieties to nitrogen level on rainfed upland field.Oryza 19(2) 104-108.

Rao, M.V., Prasad, M.(1973): Annual report of central Rice Research Inst.Cuttack, pp.96.

Rethi, K.S.& Tewari, A.N.(1979): Weed management in direct seeded paddy under irrigated condition. Indian J. Agric. Res.13(2):111-112.

Rizk, T.Y; Sayed, M.T; Hassannien,E.E.;1979/A comparision study on the use of some new herbicides in seeded rice Mesopatamia Journal of Agriculture (1979) 14(I) 109-123 (En-9v.II ref) Dept.of Agron Dinsuoms Univ.Cairo,Egypt.

Sahai, B; Bhan (1982) Competition for nitrogen between weeds and drilled rice effect of time of weed removal. In abstracts of papers annual conference of Ind.Soc. of Weed Sci.(undated) 14(En) Dept.of Agron.,Haryana. Agri.Univ.Hissar 125004.Haryana India.

Salt, U.G; Murty,R.S.,Rai,R.S.(1980): Effect of Season,nitrogen rate and planting density on harvest index in rice Oryza 17(I)28-33 CRRI.Cuttack.

Samui, R.C; Maiti, B.K.Jana,P.K.;(1979): Effect of nitrogen on prekharif direct seeded rice Indian J.of Agron 24 (I) 77-80(En 3 ref) Dept.of Agronomy; B.C.Krishi Vidyapitha Kalyani 741245 West Bengal India.

Singh B.K, Modgal S.C.1979) Pattern of dry matter accumulation and nitrogen concentration and uptake as influenced by levels and methods of nitrogen application in rainfed upland rice. Plant and soil. 52(1)9-17(En,13set) G.B.pant Univ. of agric. and Tech.Pantanagar 203145 UP.India.

Singh, H, Modgal, S.C.(1978): Studies on the nitrogen management in upland rainfed rice. Effect of nitrogen application on grain yield., its components and nitrogen uptake. Haryana Agri. Uni. J. of Res. 8(3)166-173 (En 7 ref). G.B. Pant. Univ. of Agri & Tech. Puntanagar 263145 U.P.India.

Singh, J.N; Singh.G; Sing,H.P;(1982) Chemical weed control in dryland rice. International rice research News letter 7(5) 21-22.(En) Crop physiology, Dep. N.D. Univ. of Agril Tech. Faizabad, U.P.India.

Singh J.N., Singh.G; Singh, H.P;(1983): Nutrient use efficiency and upland rice yield . Int. rice Res.News letter 8(3)(En). Crop physiology.Dept Narendra Dev.Univ. of Agril and Tech. Faizabad 224001, India

Singh, R.K; Rafey.A; Saha, G.P; Jha.K.K; (1981): Influence of split application of nitrogen on the yield of upland rice. Oryza 18(2) 98-100 (EN,15ref)Dryland Res. Cent. Birsa, Agric, Univ. Ranchi 834006, Bihar India.

Sen, Y; Kim, S.C; Lef, S.K.(haracteriltic of harvest index and dry matter production in Tongil type rice varieties as affected by nitrogen application. Res. Reports, office of rural development, S.Korea Crop expt. Sta. Milyang. S.Korea

Stone, L.F; Steinmeti. S. (1979) Nitrogen fertilization and the leaf area index of two rice cultivars under upland conditions. Indica de urea foliar and adubacao nitrogenada em arroz. Pesquisa Agropecuaria Brasileira (1979) 14(1) 25-28 (Pt, en,bref) Centro National de Pesqwsa de Arroz & Feijao 74000 Goiana; Goias, Brazil.

Tosh. G.C; Reddy, B.S; Nanda,K.C; (1981): Integrated weed management study in upland rice. In abstract of papers. Annual conference of Ind. Soc. of weed Sci. Dep. of Agron. Orissa Univ. of agric. and Tech. Bhubaneswar 753003, Orissa, India.

APPENDIX

Analysis of variance of grain and straw yield and important yield parameters

Source	Degree of freedom	Mean square values: Grain	Straw	No. of panicle/m length	Length of Panicle	Total No. of spikelets/Panicles	No. of filled grains/panicle	Test weight
Block	5	2.835*	4.505*	2.95	3.036	35249	15.256*	0.086
I	2	71.298*	78.353*	0.366	0.069	1.454	274.588*	1.505*
N	2	137.772*	149.632*	77.225*	24.007*	605.02*	566.670*	1.509*
W	2	110.726*	142.280*	32.005*	17.222*	229.474*	457.320*	1.817*
IN	4	0.132	1.254	3.518	0.016	26.538	1.991	0.137
NW	4	2.188*	2.590	2.074	0.034	25.809	18.03	0.014
WI	4	0.290	0.373	1.838	0.191	12.135	4.018	0.063
IN^2W^2	2/	0.198	1.809	3.000	0.723	24.270	1.270	0.010
IN^2W	2/	0.331	0.480	0.111	0.090	36.517	2.838	0.015
INW	2	0.048	0.919	5.630	0.038	59.800	3.569	0.027
INW^2	2	0.205*	0.252	5.227	0.329	50.509	2.901	1.873*
Control vs rest	1	1135.612*	1467.963*	214.074*	161.605*	6614.305*	519.765*	0.114*
Error	27	0.452	0.998	1.975	0.214	18.338	1.366	

* Significant at 5% level of significance

Mean yield of grain and straw as affected by different treatment (q/ha)

Particular	Chemical			Chemical + Mechanical			Mechanical		
Rainfed	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3
Grain	13.33	17.03	18.09	18.09	21.53	22.58	16.11	20.21	24.045
Straw	15.55	20.77	22.34	22.06	26.12	26.42	19.64	24.34	29.34
Total	28.88	37.80	40.43	40.15	47.65	49	35.75	44.55	53.38
Irrigation (0.5)bar									
Grain	17.03	20.735	21.79	21.40	25.0	26.68	20.865	24.05	24.32
Straw	2.77	24.215	25.94	25.97	29.20	31.4	25.775	28.625	27.215
Total	37.8	44.95	47.73	47.36	54.16	58.08	46.64	52.67	58.535
Rainfed + Irrigation (0.5)bar.									
Grain	16.5	19.94	21.40	21.395	24.435	26.155	19.675	23.38	25.495
Straw	20.5	24.03	24.73	25.28	28.575	30.595	23.705	28.18	29.815
Total	37.0	43.47	46.3	47.175	53.01	56.75	43.38	51.56	55.31
Control									
Grain		6.76							
Straw		8.94							
Total		15.7							

APPENDIX -III.

PROFILE MOISTURE DEFICIT AND EFFECTIVE RAINFALL (DAILY BASIS)

Date	Rainfall (mm)	Evaporation (mm)	Deficit (mm)	Excess (mm)	Effective rainfall (mm)
8.6.84	0	5.8	19.4	-	0
9.6.84	5.5	7.1	21.0	-	5.5
10.6.84	0.8	2.8	23.0	-	0.8
	6.3	15.7	77	-	6.3
11.6.84	3.0	5.4	25.4	-	3.0
12.6.84	8.6	3 .2	20.0	-	8.6
13.6.84	80.4	- 0	69.4	60.4	20.0
14.6.84	35.4	4.8	-	30.6	4.8
15.6.84	0	2.6	2.6	-	0
16.6.84	0.2	2.2	4.6	-	0.2
17.6.84	27.2	7.8	-	14.8	12.4
	154.8	26	52.6	105.8	49
18.6.84	25.0	5.7	-	19.3	5.7
19.6.84	16.2	3.6	-	12.6	3.6
20.6.84	0	3.1	3.1	-	0
21.6.84	0	7.4	10.5	-	0
22.6.84	0	6.8	17.3	-	0
23.6.84	3.0	1.8	16.1	-	3.0
24.6.84	0	4.5	20.6	-	0
	44.2	32.9	67.6	31.9	12.3
25.6.84	0	2.9	23.5	-	0
26.6.84	0	5.5	29.0	-	0
27.6.84	0.6	4.1	32.5	-	0.6
28.6.84	0.7	2.7	34.5	-	0.7
29.6.84	9.0	2.2	27.7	-	9.0
30.6.84	1.8	2.6	28.5	-	1.8
1.7.84	0	2	30.5	-	0
	12.1	22	206.2	-	12.1
2.7.84	0.8	2.8	32.5	-	0.8
3.7.84	6.3	3.1	29.3	-	6.3
4.7.84	64.7	0	-	35.4	29.3
5.7.84	2.8	0.5	-	2.3	0.5

APPENDIX-III (Contd...)

6.7.84	0	2.4	2.4	-	0
7.7.84	14.3	5.1	-	6.8	7.5
8.7.84	7.0	2.8	-	4.2	2.8
	95.9	16.7	64.2	48.7	47.2
9.7.84	11.6	4.5	-	7.1	4.5
10.7.84	6.2	3.0	-	3.2	3.0
11.7.84	2.8	2.5	.	0.3	2.5
12.7.84	40.7	5.3	-	35.4	5.3
13.7.84	0	3.5	3.5	-	0
14.7.84	6.0	6.9	-9.5	-	0
15.7.84	1.4	2.1	10.2	-	1.4
	62.7	26.9	23.2	46.0	16.7
16.7.84	0	5.2	15.4	-	0
17.7.84	58.2	0	-	42.8	15.4
18.7.84	45.6	4.6	-	41.2	4.6
19.7.84	11.4	1.6	-	9.8	1.6
20.7.84	0.2	4.2	4.0	-	0.2
21.7.84	49.6	6.7	-	38.9	10.7
22.7.84	26.2	5.5	-	20.7	5.5
	186.0	27.8	19.4	153.4	38
23.7.84	53.2	0	-	53.2	0
24.7.84	7.0	3.0	-	4.0	3.0
25.7.84	0	4.6	4.6	-	0
26.7.84	4.9	3.6	3.3	-	4.9
27.7.84	0.8	4.7	7.2	-	0.8
28.7.84	38.6	6.3	-	25.1	13.5
29.7.84	0	4.6	4.6	-	0
	104.5	26.8	19.7	82.3	22.2
30.7.84	10.6	3.9	-	2.7	8.5
31.7.84	42.5	5.5	-	37.0	5.5
1.8.84	34.6	5.2	-	29.4	5.2
2.8.84	16.4	2.8	-	13.6	2.8
3.8.84	0	5.3	5.3	-	0
4.8.84	0	3.8	9.1	-	0
5.8.84	0	5.5	14.6	-	0
	104.1	32.0	29.0	82.1	22.0

APPENDIX-III (Contd...)

6.8.84	10.6	4.2	8.2	-	10.6
7.8.84	5.4	1.2	4.0	-	5.4
8.8.84	51.2	3.4	-	43.8	7.4
9.8.84	5.4	1.3	-	4.1	1.3
10.8.84	6.6	3.8	-	2.8	3.8
11.8.84	0.2	2.7	2.5	-	0.2
12.8.84	0	4.5	7.0	-	0
	79.4	21.1	21.7	50.7	28.7
13.8.84	29.6	3.8	-	18.8	10.8
14.8.84	0	5.4	5.4	-	0
15.8.84	76.4	0	-	71.0	5.4
16.8.84	95.0	0	-	95.0	0
17.8.84	24.5	2.1	-	22.4	2.1
18.8.84	0	3.1	3.1	-	0
19.8.84	0.7	4.0	6.4	-	0.7
	226.2	18.4	14.9	207.2	19.0
20.8.84	2.6	4.6	8.4	-	2.6
21.8.84	0	4.2	12.6	-	0
22.8.84	48.6	8.6	-	27.4	21.2
23.8.84	26.9	6.3	-	20.6	6.3
24.8.84	39.0	2.1	-	38.9	2.1
25.8.84	5.4	3.4	-	2.0	3.4
26.8.84	14.6	5.7	-	8.9	5.7
	137.1	34.9	21.0	95.8	41.3
27.8.84	4.4	0.4	-	4.0	0.4
28.8.84	35.8	6.8	-	29.0	6.8
29.8.84	2.3	4.6	2.3	-	2.3
30.8.84	0.5	4.5	6.3	-	0.5
31.8.84	0.5	3.4	9.2	-	0.5
1.9.84	31.8	2.7	-	19.9	11.9
2.9.84	47.6	1.4	-	46.2	1.4
	122.9	23.8	17.8	99.1	23.8
3.9.84	0.5	2.1	1.6	-	0.5
4.9.84	0	1.1	2.7	-	0
5.9.84	1.5	2.2	3.4	-	1.5
6.9.84	5.0	2.8	1.2	-	5.0
7.9.84	22.6	6.6	-	14.8	7.8
8.9.84	25.0	7.0	-	18.0	7.0
9.9.84	4.0	3.8	-	0.2	3.8
	38.6	25.6	8.9	33.0	25.6
10.9.84	2.2	3.1	0.9	-	2.2
11.9.84	11.4	3.5	-	7.0	4.4
12.9.84	19.6	3.1	-	16.5	3.1
13.9.84	0	3.1	3.1		0
	33.2	12.8	4.0	23.5	9.7