STUDIES ON THE EFFECT OF IRRIGATION SCHEDULING AND IRRIGATION LAYOUTS WITH AND WITHOUT MULCH ON GROWTH, YIELD AND QUALITY OF MAIZE (*Zea mays* L.) IN *RABI* SEASON

By
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M.Sc. (Agri) First Class With Distn

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of

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DIVISION OF AGRONOMY
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September, 1989

CANDIDATE'S DECLARATION

I hereby decleare that the thesis entitled "Studies on the effect of irrigation scheduling and irrigation layouts with and without mulch on growth, yield and quality of Maize (Zea mays L.) in rabi season" or any part of the thesis has not been previously submitted by me or any other person to any other University or Institute for a Degree or Diploma.

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C E R T I F I C A T E

This is to certify that the thesis entitled "Studies on the effect of irrigation scheduling and irrigation layouts with and without mulch on growth, yield and quality of Maize [Zea mays L.] in rabi season", submitted to the Mahatma Phule Agricultural University, Rahuri Dist. Ahmednagar [Maharashtra] in a requirement for the award of degree of **DOCTOR OF PHILOSOPHY** [Agriculture] in **AGRONOMY** embodies the results of a bonafide research work of original nature carried out by **Shri Bhaskar Sakharam Jadhav** under my guidance and supervision. It is of a sufficiently high standard to warrant its submission to the University for the award of said degree. No part of the thesis has been submitted for any other Degree, Diploma, associateship, fellowship or other similar title or published in any other form.

The assistance and help received during the course of this investigation and source of literature referred to in the text, have been duly acknowledged.

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C E R T I F I C A T E

This is to certify that the research experiment on "Studies on the effect of irrigation scheduling and irrigation layouts with and without mulch on growth, yield and quality of Maize [Zea mays L.] in rabi season", in fulfilment of the requirements for the award of the degree of **DOCTOR OF PHILOSOPHY** in **AGRONOMY** to the Faculty of Agriculture, Mahatma Phule Agricultural University, Rahuri - 413 722 was conducted by **Shri Bhaskar Sakharam Jadhav** with the available facilities on the farm of the Shahu Agricultural School, and laboratory facilities at the College of Agriculture, Kolhapur during the rabi season of 1986-87 and 1987-88. The thesis embodies the results of a bonafide research work carried out under the guidance of Dr.S.B. Jadhav, Sugarcane Specialist, Central Sugarcane Research Station, Padegaon, Post-Nira, Dist. PUNE.

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This is to certify that the thesis entitled "Studies on the effect of irrigation scheduling and irrigation layouts with and without mulch on growth, yield and quality of Maize [*Zea mays* L.] in *rabi* season", submitted to the Faculty of Agriculture, Mahatma Phule Agricultural University Rahuri - 413 722 for the award of degree of **DOCTOR OF PHILOSOPHY** [Agriculture] in **AGRONOMY** embodies the results of a bonafide research carried out by **Shri Bhaskar Sakharam Jadhav** under the guidance and supervision of Dr.S.B. Jadhav, Sugarcane Specialist, Central Sugarcane Research Station, Padegaon, Post. Nira Dist. PUNE and that no part of the thesis has been submitted for any other Degree or Diploma.

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Kolhapur

September 30 , 1989.

BSJadhav

(B.S. JADHAV)

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LIST OF ABBREVIATIONS

g	-	Gram (s)
kg	-	Kilogram (s)
q	-	Quintal (s)
t	-	Ton (s)
cm	-	Centimetre (s)
m	-	Metre (s)
mm	-	Milimetre (s)
sq cm	-	Square centimetre (s)
dm	-	Decimetre (s)
ha	-	Hectare (s)
°c	-	Degree celsius
S.E.±	-	Standard error
C.D.	-	Critical difference
%	-	Per cent
N	-	Nitrogen
P	-	Phosphorus
K	-	Potassium
ASM	-	Available soil moisture
SMT	-	Soil moisture tension
atm	-	Atmospheric
Fig	-	Figure
viz	-	Namely
et al.	-	And others
@	-	At the rate of
Rs	-	Rupees
i.e.	-	That is
M calory	-	Mega calory
G calory	-	Gega calory
DAS	-	Days after sowing
&	-	And

ABSTRACT

Studies on the effect of irrigation scheduling and irrigation layouts with and without mulch on growth, yield and quality of Maize [Zea mays L.] in rabi season.

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An investigation on studies on the effect of irrigation scheduling and irrigation layouts with and without mulch on growth, yield and quality of Maize [Zea mays L.] in rabi season was carriedout at the Shahu Agricultural School Farm of the Gramsevak Training Centre, Kolhapur under the College of Agriculture, Kolhapur during the rabi seasons of 1986-87 and 1987-88. The soil of the experimental plot was clayloam in texture, medium in total nitrogen and available phosphorus and fairly rich in available potassium with good water holding capacity. In general, climate during both the seasons was favourable for crop growth and development.

The experiment was laidout in split plot design with four replications. The gross and net plot sizes were 6.0 x 4.5 and

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4.5×3.00 m^2 respectively. There were 16 treatment combinations formed due to 4 IW/CPE ratios viz 1.0, 0.8, 0.6 and 0.4 were tried in main plots and combination s of two mulching treatments viz no mulch and mulch and two irrigation layouts viz ridges and furrows and flat beds allotted to sub plots were under study.

The important growth attributes viz plant height and number of functional leaves/plant showed favourable influence of irrigation scheduling at 1.0 and 0.8 IW/CPE ratios, while the leaf area/plant, leaf area index and dry matter accumulation/plant were significantly increased due to scheduling of irrigation at 1.0 and 0.8 IW/CPE ratios. Similar trend was observed with the days to 75 per cent silking and number of cobs/net plot. The important yield contributing characters viz grain yield/plant, length and girth of cob, number of grain rows/cob, number of grains/row, number of grains/cob and 1000 grain weight were significantly higher with scheduling of irrigation at 1.0 IW/CPE ratio than at lower IW/CPE ratios.

The grain and stover yields were significantly more with scheduling of irrigation at 1.0 and 0.8 IW/CPE ratios over 0.6 and 0.4 IW/CPE ratios. The pooled grain yield was increased by 10.39, 20.03 and 24.87 per cent with 0.6, 0.8 and 1.0 IW/CPE ratios, respectively over 0.4 IW/CPE ratio.

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The gross and net monetary returns were significantly more with the scheduling of irrigation at 1.0 IW/CPE ratio than lower IW/CPE ratios. It would be, therefore, advisable to irrigate maize with 1.0 IW/CPE ratio in Kolhapur region.

The N uptake by grain, total N uptake and P uptake by stover was significantly higher with the irrigation scheduled at 1.0 and 0.8 IW/CPE ratios.

The protein production by grain and stover and total protein production and protein production efficiency were significantly higher with irrigation scheduled at 1.0 and 0.8 IW/CPE ratios than 0.6 and 0.4 IW/CPE ratios.

The energy inputs, energy outputs, energy balance and energy use efficiencies were the maximum with 1.0 IW/CPE ratio and decreased with decrease in IW/CPE ratios. The daily and total consumptive use were the highest with irrigation scheduled at 1.0 IW/CPE ratios than the lower IW/CPE ratios. However, consumptive use efficiency and water use efficiency showed reverse trends.

The application of mulch significantly produced more grain and stover yield than no mulch. The grain production efficiency

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was also significantly increased when mulch was introduced. The gross monetary returns, total N uptake, total protein production and protein production efficiency were significantly increased under mulch treatment than no mulch treatment. Mulching increased the consumptive use of water, but the consumptive use of water and water use efficiency were decreased. The energy inputs were more with mulch than no mulch, while the energy balance and energy use efficiency were negative with no mulch, whereas it was negative with mulch.

The important growth attributes, yield contributing characters, grain and stover yields, harvest index, cost of cultivation, gross and net monetary returns were not significantly influenced due to different irrigation layouts. However, irrigation layout with ridges and furrows showed superiority over flat bed layout. The N and P concentration in maize plant, N and P uptake, protein content, protein production and protein production efficiency were also not significantly influenced due to different irrigation layouts.

The grain yield/plant was positively and highly significantly correlated with dry matter/plant, cob length and grain number/row, whereas it was positively and significantly correlated with cob girth, grain rows/cob and test weight. Therefore, simultaneous

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selection of these characters are helpful for substantial yield improvement in maize. Consumptive use of water was positively and highly significantly correlated with the grain yield, whereas water use efficiency was negatively and highly significantly correlated with the grain yield. Highly significant negative correlation was also observed between consumptive use and water use efficiency.

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Introduction

1. INTRODUCTION

Maize is one of the important cereal crops of the world. In U.S.A. maize has been called the queen of cereals. It is a very efficient utilizer of solar energy and has immense potential for higher production.

In India, maize stands 5th in area, 4th in production and 3rd in productivity. The total area under maize during 1987-88 was 5541.00 thousand hectares with the production of 5629.00 thousand tonnes. The average productivity was 1250 kg/ha. In Maharashtra, the area under maize was 95.5 thousand hectares with a production of 1250 thousand tonnes and the average productivity was 1270 kg/ha, during 1987-88. However, the production per unit area in India in general and Maharashtra in particular, is as low as 1200 kg/ha, which is ¼ of the leading maize growing countries like U.S.A., France and Israel. This is mainly due to the lack of adoption of modern maize growing technology and poor economic condition of the farmers.

More than 80 per cent of total maize production, in our country, is consumed as food in various forms and several types of recipes are prepared from maize grain and its flour. It is also a good source of food for poultry and fodder for the cross-bred cattles. Maize is used as a raw material for starch, paper and textile industries in developed countries like U.S.A. With wet milling process, several useful products such as dextrine, starch, corn sugar, varnish and alcohol are obtained from corn.

It is also a source of oil which has proved to be a boon for the heart patients because of its medicinal values.

Rai, et al. (1985), Singh and Sharma (1988) and Singh (1988) have concluded from their experimentation that the cultivation of maize is more remunerative than that of wheat. Thus, there are wide chances to increase the area and production of maize in near future.

Maize is grown in kharif, rabi and summer season in India. However, growing maize during rabi season is the most advantageous because of minimum weed problem, less insect pest attack, no drainage problem, sufficient bright sunlight, optimum temperature and congenial humidity. The irrigation water is the main constraint for rabi maize production and productivity.

About eighty per cent of area under maize in Maharashtra is cncentrated in Deccan Canal area. With the introduction of major, medium and minor irrigation projects and expansion of existing irrigation projects viz Radhanagari, Tulshi, Warna, Kalammawadi etc. and more lift irrigation facilities, a sizable area of maize could be brought under irrigation during rabi season in Kolhapur region.

Water is a key factor to enhance crop productivity and is also a pre-requisite for an efficient utilization of all farming inputs. Irrigation both excess and deficit, have adverse effect on crop growth and production. Water if applied in excess, is wasted by deep percolation which finally leads to water logging.

Thus,6.0 M.ha cultivable land is prone to water logging in India. (Lal, 1986). The critical appraisal of water requirement of cereal crops in general and maize in particular reveals that the various recent research works carried out so far on the water needs of these crops have been done either by considering a certain time interval or depth of water application, without taking into account the soil moisture status or scheduling of irrigation on the basis of depletion of available soil moisture or scheduling irrigation at critical crop growth stages. All these methods have their own advantages as well as limitations. Among the several recognised criteria of irrigation scheduling, climatological approach has been observed to be very useful. It is based on the universally recognised principle that evaporative demand of the climate is the main factor in determining the water requirement of the crop. The concept of IW/CPE ratio is therefore employed in the present investigation.

Prihar et al. (1974) suggested a modified meteorological approach based on the ratio between irrigation water (IW) and pan evaporation (PE) as a practical guide for scheduling irrigation in wheat crop. Kotoria et al. (1981) working on pearl millet and maize recorded a significantly more green fodder yield at 0.6 IW/CPE ratio than 0.3 and 0.9 IW/CPE ratios. Aujla et al. (1987) suggested that the best practice was to irrigate the maize on the basis of IW/PAN E ratio of 1.2/0.9 which produced 13 per cent higher grain yield than 0.9/0.6 IW/PAN E ratio.

Rana and Malik (1981) obtained higher CU with 0.8 IW/CPE ratio than 0.6 and 0.4 IW/CPE ratios and the maximum WUE with

0.4 than 0.6 and 0.8 IW/CPE ratios. Roy and Tripathi (1987) revealed that grain yield, water use efficiency and nutrient concentration in maize were significantly higher under irrigation scheduled at 0.9 IW/CPE ratio than 0.7 and 0.5 IW/CPE ratios.

The work on use of meteorological data for scheduling irrigation to maize in Maharashtra during *rabi* season is very meagre. This approach therefore, needs to be tested critically for maize and to findout a suitable IW/CPE ratio for the scheduling the irrigation.

It will be pertinent to mention here that, the present problem is concerned not only with the scheduling of irrigation for maize, but also with the exploration of the possibility of curtailment in irrigation requirement through regulating the evaporation from the soil surface in view of the shortage in supply of irrigation water during *rabi* season. The consensus goes in favour of the provision of suitable mulches as they act as thermo-insulators and modify pattern of heat flow into the soil and water loss therefrom. Consequent upon the evaporation retardation, the situation would definitely tune upon the process of moisture redistribution and subsequent storage in the lower soil layers to be used by the crops (Hillel, 1971).

Mulches also bring down evaporation losses through insulation or obstructing against direct radiation or obstructing vapour diffusion (Adams, et al. 1976). Among the mulching materials, crop residues have been found to be very efficient in conservation of more moisture (Unger, 1977 and Arnon, 1977).

The increased irrigation potential in Kolhapur region, resulted in an increased area under sugarcane, which tended to establish a network of sugar factories. The harvesting of sugarcane starts in the month of October which coincides with the optimum sowing time of maize. Thus, ample sugarcane trash which can be utilized as a mulch in rabi maize crop is available easily.

Lawton (1946) reported that maize being sensitive to excess soil moisture, persistence of wetness within the rooting zone adversely affects the crop growth. Wiersma (1959) has stated that continued replacement and removal of soil atmosphere by diffusion is necessary for optimum root functioning and that such a diffusion is linearly related to the volume of air filled pores in the soil. The type of irrigation layout, therefore, assumes special importance in maize cultivation. The method of sowing of a crop has an intimate relationship with the method of irrigation to achieve the maximum water use efficiency.

A properly planned irrigation should result in saving of water, enhance the yields, lower the production cost and maintain or improve productivity of irrigated land.

With these considerations in view, the present investigation entitled "Studies on the effect of irrigation scheduling and irrigation layouts with and without mulch on growth, yield and quality of Maize (Zea mays L.) in rabi season" was planned and conducted at the Shahu Agricultural School Farm, under the College of Agriculture, Kolhapur with the following objectives

1.1 To find out the water requirement of maize and water economy.

1.2 To find out suitable irrigation layout for maize crop in rabi season.

1.3 To find out the consumptive use and water use efficiency of maize and water yield functions.

1.4 To study the effect of irrigation, mulch and irrigation layouts on production potential of rabi maize.

1.5 To work out the economics of rabi maize grown under irrigation, mulching and irrigation layout constraints.

1.6 To study the uptake pattern of nutrients by maize.

1.7 To study the energy relationships in rabi maize cultivation in relation to irrigation, mulching and irrigation layout constraints.

Review of Literature

2. REVIEW OF LITERATURE

There is a wide gap between the average yield of maize in India and its yield potential (Singh et al. 1986). This is mainly due to lack of use of modern technology which includes irrigation scheduling, moisture conservation techniques and irrigation layouts. This chapter deals with the review of research work carriedout by various research workers on the effect of scheduling of irrigation on the basis of IW/CPE ratios and soil moisture depletion, use of mulches as a moisture conserver and irrigation layouts on the growth, yield and quality of maize.

2.1 Effect of irrigation on maize

2.1.1 Effect of irrigation on characters of maize contributing to growth and yield

Radic (1962) observed that daily growth rate decreased when the absolute moisture content in the upper 30 cm of soil dropped below 16.4 to 17.5 per cent, despite a sufficient moisture supply in the lower soil layer.

Sahu (1967) from Bhubaneshwar stated that tasselling was the most critical stage for soil moisture. Wilting for a day or two reduced the yield by 22 per cent.

Petrunin (1967) from South East Kazakstan reported increased 1000 grain weight from 221 to 270 g and 247 to 265 g for the variety VIR 156 and Sterling, respectively, with 4 irrigations over unirrigated crop.

Flowering stage was the most sensitive to moisture stress, while the knee height stage, to excess moisture (Anonymous, 1968).

Singh and Sharma (1968) found that irrigation applied at 50 per cent ASM increased reproductive efficiency of hybrid maize significantly by 62 per cent over control.

Titev (1969) reported that plant height, leaf area index and productivity of photosynthesis per plant was the highest at soil moisture content of 70 to 80 per cent of field capacity.

Zaborsky (1969) concluded that irrigation increased dry matter and yield in maize for silage by 33.4 and 52.2 per cent for LSPMS and Topolnicky N. Varieties respectively.

Lal (1972) observed that the tasselling and silking stages were the most critical stages in the life cycle of maize plant. He further stated that leaves should not be allowed to wilt at any stage and maize crop should receive irrigation, when 50 per cent ASM in top one foot layer is depleted.

Borole (1973) reported that irrigation at 75 per cent ASM was observed to have more pronounced effect on mean plant height, leaf area, leaf area index and dry matter accumulation/plant than irrigation at 50 per cent ASM and 0.7 water use factor treatment. Further, he observed that days required for tasselling, anther dehiscence and silking were reduced in 75 per cent ASM treatment as compared to other irrigation treatments. The number of grains and weight of grains/cob were siginificantly more in 75 per cent ASM than in 50 per cent ASM and 0.7 water use factor treatment.

Sharma and Upadhyay (1973) reported that tasselling is the most critical stage followed by silking. Soil moisture stress during early vegetative growth period (6th leaf) causes delay in tasselling than in silking.

Nadanam and Morachan (1974) recorded significant increase in respect of important yield components such as grain weight per plant, 1000 grain weight and cob yield per plant with increase in the moisture level.

Bennett and Hammond (1985) from USA in their experiment with optimum irrigation number, irrigation and non-irrigation during vegetative growth on variety protador and ETAFAO 210 observed severe apparent water stress in rainfed plants and during vegetative growth for 15 days delayed irrigation. Both the varieties showed rapid early growth and development; but short duration of vegetative development resulted in low maximum leaf area index and the plant height was further reduced by water stress, except with optimum irrigation.

Krishnaveni and Vanagamudi (1986) observed maximum water requirement of 28 to 30 per cent during silking to end of pollination period.

Pathak and Mathur (1987) observed low soil water stress during sowing to tasselling most conducive to plant growth development even in many of their yield contributory characters. Cob length as well as grains/plant and the grain yield was the highest due to low soil water stress at all growth stages. On the other hand cob length was the most affected due to stress between tasselling and drying of the silk.

The height of the plant and dry matter accumulation were the maximum, when crop was irrigated at 25 per cent depletion of ASM. Higher irrigation regimes increased the length, grain number and grain weight of cob and the differences were marginal between 25 to 50 per cent depletion of ASM. The 1000 grain weight was significantly higher at 25 per cent ASM depletion and on par with 50 per cent ASM depletion (Subramanian et al. (1987).

Puste (1988) concluded that scheduling of irrigation at 0.55 atm soil moisture tension during vegetative growth and at 0.35 atm SMT during reproductive growth produced the highest number of ears/ha, while grain weight/ear was the highest with irrigation at 0.55 atm SMT throughout the growth period.

In a field trial, Alam (1988) from USA observed reduction in the shoot elongation during the vegetative period with water stress and growth rate increased, when irrigation was applied after stress. He further observed enhanced rate of silking by irrigating at early silking.

Bajwa et al. (1988) from Pakistan obtained increased grain yield and dry matter yields/plant with greater irrigation frequency. Cob length and 1000 grain weight increased with increasing nitrogen rate and irrigation frequency.

Puste and Kumar (1988) recorded the maximum number of cobs/ha, grain weight/cob and grain yield, when irrigation was applied at all the 4 stages (knee height, tasselling, silking and grain filling) and at 3 stages and these were significantly greater than without irrigation.

2.1.2 Effect of irrigation on consumptive use (CU) and water use efficiency (WUF) in maize

Devarushi (1977) calculated the WUE of 10.02 kg/ha/mm of water with alternate furrow irrigation with a saving of 38 per cent of water over paired row irrigation which saved 62 per cent water, but the yields were reduced.

Data from a field experiment carried out during the rabi season at Coimbatore showed that the highest yield was obtained with 10 irrigations. The water consumption for maximum grain and straw yield was 382.3 and 379.3 mm, respectively (Kalippa, et al. 1977).

Deboer et al. (1978) observed no effect on WUE by the depth of irrigation applied. The average rate of water removal from a 90 cm soil profile during July and August was 0.54 cm/day.

Hegde ~~and Havanagi~~ et al. (1978) working at Bangalore reported a CU of water between 30 to 54 cm for ragi, maize and groundnut which was also dependent on the season. They further reported the highest WUE with maize.

Miranda and Fuentes (1978) in their experiment with hybrid maize MA 6 recorded significantly higher grain yields with increased irrigation and also increased ear length and diameter and leaf area index, but reduced the WUE.

Reddy et al. (1979) obtained the highest average grain yield of 3.8 t/ha and the lowest WUE with normal sowing in ridges and furrows spaced 60 cm apart and irrigation in all the furrows.

Rana and Malik (1981) observed a higher CU value with scheduling of irrigation at 0.8 IW/CPE ratio, followed by 0.6 and 0.4 IW/CPE ratios, while the WUE was the maximum with 0.4 IW/CPE ratio and followed by 0.6 and 0.8 IW/CPE ratios.

Musick and Dusek (1981) reported that the seasonal ET by treatments irrigated for high yield was 60.7 - 78.9 cm, seasonal water requirements were 40 cm, yields were 9520 - 10850 kg grains/ha and seasonal WUE were 125 - 146 kg/ha/mm.

Venkataraman (1983) collected data on ET and EP at Delhi and Pantnagar in kharif and at Hebbal in summer season and concluded that a) peak ratio of ET/EP was about 1.50 ± 0.20

b) the peak period of consumption was from a month after germination to a fortnight before harvest c) ET became less than EP only a week before harvest d) the moisture requirement was about 40 per cent of pan evaporation in the first 3 weeks of sowing.

Bishnoi (1984) reported increased WUE with moisture stress in pearl millet followed by maize and sorghum. He further concluded that ID/CPE 1.0 ratio as the best for summer maize, pearl millet and sorghum under assurred irrigation.

Mohamed (1985) from Egypt observed increased WUE at 300 m^3 irrigation/feddan with increased nitrogen application. But WUE was the greatest at 50 kg urea/feddan with 400 and 500 m^3 irrigation. He further concluded that ET increased with increased irrigation and nitrogen application.

Nafis and Hammond (1985) calculated the irrigation use efficiency values of 220, 205 and 223 kg/ha/cm for the light frequent irrigation, medium infrequent irrigation and light infrequent irrigation, respectively.

Patel et al. (1985) obtained the highest WUE of 9.22 kg/ha/mm of water at the driest moisture regime i.e. 75 per cent depletion of ASM in 0-30 cm soil depth.

Roy and Tripathi (1987) observed increase in the water use efficiency with increase in irrigation frequency and fertility level. The mean WUE values over irrigation or fertilizer treatments were 144.7 and 153.7 as against 52.6 and 65.6 kg/ha/cm under control in first and second year, respectively.

Alam (1988) from USA reported maximum ET of 570 mm for the growing period of irrigated maize and 310 mm for unirrigated plots. He further stated that irrigattion at the start of tasselling followed by another irrigation at early silking resulted in maximum WUE for grain yields. Maximum WUE for dry matter production was observed, where no stress was allowed at vegetative period coupled with irrigation at early silking.

Pisarenko et al (1988) working on the water requirement of maize in Romania reported the water requirement for midearly, midseason, midlate and late hybrids as 3374 - 4845, 3432 - 4759, 3689 - 5390 and 4049 - 5452 m^3/ha, respectively.

Nita and Naescu (1989) from Romania calculated the WUE of 443 litre water/kg of grain.

2.1.3 Effect of irrigation on yield and uptake of maize

Robins and Domingo (1953) observed that soil moisture depletion to the wilting point for a period 1 to 2 days at the tasselling stage resulted in yield reduction of as much as 22 per cent, while such deficit for 6 to 8 days at this stage reduced yield by about 50 per cent.

Three irrigations amounting to about 150 mm of water gave the maximum yield during the kharif season. During the rabi season, however, five irrigations were needed with 330 mm delta, the total water requirement being about 440 mm on medium black soils, at Arbhavi (Anonymous, 1956).

Alaggia (1957) stated that when the irrigation was applied upto field capacity and the moisture content of the soil was 2/3 of capacity, the yield of irrigated plot increased to 1454 kg/ha over nonirrigated plot.

Denmead and Shaw (1960) reported that moisture stress, prior to silking, at silking and after silking reduced the grain yield by 25, 50 and 21 per cent, respectively.

Sommerfeldt (1960) also recorded increased grain yield from 67.76 to 103.12 q/ha with increasing soil moisture.

Holt and Van Doren (1961) observed that water requirement for corn was the greatest during the period from tasselling to kernel formation and it dropped sharply after kernel formation.

Coifan (1963) reported that the most favourable irrigation rates for maize for grain and for silage were 2200 m^3/ha (5 irrigations) and 1900 to 2000 m^3/ha (6 irrigations), respectively.

Moustafa (1963) recorded the highest yields of maize by irrigating the field 14 days after sowing and then at an interval of every 12 to 15 days.

Afendulov (1965) observed that when maize hybrid was grown under various irrigation regimes with one irrigation one week before tasselling, grain yield of 40.20 q/ha was obtained. Second irrigation applied during tasselling raised this yield to 48.0 q/ha. The third irrigation 10 days later yielded 56.4 q/ha and the fourth irrigation after a further period of 10 days yielded 64.8 q/ha.

Cornu and Michel (1965) observed that two irrigation treatments, one before flowering and one after flowering, had more consistent effect on maize yield than one irrigation given before flowering, the effect of which dependend on spring rainfall. The average increases in yield obtained with one and two irrigations were 60 and 95 per cent for early hybrids and 50 and 104 per cent for semi early hybrids.

Joshi & Dastane (1965) revealed that seedling and flowering stages were very sensitive to excess soil moisture conditions and the yield reductions, even with four days of soil saturation, were to the extent of 50 per cent.

Badhe and Gautam (1966) concluded that 2 to 3 irrigations amounting to 150 mm of water was required before the onset of monsoon for establishment of the hybrid maize crop. The optimum moisture range for irrigation was found to be from field capacity to 0.65 atm tension measured at 15 cm depth for Ganga hybrid 101.

Sharma and Thakur (1966) reported that the maximum yield of maize was obtained, where irrigations were applied before the available soil moisture fell below 50 per cent in the surface 60 cm soil layer.

Sahu (1967) working at Bhubaneshwar stated that irrigation requirement of hybrid maize needs 2, 11 and 18 irrigations with 100, 150 and 900 mm during kharif , rabi and hot weather seasons, respectively.

Petrunin (1967) from south east Kazakstan recorded the grain yields of 14.7 and 26.00 q/ha of unirrigated maize with cv. VIR 156 and sterling, respectively. However, application of 4 irrigations raised the yields to 60.1 and 65.5 q/ha, respectively.

Pandey (1968) recorded the highest grain yield of maize in rabi season with six irrigations of 50 mm each at 50 per cent available soil moisture and 12 irrigations amounting to 720 mm of water at 10 days interval during hot weather season.

Singh and Sharma (1968) concluded that irrigation applied at 50 per cent available soil moisture increased the yield of grain, stover and total produce of hybrid maize significantly, the increase being 228, 68 and 81 per cent, respectively over unirrigated conditions.

Patil et al. (1969) while studying hybrid maize during summer on heavy black soil with 3 moisture regimes of 75, 50 and 25 per cent of availability of water in top 30 cm layer recorded the maximum yield at 50 per cent available soil moisture.

Slepicka (1969) reported increase in grain and stover yields of maize by 37.7 and 54.5 per cent, respectively due to irrigation application over no irrigation.

Titev (1969) observed the highest grain yield/plant and per unit area at soil moisture content of 70 or 80 per cent of field capacity.

Doss et al. (1970) recorded increase in grain yield ranging from 4240 to 5700 and from 5640 to 7210 kg/ha for non-irrigated and irrigated corn, respectively.

Nair (1972) observed that tasselling and silking stages are the most critical stages in the life cycle of maize. Delay in irrigation even by 2 days during these stages reduced the yield by 20 per cent.

Kaul et al. (1972) recorded significantly higher yield with no soil moisture stress over other 2 treatments. They further observed that silking and grain filling stages as the most critical ones, for irrigation. Adequate irrigations with no stress at any stage gave better response, when they were applied in conjunction with nitrogen.

Borole (1973) reported that the grain and dry fodder yields/ha were not influenced due to different irrigation treatments, but green fodder yield was significantly increased when irrigated at 75 per cent ASM.

Malik (1973) reported consistently higher grain yield under the 75 per cent available soil moisture level. However, the differences were significant in 1970, but not in 1969 due to excess rainfall.

Kaliappa et al. (1977) reported that 10 irrigations were sufficient for maximum grain yield of maize. The total water consumption for maximum grain and stover yields were 382.3 and 379.7 mm, respectively. The unit efficiency calculated indicated that 175 : 150 was the best for fodder and 175 : 125 for grain yield. They recommended 175 : 150 unit efficiency for optimum yield.

Nadanam and Morachan (1974) reported the water requirement of maize as 27.65 acre inches. They also observed that moisture level of 60-80 per cent was most congenial for the highest grain and stover yields.

Ali (1976) recorded significantly increased grain yield of maize at 70 per cent available soil moisture of irrigation scheduling compared to 40 or 25 per cent ASM. He observed stunted growth, temporary wilting and poor pollination due to increased soil moisture stress, which led to decreased yield.

Grain and stover yields were consistently higher with irrigation applied at 80 per cent available soil moisture (Verma and Singh, 1976).

Deboer et al. (1978) observed that the grain yield remained unaffected by irrigation depth and it ranged from 7.28 to 8.85 t/ha in 1972 and 1973 with lower yields in 1974 due to poor germination and extreme temperature at pollination.

Miranda and Fuentes (1978) from Chile in their experiment with maize hybrid MA 6 observed significantly higher grain yield with increased irrigation. They also observed increased ear length and diameter and leaf area index, but reduced water use efficiency with increased irrigation.

Ballatore et al. (1979) from Italy in their experiment on maize cv Dekalb, 423 and Funks G 18/A using 2157 m^3/water/ha applied after sowing and at tasselling and at seed setting, recorded yields of 3.27 and 4.08 t/ha, respectively. They further observed that irrigation on the basis of evaporation gave the highest yield of 5.75 t/ha with Dekalb and 5.98 t/ha from Funks G 18/A with an average of 7 irrigations.

The maximum yield of 73.5 q/ha with ridge planting in conjuction with irrigation scheduled at 1.2 IW/CPE ratio was recorded at Delhi under AICOMIP, however, the results were not statistically significant (Anonymous, 1980-81).

Kotoria et al. (1981) working on pearl millet and maize reported the highest fodder yield (green forage, dry fodder and total digestible nutrients) at 0.6 IW/CPE ratio and it was significantly superior to 0.3 and 0.9 IW/CPE ratios.

Musick and Dusek (1981) from Texas USA obtained an yield of 9520 - 10850 kg grain/ha with seasonal WUE of 125 -

146 kg/ha/cm of water for the seasonal ET of 66.7 to 78.9 cm and the seasonal irrigation water requirement of 40 cm. Water deficit reduced the average grain yields by 172 - 289 kg/ha/cm and average seasonal WUE by 67-94 per cent below the adequate water high yield treatment.

At Varanasi, the All India Co-ordinated Maize Improvement Project recorded significantly superior grain yields by applying 6 irrigations at all the 6 critical stages of crop growth and scheduling of irrigation at 50 per cent available soil moisture during vegetative growth stage and at 70 per cent ASM during reproductive stage, produced almost comparable identical grain yield, which was significantly superior to other treatments. Missing irrigation at tasselling, silking or dough stages resulted in significant yield reduction rather than missing irrigation upto late knee height (Anonymous, 1982-83).

The highest grain yield of 37.7 q/ha was obtained in water management project at Rahuri (Maharashtra) with scheduling of irrigation at 0.6 IW/CPE ratio, which was statistically on par with the treatment receiving one irrigation at 0.6 bar atmospheric tension (Anonymous, 1981-83).

At Pusa, under the same scheme, irrigation at higher IW/CPE ratios increased the grain yield upto IW/CPE ratio 1.0, but the differences between grain yields at IW/CPE ratios 0.8 and 1.0 were not appreciable during 1981-82. At Madhipura Centre, it was noted that the grain yield of maize showed an increasing trend with increase in IW/CPE ratio from 0.6 to 1.05 in both the seasons, but the differences in the grain yields at IW/CPE ratio of 0.9 and 1.05 were non significant during 1979-80.

However, at Hyderabad the application of irrigation at 0.9 IW/CPE ratio increased the grain yield significantly over 0.6 IW/CPE ratio during 1980.81. The differences between IW/CPE ratios of 0.75 and 0.9 were not significant. The highest grain yield of 46.9 q/ha was obtained at IW/CPE ratio 0.9 maintained throughout the growing season at Kharagpur (Anonymous, 1981-83).

At Delhi 0.6 IW/CPE ratio was found to be the best for maize crop (Anonymous, 1982-83).

Sondge and Khuspe (1983) observed that scheduling irrigation at 20 per cent depletion of available soil moisture produced significantly more forage yield.

Rajput (1983-85) obtained the highest grain fodder yield at IW/CPE ratio of 2.00, which required 102 cm of irrigation water in 17 irrigations.

Application of 5 irrigations at IW/CPE ratio of 1.0 resulted in significantly higher yield of 38.1 q/ha as compared to 3 irrigations applied at IW/CPE ratio of 0.6 at Pusa. The yield increase at IW/CPE 1.0 over IW/CPE 0.6 was about 80 per cent (Anonymous, 1983-85). They further reported that effects of scheduling irrigation at 0.4, 0.6 and 0.8 IW/CPE ratios were non-significant, though water table depth was 1.75 to 2.25 m below ground level at Hissar. The grain yield was the highest at IW/CPE ratio of 0.8 with 6 cm depth in both the years and was 26 per cent and 75 per cent more than rainfed control, during 1983 and 1984, respectively at Kota.

Barbieri and Cuocolo (1985) obtained the highest grain and protein yield with 240 kg N/ha and irrigation at 40 mm pan evaporation.

Lal and Saini (1985) reported that 5 irrigations be given at 6 leaf, late knee height, tasselling, 50 per cent silking and dough stages, 4 irrigations at 6 leaf, late knee height, 50 per cent silking and dough stages, while 3 irrigations at early knee height, tasselling and 50 per cent silking stages, to obtain optimum yield.

Mohamed (1985) from Cairo Egypt, observed increased yields of grain, stalks and total dry matter with increased irrigation and fertilizer application. He also observed increased evapotranspiration with increased irrigation and nitrogen application.

Nafis and Hammond (1985) recorded 10 to 200 per cent higher periodic water depletion rates in the irrigated plots than those in the nonirrigated plots. The average corn yields were 2112, 7723, 7084 and 7071 kg/ha for control, light frequent, medium infrequent and light infrequent irrigations, respectively. Thus, the yields from irrigated treatments were significantly higher than from nonirrigated treatment at one per cent probability level. The irrigation use efficiencies based on corn yields were 220, 205 and 223 kg/ha/cm for light frequent, medium infrequent and light infrequent irrigations, respectively.

Patel et al. (1985) working at Navsari (Gujarath) observed significant differences in yield of grain and fodder due to various levels of soil moisture regimes. Irrigation scheduled at 25 per cent depletion of available soil moisture gave the highest grain yield of 4793 kg/ha and fodder yield of 13402 kg/ha which was significantly superior to 50 and 75 per cent depletion of ASM in 0-30 cm depth. The total number of irrigations given were 11, 9 and 7 with 635, 580 and 428 mm of irrigation water, respectively.

Rai et al. (1985) reported that 4-6 irrigations are sufficient for maize growing. They further reported that 30, 60, 90, 110 and 125-30 days after sowing are the best times for irrigation. Tasselling and silking were the most critical stages observed by them. Wilting for one or two days reduced yield by 22 per cent and 6.8 days by 50 per cent.

Sipp et al. (1986) obtained an increased yield of 5 t/ha over the period of 7 years experimentation with irrigation and drainage.

Singh and Singh (1986) revealed that during winter season 4 irrrigations are essential at 30, 60, 90 and 120 days after sowing, besides presowing irrigation, if required. They recorded an increase in yield by 25.5 and 30.1 per cent with four irrigations as compared to control during 1983-84 and 1984-85, respectively.

Szaloki and Hemeth (1986) from Hungary obtained average grain yields of 4.3, 6.3, 8.3, and 9.0 t/ha with 0, 60, 130 and 187 mm irrigation water, respectively.

Aujla et al. (1987) concluded that the best practice was to irrigate the crop on the basis of IW/PAN-E ratio of 1.2/0.9 which produced 13 per cent higher average grain yield, than irrigation based on IW/PAN-E ratio of 0.9/0.6.

Roy and Tripathi (1987) recorded significantly higher grain yield with scheduling of irrigation at 0.9 IW/CPE ratio over 0.7 and 0.5 IW/CPE ratios during 1980-81 and 1981-82.

Subramanian et al. (1987) reported significantly higher grain yield at 25 per cent ASM depletion, which was on par with 50 per cent ASM depletion.

Bajwa et al. (1988) from Pakistan reported increased grain and plant dry matter yields by 3.4 and 10.0 t/ha, respectively, with greater irrigation frequency. Yield components increased with increasing nitrogen rate and irrigation frequency.

Boquet et al. (1988) in USA recorded yield by an average of 10 bu/acre with irr at soil water tension of 700 m bar at 10 or 20 inches depth as compared with unirrigated treatment.

Papendick (1988) from USA obtained the greatest corn yield with full season irrigation. He estimated 240 kg/ha of corn grain for every cm of irrigation water, provided the optimum irrigation management practices are employed.

Puste and Kumar (1988) reported knee height, tasselling, silking and grain filling stages as the most critical stages and irrigation applied at all the 4 stages produced significantly greater grain yield than without irrigation.

Tkac (1988) from Czechoslovakia obtained 20-35 per cent increased grain yield with irrigation than no irrigation and there were no differences between irrigation regimes.

Nita and Naescu (1989) from Romania working on maize variety Fundulea 420, recorded annual water consumption of 317.3, 541.7 and 578.3 m^3/ha and grain yields of 8.59, 13.88 and 14.01 t/ha with no irrigation or irrigation at 70 or 50 per cent field capacity, respectively.

2.1.4 Effect of irrigation on quality of maize

Dimitrov (1969) observed that the crude protein content of maize grain decreased, but the fat content was slightly increased by irrigation.

Borole (1973) observed that protein percentage in grain increased significantly by irrigation treatment. However, protein content of grain increased in 75 per cent available soil moisture over 50 per cent ASM and 0.7 water use factor.

Malik (1973) reported decreased grain protein content with increased irrigation.

Kotoria et al. (1981) observed significantly superior total digestible nutrients with 0.6 IW/CPE ratio as compared to the 0.3 and 0.9 IW/CPE ratio. But increasing level of irrigation decreased the yield of crude protein, which led to an increase in the nutritive ratio with the increasing level of irrigation.

Barbieri et al. (1985) obtained the highest protein yield with irrigation at 40 mm pan evaporation, and 240 kg N/ha.

Roy and Tripathi (1987) working on maize at Kharagpur (India) reported increased concentration of N, P and K with increase in irrigation and fertilizer.

Bajwa et al. (1988) from Pakistan reported increased crude protein content with increasing nitrogen rate and irrigation frequency.

Boquet et al. (1988) from USA reported reduced grain crude protein content by irrigation at the soil water tension of 700 m bar at 10 or 20 inches depth over unirrigated treatment.

2.2 Studies on mulches

The practice of spreading a mulch on a soil surface has been referred to in English literature as early as 1882. Any material used at the surface of a soil to reduce evaporation losses, to keep down weeds, to dampen temperature fluctuation or to promote soil productivity, generally may be designated as a mulch (Jacks, et al., 1955).

2.2.1 Effect of mulches on moisture conservation

Duley and Russell (1939) conducted intensive studies on soil moisture under application of 2 ton of straw/acre as compared with disced plots with no straw cover. Penetration of soil moisture was 1½ times more with straw cover as compared to no straw.

Russell (1939) reported that the main effect of mulch on evaporation, persisted for a period of two days following rain. He observed optimum conservation of moisture by residues in the order of 2 tons per acre.

Duley et al. (1941) and Beale et al. (1955) have shown that stubble mulching besides reducing soil loss and run off, also increase the storage of moisture in the soil.

The value of mulching as a means of conserving soil moisture, in tropical agriculture was illustrated by experiments conducted with cane trash in Puerto Rico (Vicente Chandler, 1953). The average monthly losses of water by evaporation from bare and mulched soils were 2.12 and 0.90 inches, respectively. The saving of water by mulching was estimated to be equal to 3 inches irrigation water per month.

Schaller and Evans (1954) reported that the soil moisture was frequently higher under mulched soil than under bare soil which may be due to a higher infiltration rate and lower evapotranspiration rate under the condition of mulching.

As reported by Hanks et al. (1967) and Bond and Willis (1969), mulching the surface with plant residues can reduce the intensity of temperature with which external factors such as radiation and wind act upon the surface.

Moody et al. (1963) reported that the available soil moisture of mulched soil averaged for 3 years was 28 per cent higher in July and 17 per cent higher in August than the bare surface plots.

Ray (1963) reported beneficial effect of straw mulch in conserving soil moisture in the upper 45 cm of soil layer under low soil moisture condition.

Greb (1966) opined that reduction in soil water losses could be brought about by mulches through reduction in soil temperature, impeding vapour diffusion, acting as periodic focal points for temporary vapour condensation and absorption into mulch tissue and reduction in wind velocity at soil surface.

Evaporation during the constant rate of drying can be retarded by soil surface treatments with plant residues. The retardation of initial evaporation can enhance the process of internal drainage and thus, will allow more water to move down into the deeper layers of profile, where it is conserved for a longer period and is less likely to be lost by evaporation (Hillel, 1968).

Straw and polythene mulches conserved 24.7 and 32.2 per cent moisture, respectively, over control (Rajput and Singh, 1970).

Hazra et al. (1973) observed that straw mulch conserved higher amount (122.2 mm) of moisture as compared to no mulch plots (108 mm) in 0-120 cm soil profile of sandy loam soil.

Application of mulch between crop rows can conserve 50 per cent extra moisture in dry farming areas (Umrani et al. 1973).

Ali et al. (1974) proved the organic mulches as an effective method of soil moisture conservation in dry farming.

Verma and Meyers (1975) studied the influence of surface mulching on moisture, temperature and cracking in vertisoils. They observed that sorghum stubbles @ 7.5 t/ha was proved to be the most effective and shown superiority in reducing moisture evaporation.

Ranga Rao, et al. (1980) working at Bellary (Karnataka) observed that surface mulching with straw @ 5 t/ha immediately after sowing conserves more moisture and give 60 per cent increased yield of sorghum than control.

It has been reported by quite a large number of workers from abroad (Russell, 1939; Alderfer and Merkle, 1943; Geytenbeek, 1951; Chandler, 1953; Henin and Monnier, 1961; Adams, 1966; Black 1973; Jakobsen and Jenson, 1981) that straw mulch applied on the surface considerably increased the moisture storage in the soil.

In India, many studies pertaining to the efficiency of various plant residues as mulch under dry farming condition were made by several workers (Chowdhary and Chatterjee, 1977; Singh et al.. 1967; Rajput and Singh, 1970; Bansal et al. 1970; Tiwari et al. 1970; Umrani et al. 1973) and it has been reported that fairly good amount of moisture was conserved.

2.2.2 Effects of mulches on plant growth and yield

Other Crops

Duley and Russell (1948) reported the effect of sweet clover residue left on the soil surface, on the yield of maize, oats and sorghum. The crop yields were higher on the land protected by residues due to conservation of water in soil.

Singh and Nijhawan (1944) observed that the yield of cotton plants mulched with bajra stalk was of the order of 1423 lb per acre as against 541 lb per acre on soil with unmulched plot. They also noted higher yield of barley under wheat straw mulch than no mulch.

Isenberg and Odland (1951) observed on an average 25-35 per cent increase in the yield of vegetable crops like cucumber, tomato and sweet corn due to application of organic mulches as compared to no mulch.

Samed et al. (1957) observed marked increase in vigour of cotton plants grown with straw mulch. The yield obtained under mulch was 2.7 times more than the yield of no mulched plots.

Ashriff and Thornton (1965) recorded increased yield of groundnut with the application of grass mulch @ 5 t/ha.

Chowdhary and Chatterjee (1967) observed improved plant growth, (number of leaves, tillers etc.) root development, grain and straw yield of barley due to application of straw mulch.

Black (1970) obtained significantly higher yield of winter wheat under straw mulch in the semi-arid condition. He further indicated that yield responses to straw mulch were higher with the increase in the number of moist day.

Rajput and Singh (1970) reported that application of straw mulch led to the production of taller cotton plants. The improved development of plants was reflected in terms of increased yield per plant under straw mulch.

Koshi and Fryrear (1971) obtained increased cotton yield with the application of cotton bur @ 11.12 q/ha as a mulch, which also improved water storage and utilization of the soil.

Bansal et al. (1971) applied straw mulch as 2 cm thick typha-mat and got an increased yield by 35 per cent, apparently because of its favourable effect on soil moisture.

Umrani et al. (1973) got an increase in yield of sorghum grain and fodder by about 28 and 19 per cent, respectively by applying dry grass mulch between the crop rows at the rate of 5 t/ha.

Bhan (1976) observed marked improvement in the root development with consequently better moisture extraction, yield and WUE of brown sarson due to the application of paddy straw @ 2 t/ha.

Reddy (1976) got significantly increased yield of safflower due to straw mulch as compared to no mulch.

Dahiya and Singh (1977) recorded an increase in grain and stover yields of 9.7 and 12.8 per cent, respectively with straw mulch @ 3 t/ha in pearl millet over unmulched plots.

Bhan and Khan (1980) observed that application of paddy straw mulch or sugarcane trash mulch @ 2.5 t/ha enhanced the yield of sunflower by about 2 q/ha with an additional yield return of Rs.464 and 542/ha over unmulched plot.

At Agra, Bellary, Hissar and Udaipur centres of All India Co-ordinated Research Project for dry land agriculture, mulching was found beneficial for kharif and rabi crops. In case of pearl millet the mulching with wheat straw @ 5 t/ha increased the yield by 56.5 per cent, whereas with pearl millet husk @ 4 t/ha, the increase in wheat yield was 10.7 per cent (Anonymous, 1980-81).

Jakobsen and Jensen (1981) got the increased yield of barley due to application of mulch.

Mane and Umrani (1981) reported that application of mulch, increased the grain yield of sorghum.

The use of Basoti mulch produced the maximum yields of both wheat and maize, and was significantly superior to no mulch. This material was statistically superior to Sarkanda mulch in case of maize only (Annoymous, 1985).

Maize :

Collings (1961) recorded maize yield of 2034, 1857 and 768 lbs/acre with heavy mulch, light mulch and no mulch, respectively.

Taylor et al. (1964) obtained excellent control of soil and water losses from corn after corn on steeply slopping deep loose soil with the application of corn stover and barnyard manure.

Bansal et al. (1971) in their experiment with 2 cm thick straw mulch got 35 per cent higher yields of maize due to favourable effect of mulch on soil temperature.

Tamlin, et al. (1973) found that late mulching with straw 5 week after planting proved beneficial as it increased grain and dry matter production of maize.

Choudhary and Prihar (1974) reported better plant growth and higher yields of corn due to straw mulching as it enhanced the root growth in the upper 15 cm of soil and increased the lateral spread of roots, but less roots, below 15 cm than control.

Ratan Lal (1974) observed an increase in grain yield of maize by 46, 52, and 22 per cent in 1970, 71 and 72, respectively due to mulching over no mulch. He also observed higher plant growth rate and vigour with mulched plants and chlorotic symptoms of nutritional disorders with unmulched plants. Mulching significantly decreased the maximum soil temperature measured at 5,10,20 cm depth. Finally, grain yield was also increased with mulched plot.

Olson and Horton (1975) observed that straw mulch applied to corn field modified soil temperature and the microclimate sufficiently to increase the crop growth and yield.

Khera et al. (1976) reported increase in the dry forage yield by 11.8 q/ha or 25 per cent due to mulching.

Prihar et al. (1979) studied the effect of mulching in standing maize or fallow on the yield of the maize and following wheat. Mulching maize with green twigs of "Basooti" a few weeks before harvest increased its yield by 16 per cent.

Reddy et al. (1979) recorded increased grain yield upto 0.44 t/ha by the use of mulch.

Significant increase in grain and straw yield of maize and green gram has been reported by Gaur and Mukherjee (1980).

Bhan (1980) reported increased maize grain yield by 6.4 q/ha (88 per cent) with the application of straw mulch @ 20 q/ha combined with pre-emergence application of simazine @ 1.0 kg a.i./ha over control.

Aina (1981) from Western Nigeria reported 63 per cent higher grain yield with full season mulching. Further, he observed positive growth and yield trend for early mulching in the 7 days after sowing. So also yields were increased by applying mulch early and for a long duration (more than 6 weeks).

Kromer et al. (1981) in their experiment with plastic film mulching recorded increased silage and grain yields of maize by 2.2 to 12.4 and 0.9 to 2.7 t/ha, respectively. Further, they observed that the plastic film mulching caused eariler ripening and lower moisture content in the grain.

Mourya et al. (1981) recorded more yield with translucent polythene and straw mulch material than unmulched ridges and transparent polythene treatments.

Okigbo (1981) observed significantly higher dry matter, stover yield and grain with legume (soyabean tops, pigeon pea tops, legume husks etc.) plus rice husk mulches than other mulches. Further, he observed significant differential mulch effects on tasselling, anthesis and silking dates, nematode incidence, lodging and maize height.

At Ludhiana no beneficial effect of mulch on maize crop was observed under All India Co-ordinated Research Project on Dry Land Agriculture (Anonymous 1981-82).

Khybri (1983) observed no influence of mulch on grain yield of maize.

Rao et al. (1983) recorded increased maize yield by application of 6 t organic mulch/ha. Ear length, number of grains and grain weight were increased by mulching.

Stoichev (1985) reported no effect on quantity of available soil moisture and yield of maize crop due to mulching as an independent treatment.

Balaswamy et al. (1986) in their experiment with maize observed that mulching with 8 ton paddy straw/ha increased the plant height, dry matter production and all yield attributes in both the years.

Aujla et al. (1987) obtained increased grain yield of maize by 17 per cent in 1981-82 when the reproductive phase of the crop got extended to hot and dry summer period with the application of straw mulch @ 6 t/ha as compared to no mulch treatment.

Shekour et al. (1987) from USA reported that the mulch and antitranspirant treatments resulted in mean increase in plant height and leaf area of 21.1 and 4.8; 34.5 and 5.7 per cent, respectively. Fresh ear and total dry matter mean increases were of 75 and 20.0; 89.7 and 42.0 per cent, respectively as compared to the limited irrigated control. Only the mulched treatment produced growth and yield similar to the irrigated control.

2.3 Effect of irrigation layouts on Maize

Maize being sensitive to excess soil moisture, persistance of wetness within the rooting zone adversely affects the crop growth (Lawton, 1946). Joshi and Dastane (1963 and 1966) found that seedling and flowering stages were very sensitive to excess soil moisture condition. Wiersma (1959) has stated that continual replacement and removal of soil atmosphere by diffusion is necessary for optimum root functioning and that such a diffusion is linearly related to the volume of air filled pores in the soil. The type of layout, therefore, assume special importance in maize cultivation, to achieve maximum efficiency of the water used. The objectives for the better method of sowing are as following.

a] Lower water runoff and erosion

b] convenience of the farmer

c] avoid ill effects of water stress and water logging or flooding

d] reduce power machinery and labour cost

e] weed control

In addition to modifying soil environment for enhancing plant growth, a sowing method must provide for the desired control of weeds seed placement, water infiltration, water evaporation and transpiration. The objective in irrigation layout is to manage these interalated components so as to optimize their control.

Singh (1932) obtained higher yield of maize on ridge planting compared to that on level planting. The average difference in favour of ridge planting recorded by him was 12.9 per cent. He further, stated that on ridges, maize has darker green leaves and made more rapid growth.

Dungan et al. (1958) observed a small difference of 0.8 bu/acre in grain yield of maize in favour of ridging over level cultivation on well drained soil.

Beer et al. (1961) reported substancially higher maize yields on ridge plots than on level plots during 1954-59 on soil with poor internal drainage.

Collings (1961) harvested 1337 lbs of grain yield / acre on flat cultivation as against the yield of 1553 lbs/acre on ridge layout.

Joshi (1962) reported that upto 36 days after planting, the flat layout showed higher dry matter/plant but at 46 and 48 days after sowing ridge layout showed significantly greater dry matter accumulation. Later on the trend was in favour of ridging. Although there was no significant difference in stover yield under two layouts, grain yield was 22 per cent higher under ridge layout.

Shah (1968) concluded that planting of maize on ridges was beneficial as it allows enough aeration for the roots during period of excess rainfall.

Jain (1974) reported that of ridges and furrows are quite useful as they serve dual purpose of irrigation and drainage.

Singh et al. (1979) obtained 57.1 per cent and 101.0 per cent more yield of maize during 1975 and 1976, respectively, with the improved practice of sowing on ridges and furrows at 60 x 20 cm apart over local (Kera) method of sowing.

Under AICORP for Dry Land Agriculture at Jhansi centre Anonymous (1979-80) obtained 40.2 and 34.9 q/ha grain yield of maize with flat bed and ridge furrow irrigation, respectively, which were statistically significant.

Under All India Co-ordinated Maize Improvement Project at Delhi, no significant differences in maize grain yields were observed due to planting on flat beds, flats + earthing up and ridge planting. Although maximum yield of 73.5 q/ha was obtained with ridge planting in conjuntion with irrigation scheduled at IW/CPE ratio of 1.2 (50 mm) (Anonymous, 1980-81).

Banswara and Bahraich centres of AICOMIP found no significant difference between method of sowing and date of sowing. However, at Varanasi sowing on flat beds gave significantly superior yield over ridge sowing (Anonymous, 1981). During 1982, the results at all the centres were non-significant but centre Bahraich recorded the highest average yield of 68.8 q/ha when sown on June, 25 direct on ridges. So also sowing on ridges at all sowing dates was advantageous.

Gupta et al. (1981) while working on maize and sorghum on black clay soils in the rainy season of 1976-77 with a slope of 1.2, 0.6 and 0.3 per cent on ridge and flat bed recorded 14 to 106 per cent more yield of maize and 6 to 54 percent of sorghum on ridge planting. They further, reported that as the slope increases the ridging becomes ineffective, Ridging also improved seedling emergence and plant fresh weight.

Under AICOMIP at Delhi centre flat sowing of maize followed by earthing up was significantly superior to ridge sowing. However, differences between flat x flat followed by ridge were nonsignificant. Interaction were also nonsignificant (Anonymous, 1982-83).

Rao (1983) in his book on "Hybrid maize" recommended that sowing of maize should be done on ridges 75 cm apart and dibbling on ridge at 25 cm.

At Ludhiana under AICOMIP no significant differences due to method of sowing and spacing were observed though the trend was in favour of ridge method of sowing and wider spacing of 60 x 20 cm (Anonymous, 1983-84).

At Banswara, Udaipur and Varanasi Centre of AICOMIP, 3 methods of sowing viz flat, ridge and flat and ridge, the interaction was non significant. However, flat method of planting at Varanasi was found to be significantly superior and recorded 16 per cent higher grain yield over ridge method. At Udaipur, though results were not statistically significant, the trend was in favour of flat planting (Anonymous, 1984).

Narang (1984) has recommended sowing of winter maize on ridges and furrows in Punjab in rabi season.

Singh et al. (1984) concluded that if planting is done before 15th November the yield differences between flat and ridge are not usually of considerable extent. But if sowing is done after 15th of November, sowing of seed on southern slope of east west ridges resulted in early germination, early seedling vigour, early maturity and minimum damages due to cold and thus, higher yield.

At Mandsaur centre of AICOMIP, flat followed by earthing up was found significantly superior to flat and ridge planting, but at Jullendhar, ridge method gave higher grain yield over flat (Anonymous, 1985-86).

Bhinder et al. (1985) reported that sowing on south side of ridges layout in an East West direction accelerated the seedling emergence by 4 days in crops sown in December and January. They further recorded increase in $\overline{RGR}$, LAI, dry matter production and grain yield as compared with sowing on flat seed bed.

Lal et al. (1985) revealed that it is desirable to plant maize on ridges and furrows.

Rai et al. (1985) reported that planting of maize should be done on ridges and furrows at 75 x 20 cm apart.

Bhinder and Sawhney (1986) obtained significantly higher yields due to sowing on ridges than on flat beds.

Reddy et al. (1986) reported the highest growth and yield attributes in maize, normal sowing with irrigation in all the furrows over double file sowing in deep furrows. They further reported the lowest values of growth and yield attributes with normal sowing and irrigation in alternate furrows.

Singh and Awasthi (1987) recorded that line sowing was significantly superior over broadcasting and an increased grain yield by 45.7 per cent with net returns of Rs. 2344/ha.

Elmani et al. (1987) working at the College of Agriculture, Baghdad, Iraq obtained 7.37 and 11.9 t/ha grain yields from spring and autumn sowing, respectively with sowing on ridge with base listing and with 25-30 cm ploughing depth.

Eckert (1988) from USA stated that corn planted on ridges generally produced yields equivalent to or greater than corn planted following fall ploughing for continuous corn and corn soybean rotations, with or without tile drainage. He further, observed that in one of two years in which soil moisture condition permitted earlier planting of corn on ridges yielded more than fall plowed plots.

Singh (1988) reported that, maize is sensitive to excess water and hence, it is advisable to plant it on ridges and furrows or make ridges and furrows in the field after its establishment. He further stated that, it is convenient and economical to irrigate maize through the furrows, which may serve as drainage channels as and when required.

Significantly higher grain yield of 29.0 q/ha by sowing on flat beds followed by earthing up after 30-35 days as compared to ridge (22.0 q/ha) and flat (22.8 q/ha) method of sowing was obtained at Dholi centre of AICOMIP (Anonymous, 1988).

2.4 Correlation study

Alessi and Powar (1965) concluded that forage and grain yields were positively correlated with total available soil moisture. Grain and silage yields were reduced under low stored moisture at planting.

Elsahookie and Wassom (1985) observed positive correlation with yield efficiency and yield per plant in irrigated plants.

Muthukrishnan and Subramanian (1980) found existance of strong relationship between yield and 1000 grain weight, grain number per cob, length of cob and leaf area index at 1 per cent level of significance.

Subramanian et al. (1981) observed positive and highly significant correlation between grain yield and length of cob, 1000 grain weight and grain weight per cob. They further reported that positive correlation coefficient between the agronomic characters considered with grain yield and indicated that there exists a strong association between these characters and yield.

Materials & Methods

3. MATERIALS AND METHODS

The present investigation was carried out on maize crop during rabi season of 1986-87 and 1987-88, for two successive years. The field experiment was conducted at the same site without changing the randomization of the treatments. The details of the materials used and techniques followed during the conduct of this investigation are given in this chapter under different headings as follows :

3.1 Details of the experimental materials

3.1.1 Experimental site

The experiment was conducted at the Shahu Agricultural School farm under the College of Agriculture, Kolhapur on plot No.10. The experimental field was uniform in soil depth upto 90 cm and fairly levelled for irrigation.

3.1.2. Soil

The soil of the experimental field was medium black [vertisol] and well drained. In order to understand the physical nature and fertility status of the soil, representative composite soil samples upto 0-30 and 30-60 cm depth from 10 different locations of the experimental field were taken before the start of the experiment during rabi 1986-87. These soil samples were analysed for various physico-chemical properties. The relevant data obtained on these attributes are given in Table 1.

It is observed from the data presented in Table 1 that the soil of the experimental field was clay loam in texture.

Table 1 : Physico - chemical composition of the experimental soil

Soil properties	Composition 0-30 cm	30-60 cm	Method used
A. Physical properties			
1. Coarse sand (%)	7.90	6.10	International Pipette
2. Fine sand (%)	21.90	21.70	Method (Piper, 1966)
3. Silt (%)	26.41	26.55	
4. Clay (%)	42.40	44.30	
5. Organic matter (%)	1.39	1.35	
6. Calcium carbonate	4.90	-	Rapid Titration Method (Piper, 1966)
7. Textural class	clay loam	clay loam	
B. Chemical properties			
1. Organic carbon (%)	0.81		Walkley and Black Rapid Titration Method (Piper, 1966)
2. Total nitrogen (%)	0.074		Modified Kjeldahl's Method (A.O.A.C. 1975)
3. Available P_2O_5 (kg/ha)	19.20		Olsen Method (1954)
4. Available K_2O (kg/ha)	760		Flame Photometer Method (Hanway and Heidal, 1967)
5. pH(Soil : Water) (1 : 2.5)	7.7		Glass Electrode Method (Piper, 1966)
6. Electric conductivity (mm hos/cm) Soil : Water 1 : 2.5	0.42		Platinum Electrode Method (Piper, 1966)
7. C : N ratio	10.90		
C. Single value physical constants			
1. Max. water holding capacity (%)	58.50	57.20	Perforated Dish (Piper, 1966)
2. Moisture at 1/3 bar (Field capacity)	36.50	37.10	Field Method (Dastane, 1972)
3. Moisture at 15 bar (Permanent wilting point)	20.80	21.10	Pressure Membrane Apparatu (Richards, 1965)
4. Bulk density (g/cm^3)	1.13	1.17	Core Sampler Method (Dastane, 1972)

According to the criteria laid down Muhr et al.[1965], the chemical composition indicates that the soil was medium in total nitrogen and available phosphorus and fairly rich in available potassium

3.1.3 Climate

A] General

Geographically, Kolhapur comes under submountain zone [Transitional Belt I] and is situated between Western Ghat zones. It is situated on the bank of river Panchganga, at an elevation of 574 metres above the mean sea level, on 16°-43' North latitude and 74°-14' East longitude. The weather data for the last 10 years are given in Table 2 and depicted in Fig.1. From the data presented in Table 2, it could be observed that the average annual precipitation of this place is 961 mm with 77 rainy days. Of the total precipitation, 75 per cent is received between June and September from the South-West monsoon, 15 per cent from October to February from the receding monsoon and 10 per cent in the month of March, April and May as pre-monsoon showers. July and August are the wettest months, while January and February are the driest months, when there are practically no rains. Pre-monsoon showers are beneficial for the preparatory tillage operations of kharif crops. The rainfall is well distributed throughout the kharif.

At Kolhapur, the mean maximum temperature is observed in April and May. In April, it is 36.16°C and in May, it is

Table 2 : Mean meteorological data for the last 10 years (1976 to 1985)

Months	Temperature °C		Humidity per cent		Rainfall	
	Maximum	Minimum	Morning (7.30) hrs.	Evening (14.30) hrs.	mm	Rainy days
January	30.27	13.91	84	42	0.42	1
February	32.56	13.95	79	34	7.13	1
March	35.17	17.64	76	30	5.94	1
April	36.16	20.51	78	33	40.34	3
May	35.83	21.39	83	35	45.32	3
June	29.98	22.00	87	61	197.44	11
July	27.70	21.24	90	74	233.71	20
August	27.98	20.63	90	71	225.44	19
September	29.63	20.22	90	58	83.23	9
October	32.11	19.38	89	50	76.82	4
November	30.89	17.14	85	45	42.48	4
December	30.74	16.70	84	44	3.47	1

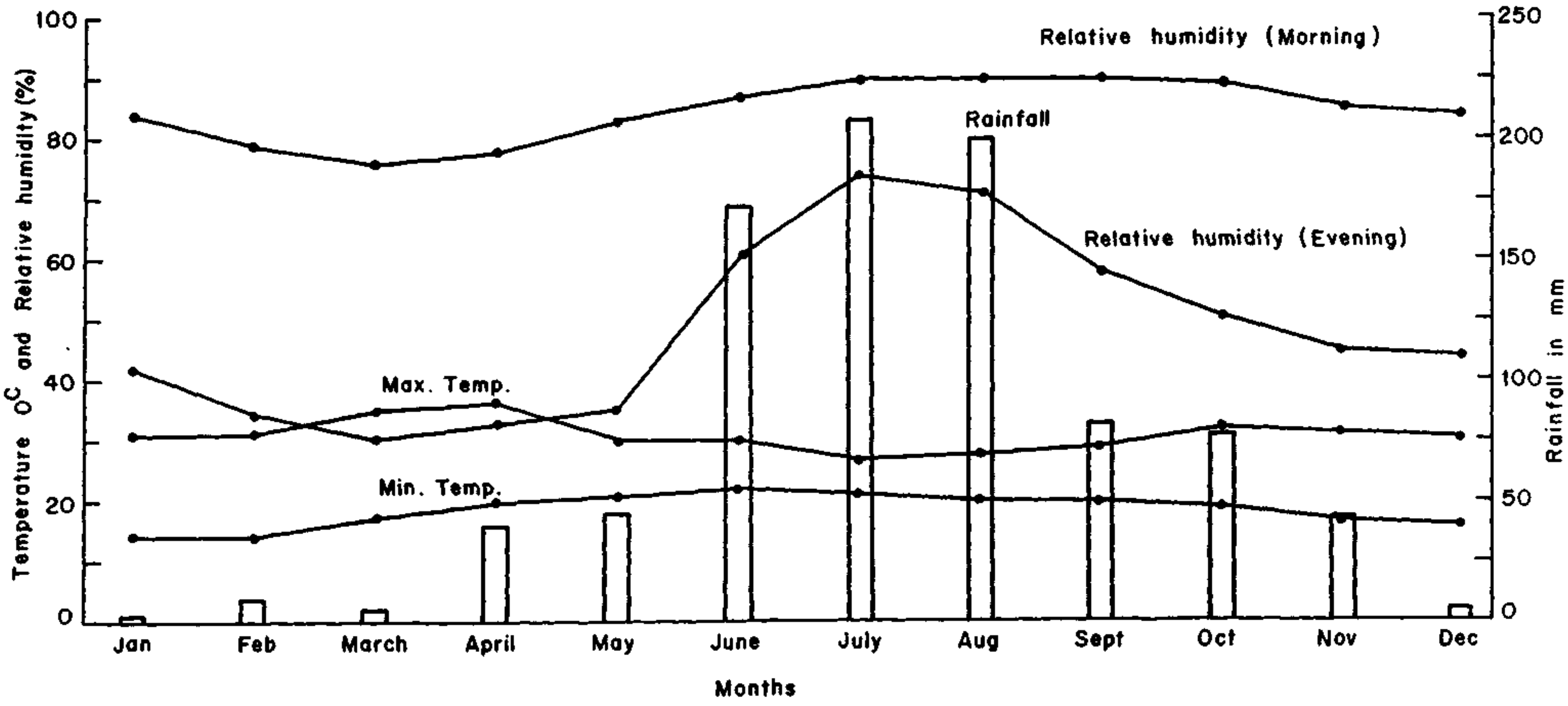


Fig. 1. Mean meteorological data for last 10 years (1976-1985).

35.83°C. Thus, April and May are the hottest months at Kolhapur. With the commencement of South-west monsoon, the temperature falls to 29.98°c in June and fluctuates between 27.70 to 29.63°c from the month of June to September. Again, it rises to 32.11°c in the month of October, untill winter season begins. From November to January, the mean maximum temperature ranges between 30.89 to 30.27°c, and thereafter it rises to 32.56 and 35.17°c in February and March.

The mean minimum temperature is about 13.91°c in the month of January. Then it gradually rises and is 22.0°c in June. From July onwards, it gradually drops and reaches to 16.70°c in December. The morning humidity during the South - West monsoon period is as high as 90 per cent and more or less constant from July to October. It then, gradually declines and reaches 76 per cent in March, and again rises from April. The evening humidity ranges between 30 to 74 per cent. However, it declines from August till March. The mean maximum and minimum humidity during the month of March, April and May are the lowest. Thus, mostly dry and medium hot weather prevails during the summer season at Kolhapur.

B] Climatic condition during the experimental period :

The weekly relevant data of the weather parameters obtained from the Agricultural, Meteorological observatory, located at the Agricultural College Farm, Kolhapur for both the years of the experimentation are presented in Table 3 and 4 and depicted in Fig.2 and 3.

It would be seen from the Table 3 and 4 that the mean maximum temperature ranged between 28.90 and 36.10°c, and 26.7 and 37.1°c during 1986-87 and 1987-88, respectively, while the minimum temperature ranged between 6.82 and 20.30°c and 6.10 and 17.8°c, respectively. The mean morning relative humidity ranged between 56 and 94; and 60 and 92 per cent during 1986-87 and 1987-88, respectively, while the evening humidity ranged between 18 and 62; and 18 and 64 per cent, respectively.

The total rainfall received during 1986-87 and 1987-88 was 110.4 and 143.8 mm with 9 and 14 rainy days, respectively during the crop growth period. The rains received during the 42nd and 43rd meteorological week in 1986-87 were helpful for the initial growth of maize.

The bright sunshine hours ranged from 5.92 to 10.7 and 2.1 to 10.5 hrs during 1986-87 and 1987-88, respectively. However, the mean pan evaporation ranged from 3.22 to 6.9 and 3.1 to 7.5 mm, during 1986-87 and 1987-88, respectively.

3.1.4 Cropping history of the experimental field

The information regarding the crops grown on the experimental plot during previous three years of this investigation are presented in Table 5.

Table 3 : Meteorological data for the year 1986-87 recorded at the meteoro logical observatory, College of Agriculture, Kolhapur.

Met. week	Date	Rainfall (mm)	Rainy days	Mean Temperature °c		Mean relative humidity (per cent)		Sun shine (hr)	Evap- orat- ion USA std (mm)
				Max.	Min.	Mor ning (7.30 hr)	Even- ing (14.30 hr)		
				October, 1986					
40	1 - 7	37.2	2	32.20	17.70	91	59	6.95	3.51
41	8 - 14	-	-	33.20	17.10	90	47	7.88	4.38
42	15 - 21	-	-	32.17	15.83	88	43	9.70	4.57
43	22 - 28	-	-	33.60	14.00	81	33	8.43	5.52
				November, 1986					
44	29 - 4	30.4	2	30.40	20.30	86	62	7.10	4.70
45	5 - 11	21.0	3	30.16	18.60	94	60	5.92	3.22
46	12 - 18	-	-	32.00	13.76	73	35	8.80	4.24
47	19 - 25	-	-	36.10	12.14	62	31	10.42	4.41
48	26 - 2	-	-	35.62	12.50	60	40	9.79	4.41
				December, 1986					
49	3 - 9	-	-	29.42	6.82	87	39	9.80	4.25
50	10 - 16	-	-	30.00	8.34	80	40	9.85	4.17
51	17 - 23	-	-	30.00	9.40	81	39	9.90	4.90
52	24 - 31	-	-	29.10	11.10	85	49	8.80	4.70
				January, 1987					
1	1 - 7	-	-	29.00	8.00	80	34	10.20	4.40
2	8 - 14	-	-	28.90	9.40	81	42	9.50	4.00
3	15 - 21	-	-	31.00	12.50	76	42	8.60	4.60
4	22 - 28	-	-	31.50	12.20	68	38	9.50	4.20
				February, 1987					
5	29 - 4	-	-	31.90	10.20	57	30	9.40	4.50
6	5 - 11	-	-	30.80	9.90	56	33	10.20	6.70
7	12 - 18	-	-	32.20	11.50	73	34	10.00	6.20
8	19 - 25	21.8	2	33.00	14.60	71	27	9.50	6.10
				March, 1987					
9	26 - 4	-	-	32.30	11.00	74	27	10.00	6.60
10	5 - 11	-	-	33.81	14.91	73	29	8.90	6.90
11	12 - 18	-	-	32.20	12.80	79	30	10.70	6.30

Table 4 : Meteorological data for the year 1987-88 recorded at the meteorological observatory, College of Agriculture, Kolhapur.

Met week	Date	Rainfall (mm)	Rainy days	Mean Temperature °c		Mean relative humidity (per cent)		Sun shine (hr.)	Evaporation USA std (mm)
				Max.	Min.	Morning (7.30 hr)	Evening (14.30 hr)		
				October, 1987					
40	1 - 7	17.6	4	29.4	17.8	92	64	5.5	3.3
41	8 - 14	3.4	1	31.9	15.9	85	44	8.3	4.0
42	15 - 21	9.6	2	30.9	16.7	86	54	6.3	4.1
43	22 - 28	2.0	1	31.2	12.3	79	43	8.1	4.8
				November, 1987					
44	29 - 4	-	-	31.9	12.3	68	42	10.5	4.7
45	5 - 11	-	-	30.1	13.4	79	47	7.5	3.9
46	12 - 18	51.2	3	28.2	17.1	80	63	2.1	3.1
47	19 - 25	-	-	30.3	11.4	81	40	8.6	3.5
48	26 - 2	-	-	30.3	8.9	63	30	8.4	4.3
				December, 1987					
49	3 - 9	-	-	30.5	11.1	69	43	9.8	4.1
50	10 - 16	60.0	3	28.4	15.1	87	59	5.1	3.2
51	17 - 23	-	-	26.7	6.1	74	34	10.1	3.2
52	24 - 31	-	-	28.8	10.1	86	49	9.7	3.3
				January, 1988					
1	1 - 7	-	-	28.8	8.4	85	44	9.5	3.3
2	8 - 14	-	-	29.0	8.4	77	40	9.7	3.5
3	15 - 21	-	-	30.7	10.1	89	39	9.5	3.9
4	22 - 28	-	-	31.4	10.0	84	36	9.8	4.8
				February, 1988					
5	29 - 4	-	-	33.1	13.3	68	30	10.0	5.0
6	5 - 11	-	-	33.0	9.5	71	26	9.2	5.7
7	12 - 18	-	-	33.1	12.2	71	32	9.6	6.0
8	19 - 25	-	-	35.2	11.9	79	27	9.7	6.2
9	26 - 3	-	-	34.5	10.6	73	18	9.1	7.1
				March, 1988					
10	4 - 11	-	-	35.2	13.2	60	24	9.1	7.3
11	12 - 17	-	-	37.1	14.9	65	28	9.2	7.5

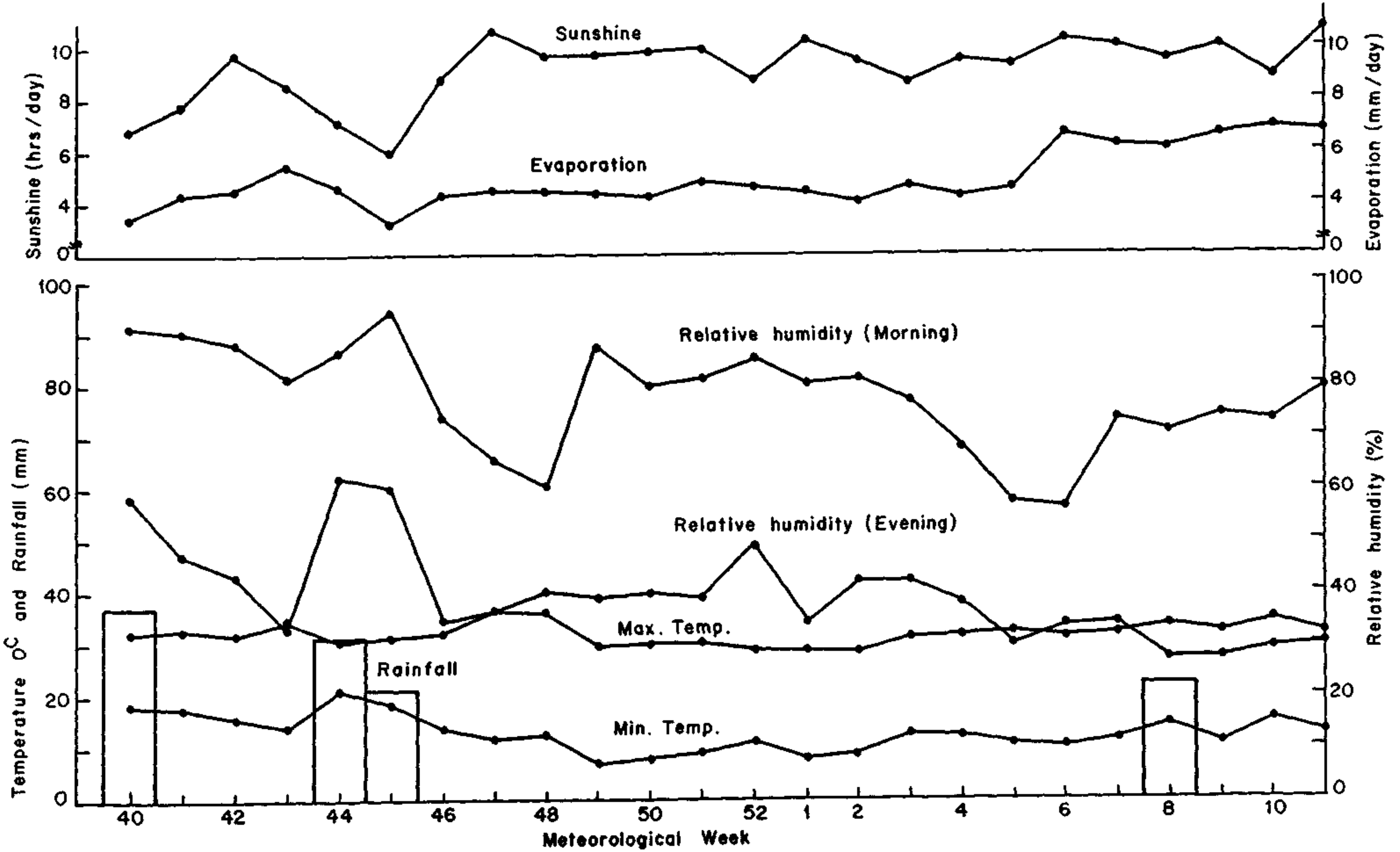


Fig. 2. Mean meteorological data for the year 1986-87.

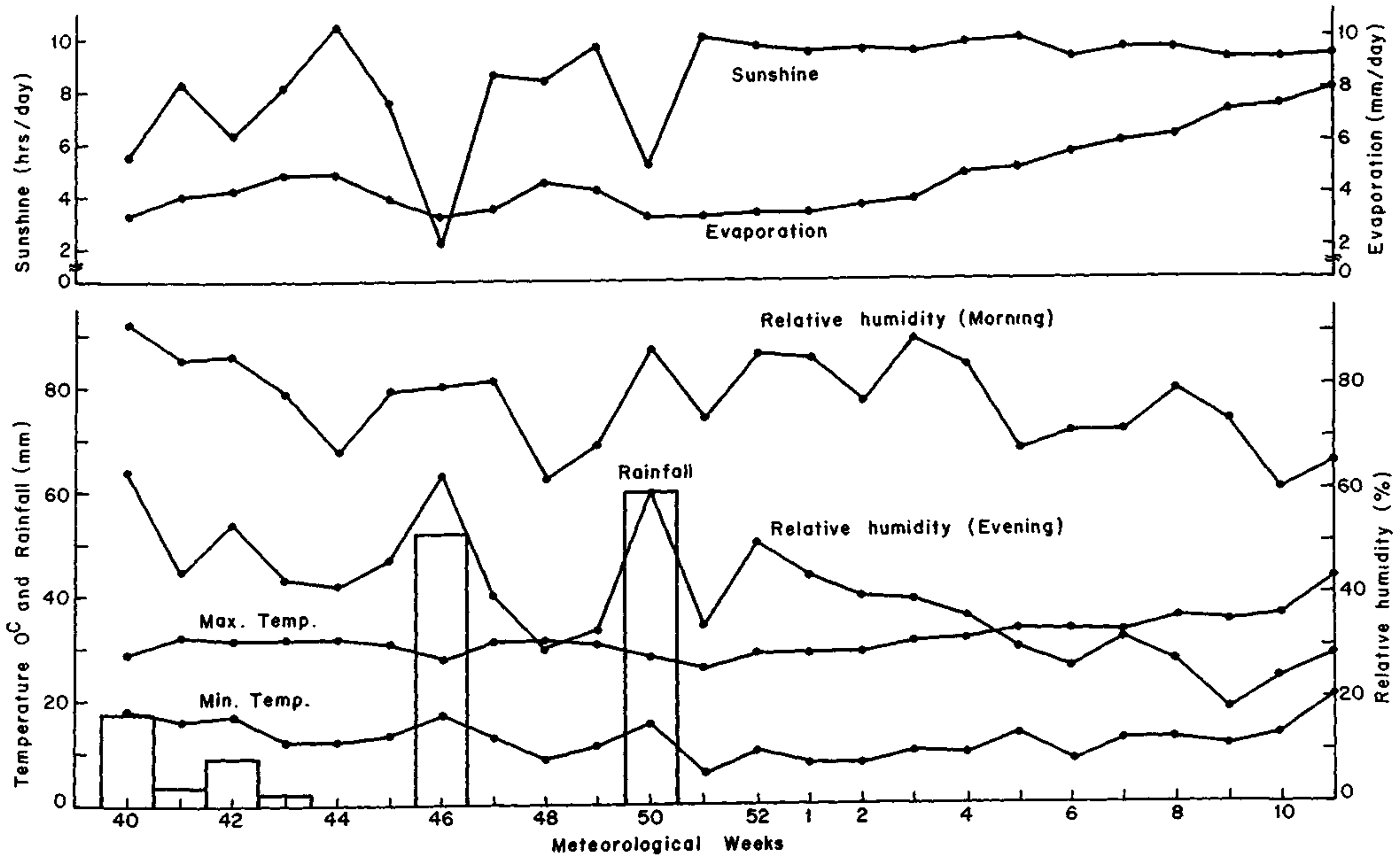


Fig. 3. Mean meteorological data for the year 1987-88.

Table 5. Cropping history of the experimental plot for previous three years.

Year	Crops grown in previous years		
	Kharif	Rabi	Summer
1983-84	-	Maize	-
1984-85	-	Maize	-
1985-86	Maize	Maize	-
1986-87	-	Present investigation	

3.1.5 Experimental details

The field trial was laid out in split plot design with four replications. There were four IW/CPE ratios for scheduling irrigation, two irrigation layouts with and without mulch. Thus, there were 16 treatment combinations. The trials were conducted during rabi season of 1986-87 and 1987-88. The details of the treatments are as follows :

A) Main plot treatments

Scheduling of irrigation at IW/CPE ratios	Symbol
1. 1.0	I_1
2. 0.8	I_2
3. .0.6	I_3
4. .0.4	I4

Depth of irrigation was 60 mm.

B] Sub-plot treatments [combination of mulch and irrigation layouts]

I] Mulch

1. No mulch M_0
2. Mulch M_1

II] Irrigation layouts

1. Ridges and furrows L_1
2. Flat beds L_2

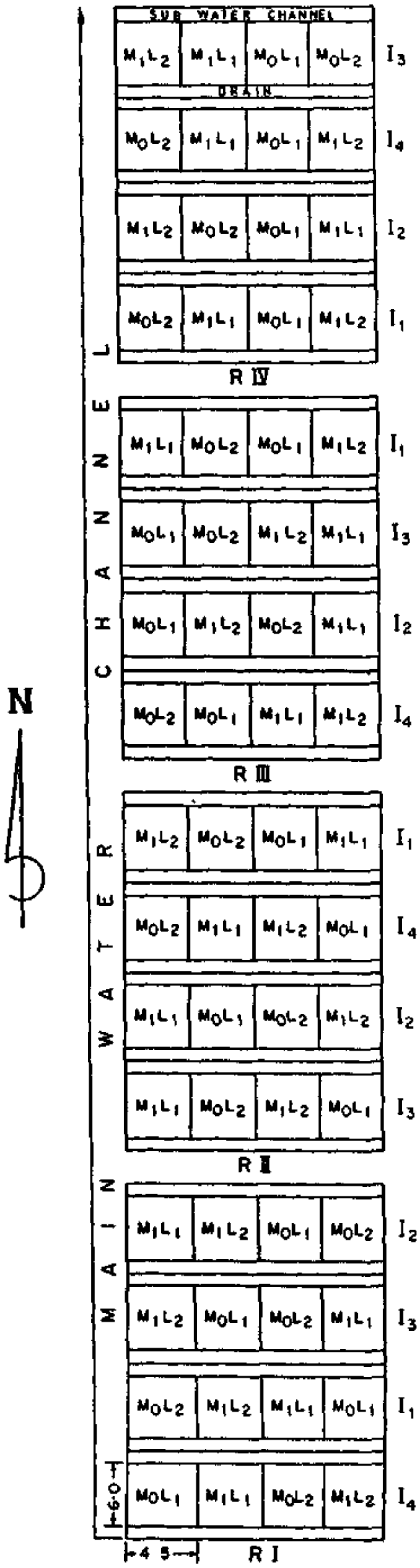
3.1.6 Layout of the experiment

The experimental field was laidout in 64 unit plots, having gross and net plot sizes of 6.0 x 4.5 m^2 and 4.5 x 3.0 m^2 respectively. The experiment was conducted at the same site without changing the randomization of the treatments.

The plan of layout with allocation of treatments to different experimental units are depicted in Fig.4.

3.1.7 Brief description of the variety

Ganga safed 2 has been released in 1963. It is a double cross between [M400 x CM300] and [CM600]. It is a white semiflint hybrid of medium maturity. It has considerable resistance to bacterial and pythium stalk rot. It tops in terms of total seed sale.



- Design — Split plot
- Replications - Four
- Main plot treatments
  Irrigation scheduling
  (IW/CPE ratios)
  i 1 0 - I_1
  ii 0 8 - I_2
  iii 0 6 - I_3
  iv 0 4 - I_4
- Sub-plot treatments
  Mulching
  i No mulch - M_0
  ii Mulch — M_1
  Irrigation layouts
  i Ridges and furrows - L_1
  ii Flat beds —— L_2
- Plot size
  Gross - 6 0 x 4·5 m^2
  Net - 4 5 x 3 0 m^2

Fig. 4 . Plan of layout

3.1.8 Cultural operations

The datewise details of the cultural operations carried out in the experimental field of maize are given in Table 6a.

3.1.9 Seeds and sowing

The certified seed of maize variety Ganga safed 2 was procured from the Sheti Beej Bhandar of Shetakari Sahakari Sangh, Shahupuri, Kolhapur. The flat beds were marked at 75 x 25cm apart with the marker and two seeds were dibbled per hill with the manual labour. On ridges and furrows which were opened at 75 cm apart with the ridger, 2 seeds were dibbled on the western side of the ridge at 2/3 height from the bottom, at 25 cm apart.

3.1.10 Fertilizer application

Nitrogen was applied @ 120 kg/ha in 3 split doses viz 1/3 at sowing, 1/3 at knee height and 1/3 at tasselling through urea containing 46 per cent nitrogen.

Phosphorus was applied @ 80 kg/ha in 2 split doses viz 1/2 at sowing and 1/2 at tasselling through single super phosphate containing 16 per cent P_2O_5.

3.1.11 Irrigation

3.1.11.1 Availability of irrigation

Irrigation water was available from the dutchbar well situated near the experimental site. The water was delivered to the plot head through PVC pipes.

Table 6a : Schedule of cultural operations carried out in the experimental plot during 1986-87 and 1987-88

Sr. No.	Cultural operations	Frequency	Date of operation 1986-87	1987-88
A.	**Pre-sowing**			
	1. Ploughing with tractor plough	1	9/10/86	12/10/87
	2. Clod crushing with disc-harrow	1	9/10/86	12/10/87
	3. Levelling with wooden plank	1	9/10/86	12/10/87
	4. Layout and opening ridges and furrows	1	10/10/86	14/10/87
	5. Mending of layout	1	13/10/86	17/10/87
	6. Presowing irrigation	1	18/10/86	20/10/87
	7. Fertilizer application	1	21/10/86	23/10/87
B.	**Sowing**			
	1. Sowing (Dibbling)	1	21/10/86	23/10/87
C.	**Post-sowing**			
	1. Post-sowing common irrigation	1	5/11/86	7/11/87
	2. Thinning and gap filling	1	5/11/86	1/11/87
	3. Weeding	2	30/10/86 10/11/86	7/11/87
	4. Mulching	1	7/11/86	9/11/87
	5. Irrigation		As per treatments	
D.	**Plant protection**			
	1. Spraying of endosulfan	2	30/10/86 7/11/86	9/11/87
	2. Spraying of endosulfan	2	8/12/86 9/1/87	27/11/87 -
	3. Spraying of Dithane M-45	2	-	1/12/87 24/1/88
E.	**Harvesting**			
	1. Detaching cobs	1	3/3/87	7/3/88
	2. Cutting the plants	1	4/3/87	8/3/88
	3. Shelling	1	10/3/87	19/3/88

3.1.11.2 Presowing and postsowing common irrigation

The presowing irrigation was given on 18.10.1986 and 20.10.1987 during 1986-87 and 1987-88, respectively. It helped easy sowing and better germination. The rains received subsequently, insured good germination. A uniform post sowing common irrigation to a depth of about 60 mm was given to all the plots on 5.11.86 and 7.11.1987 during 1986-87 and 1987-88, respectively, so as to maintain optimum plant population. Further, irrigations were applied as per the IW/CPE ratios.

3.1.11.3 Irrigation scheduling

In the present investigation, irrigation scheduling was based on IW/CPE ratios. The depth of irrigation water applied per turn was 60 mm. Daily pan evaporation was measured with the help of U.S.W.B. Standard open pan evaporimeter [with wire mesh] installed at the meteorological observatory situated at the Agricultural College Farm, Kolhapur. According to IW/CPE ratio, cumulative pan evaporation was worked out for each irrigation treatment as the basis for scheduling irrigation. Thus, for scheduling irrigation at 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios, CPE values were 60,75, 100 and 150 mm, respectively. In the event of receipt of rainfall during the crop growth period, the effective rainfall was calculated and deducted from the CPE of that particular treatment. The dates of irrigations as per treatment are given in Table 6b.

Table 6 b : Dates of irrigations given during both the years of experimentation

Irrigation scheduling at IW/CPE ratios	Dates of irrigation 1986-87	Dates of irrigation 1987-88
1.0	18/10/1986	20/10/1987
	5/11/1986	7/11/1987
	20/11/1986	4/12/1987
	4/12/1986	5/1/1988
	3/1/1987	21/1/1988
	17/1/1987	3/2/1988
	1/2/1987	-
0.8	18/10/1986	20/10/1987
	5/11/1986	7/11/1987
	23/11/1986	7/12/1987
	11/12/1986	13/1/1988
	29/12/1986	31/1/1988
	17/1/1987	-
	4/2/1987	-
0.6	18/10/1986	20/10/1987
	5/11/1986	7/11/1987
	29/11/1986	30/12/1987
	22/12/1986	26/1/1988
	17/1/1987	-
	8/12/1987	-
0.4	18/10/1986	20/10/1987
	5/11/1986	7/11/1987
	11/12/1986	13/1/1988
	17/1/1987	-

3.1.11.4 Frequency and number of irrigation

The treatmentwise number of irrigations, interval between two irrigations and average interval between the irrigations was worked out for both the years of the experimentations.

3.1.11.5 Measurement of irrigation water

In order to apply 60 mm depth of irrigation water at each irrigation the quantity required for each plot [6.0 x 4.5 m^2] worked out to 1620 litres/plot. This quantity of irrigation water was measured with the help of a water meter having 6.25 cm diameter.

3.1.12 Mulching

Sugarcane trash, @ 5 t/ha was used as a mulching material in the present investigation. The sugarcane trash was procured from two nearby private cultivators Shri Shivajirao Randive and Shri Bajirao Randive during 1986-87 and 1987-88, respectively. The per plot quantity worked out was 13.5 kg. The trash was applied as per the treatments on the third day from the common irrigation with the manual labour. It was spread uniformly on the soil surface in between the two lines and the two plants covering all the open surface. The thickness of mulch was measured and it was about 5-6 cm.

3.1.13 Plant protection

The spraying of endosulfan and endosulfan plus nuvacron was taken up twice during 1986-87, while endosulfan was sprayed twice and Dithane M-45 once, during 1987-88 as preventive measure against jassids and apphids and rust.

3.2 Biometric and other observations

3.2.1 Sampling technique

To record various growth observations, five plants were selected at random from each net plot. They were labelled for easy location. The observations on height of plant, number of leaves, number of cobs/plant, number of grains/plant, weight of grains/plant, number of grain rows/cob were recorded on these plants. The details of schedule adopted for recording various growth observations are given in Table 7.

3.2.2 Growth studies

3.2.2.1 Plant count

The number of plants that emerged was recorded on the 15th day from sowing. From each plot, all plants were counted and then the percentags were worked out.

3.2.2.2 Height of the plant

Randomly selected five plants were used for recording the height of the plant. It was measured on the main shoot from the ground level to the base of the last fully open leaf upto the stage of silking. After silking, the height was measured from the ground level to the base of the flag leaf.

Table 7 : Schedule of biometric observations recorded on maize during the period of experimentation.

Character observed	Frequency	No. of plants plants selected randomly	Observations recorded in days after sowing/ at harvest
A) Pre-harvest study			
1. Germination count	1	All plants	15
2. Plant height (cm)	7	5	30,45,60,75,90, 105 and at harvest
3. No. of functional laeves /plant	6	5	30,45,60,75,90 and 105
4. Leaf area/plant (dm^2)	6	1	30,45,60,75,90 and 105
5. Dry matter (aerial parts)/plant	7	1	30,45,60,75,90,105 and at harvest
6. Days required for 75 per cent silking	1	One metre running	-
7. Days required for maturity	1	One metre running	-
8. No. of cobs/net plot	1	All plants	-
B) Post harvest study			
1. Length of cob (cm)	1	5	At harvest
2. Girth of cob (cm)	1	5	At harvest
3. No. of grain rows/cob	1	5	At harvest
4. No. of grains/row	1	5	At harvest
5. Weight of grains/cob(g)	1	5	At harvest
6. Weight of grains/plant(g)	1	5	At harvest
7. Thousand grain weight (g)	1	All plants in net plot	At harvest
8. Biological yield/net plot (kg)	1	All plants in net plot	At harvest
9. Grain yield/net plot (kg)	1	All plants in net plot	At harvest
10. Stover yield/net plot (kg)	1	All plants in net plot	At harvest

3.2.2.3 Number of functional leaves

The total number of fully opened green leaves/plant was taken as a functional leaf. While counting the number of functional leaves, the leaves dried 50 per cent or more of its area, were excluded.

3.2.2.4 Leaf area/plant

Single plant from each plot was uprooted for dry matter study and was used for determining the leaf area. The functional leaves were carefully removed from the stem and they were grouped in three classes viz small, medium and large as per the size. The number of leaves in each class was counted and from each group, one representative leaf was selected randomly. The maximum length and breadth of these leaves was recorded and the leaf area was calculated by using the formula suggested by Saxena and Singh [1965].

Leaf area = Maximum length x Maximum breadth x 0.75

Thus, leaf area of each leaf was multiplied by the respective number of leaves and finally, 3 classes leaf area were summed up.

3.2.2.5 Leaf area index [LAI]

The leaf area index was calculated by multiplying leaf area/plant using the formula given by Watson [1977].

$$\text{LAI} = \frac{\text{Total leaf area}}{\text{Land area}}$$

[Both expressed in the same unit]

3.2.2.6 Dry matter/plant

The first observation for dry matter [aerial parts] was recorded 30 days after sowing and the subsequent observations were recorded at an interval of 15 days upto 105 days after sowing and at harvest. One plant from each net plot was selected randomly. This plant was uprooted and the roots were cut off. The same plant was also used for determining the leaf area. The leaves, stem and cob were seperated from the plant. First, they were dried in open air and later on in the thermostatically controlled oven at 50 ± 2 °c till the constant weight was recorded separately. Stem and cobs were chopped in to small pieces, before they were transferred for drying.

These dry matter weights of the plants were used in estimating the crop growth rate [$\overline{CGR}$], relative growth rate, [$\overline{RGR}$] and net assimilation rate [$\overline{NAR}$].

3.2.3 Growth analysis

The physiological studies on growth parameters like Leaf Area Index [LAI], mean Crop Growth Rate [$\overline{CGR}$], mean Relative Growth Rate [$\overline{RGR}$] and mean Net Assimilation Rate [$\overline{NAR}$] were measured under field condition in order to study the effect of weather on the growth and development of the plants as a consequence of the variation in the scheduling of irrigation, irrigation layouts with and without mulch on the maize crop.

3.2.3.1 Mean Crop Growth Rate [$\overline{CGR}$]

The mean crop growth rate was calculated by using the following formula.

$$\overline{CGR}\ [\text{Height}] = \frac{[H_2 - H_1]}{[t_2 - t_1]}$$

$$\overline{CGR}\ [\text{Dry matter}] = \frac{[W_2 - W_1]}{[t_2 - t_1]}$$

where, H_2 and H_1 and W_2 and W_1 refer to height and total dry matter weight at time t_2 and t_1 respectively.

3.2.3.2 Relative Growth Rate [$\overline{RGR}$]

The relative growth rate at which a plant incorporates additional material into its substance was measured by $\overline{RGR}$ of dry matter accumulation. Blackman [1919] considered the increase in the dry matter of the plants as a process of continuous compound interest wherein the increment in any internal adds to the capital for the subsequent growth. The rate of increment is known as relative growth rate and was calculated from the formula given by Briggs et al. [1920].

$$\overline{RGR} = \frac{[\mathrm{Log}_e\ W_2 - \mathrm{Log}_e\ W_1]}{[t_2 - t_1]}$$

where, W_2 and W_1 represents total dry matter weight at time t_2 and t_1, respectively.

3.2.3.3 Mean Net Assimilation Rate [$\overline{NAR}$]

The Net Assimilation Rate [$\overline{NAR}$] represents the relationship between leaf area and dry matter accumulation. It was calculated by using the formula suggested by Gregory [1926].

$$\overline{NAR} = \frac{[W_2 - W_1]\ [\mathrm{Log}_e\ L_2 - \mathrm{Log}_e\ L_1]}{[t_2 - t_1]\ \ [L_2 - L_1]}$$

where, W_2 and W_1 and L_2 and L_1 represents the total plant dry weight and leaf areas at times t_2 and t_1, respectively.

3.3 Post harvest studies

3.3.1 Length of cob

The length of cob was measured from the base of the cob to the tip of the cob, from 5 observation plant cobs and the mean length of cob was worked out.

3.3.2 Girth of cob

The circumference [cm] at the centre taken for observation was measured and mean girth of 5 cobs was worked out and recorded.

3.3.3 Number of grain rows/cob

The ears used for recording length and girth were used for counting the grain rows/cob and the mean number of grain rows/cob was recorded.

3.3.4 Weight of cob per plant

Five cobs were weighed together and the mean weight of cob/plant was recorded.

3.3.5 Number of grains/cob

The grains from 5 cobs were separated and counted and then the mean number of grains per cob was worked out.

3.3.6 Grain weight/cob

The grains separated from five cobs were weighed together and the mean weight of grains/cob was recorded.

3.3.7 Thousand grain weight

A random sample of grains from the net plot produce was taken. Thousand grains were counted and their weight was recorded.

3.3.8 Number of cobs per hectare

The cobs from each net plot were harvested separately and their number was counted and worked out on/hectare basis.

3.4 Yields

3.4.1 Biological yield/net plot

The harvested produce [grain + stover] from the net plot was dried in the sun for eight to ten days and was weighed to record the total produce/net plot.

3.4.2 Grain yield/net plot

The cobs of the plants from the net plot were shelled after drying. The grains were cleaned by winnowing. The grain weight obtained was recorded as per the treatment.

3.4.3 Stover yield/net plot

From the total weight of biological produce, [3.4.1], the weight of grain [3.4.2] was deducted to obtain the weight of stover/net plot.

3.4.4 Harvest Index [HI]

The harvest index was calculated by using the following formula

$$\text{H.I.} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.4.5 Grain production efficiency

The production of grain/hectare/day was calculated as below

$$\text{Grain kg/ha/day} = \frac{\text{Grain yield kg/ha}}{\text{Number of days to maturity.}}$$

3.5 Response curve

The relationship between levels of IW/CPE ratios and the corresponding yields was estimated. Response curve was estimated with the production function analysis. The test of significance for linear, quadratic and cubic response was calculated using orthogonal polynomal method.

3.6 Economics

3.6.1 Gross monetary returns

The gross monetary returns [Rs/ha] obtained due to different treatments in the present investigation, were worked out by considering following the market prices during the experimental years.

	1986-87	1987-88
Grain	Rs.210/q	Rs.230/q
Stover	Rs. 20/q	Rs. 20/q

3.6.2 Cost of cultivation

The cost of cultivation [Rs/ha] of each treatment was worked out byconsidering the rates and prices given in Appendix - A.

3.6.3 Net monetary returns

The net monetary returns [Rs/ha] obtained due to each treatment was worked out by deducting the mean cost of cultivation

[Rs/ha] of each treatment from, the gross monetary returns [Rs/ha] gained from the respective treatments.

3.6.4 Benefit - cost ratio

The benefit - cost ratio of each treatment was calculated by dividing the net monetary returns by the mean cost of cultivation.

3.7 Chemical studies

3.7.1 Plant analysis

Plant samples at harvest were oven dried at 60° ± 5°c and put in a willey mill to pass through 20 mesh and used for chemical analysis. Maize grain samples were drawn randomly from the net plot produce of the crop. It was dried, powdered in an electric grinder and used for chemical analysis.

3.7.2 Nitrogen content

Nitrogen content in maize plant [Leaves, stalk, stover and grain] was determined by the Modified Kjeldhahl's Method [Parkinson and Allen, 1975].

3.7.3 Phosphorus content

The phosphorus content in maize plant [leaves, stalk, stover and grain] was estimated by the Vanadophosphomolybdate Yellow colour method [Parkinson and Allen, 1975].

3.7.4 Nutrient uptake

The uptake of nitrogen and phosphorus by grain and stover was calculated by multiplying the per cent N and P content with corresponding grain and stover yields of each treatment. The total uptake was recorded by summing up the uptake by grain and stover. The total N and P uptake was pooled.

3.7.5 Protein content

The protein content in maize grain and stover was worked out by using following formula [A.O.A.C., 1975].

$$\underset{\text{[per cent]}}{\text{Protein content}} = \underset{\text{[per cent]}}{\text{Nitrogen content}} \times 6.25$$

3.7.6 Protein production

Protein production was calculated as follows.

Protein yield [q/ha]

$$\text{Grain} = \frac{\text{Grain protein per cent}}{100} \times \text{Grain yield}$$

$$\text{Stover} = \frac{\text{Stover protein per cent}}{100} \times \text{Stover yield}$$

Protein production by maize grain and stover was summed up together and thus the total protein production was recorded.

3.7.7 Protein production/day/hectare

Protein production per day per hectare was worked out as indicated below.

$$\text{Protein kg/day/ha} = \frac{\text{Total protein production kg/ha}}{\text{Number of days to maturity}}$$

3.7.8 Soil analysis

Composite soil samples from 0-30 and 30-60 cm layer from the experimental field were collected by random sampling technique, before the experimentation. The air dry samples, ground in wooden pestle and mortar and passed through 2 mm sieve, were used for chemical studies. The soil sample was passed through 0.6 mm sieve for determination of organic carbon.

3.7.8.1 Organic carbon

Organic carbon was determined by Walkley and Black Rapid Titration Method [Piper, 1966].

3.7.8.2 Total nitrogen

The total nitrogen was determined by Modified Kjeldahl's Method [A.O.A.C.,1975].

3.7.8.3 Available phosphorus

It was determined by Modified Olsen's Method [Olsen, 1954].

3.7.8.4 Available potassium

The available potassium was determined by Flame, Photometer Method [Hanway and Heidal, 1967].

3.8 Soil moisture studies

3.8.1 Moisture percentage

Soil samples were collected before and after each irrigation from planting till the harvest with a screw augur. The soil samples were collected from two depths viz 0-30 and 30-60 cm which were kept in the oven at 105 ± 2°c till the constant weight was obtained. The moisture percentage was workedout by the formula outlined by Dastane [1972].

$$\text{Moisture percentage} = \frac{W_1 - W_2}{W_2} \times 100$$

where, W_1 = Weight of moist soil

W_2 = Weight of oven dry soil

3.8.2 Profile water depletion

The moisture deficit or the depth of moisture depleted from the different soil layers during an irrigation cycle or between two samplings, taken after 48 hours of irrigation and just before the next irrigation, was calculated by using the following equation.

$$d = \sum_{i=1}^{n} \frac{Pfci - Pbi}{100} \times Asi \times Di$$

where,

d = Soil moisture depletion in the root zone in mm

Pfci = Field capacity of the ith layer, viz moisture content two days after irrigation

Pbi = Moisture content just before irrigation

Asi = Bulk density of the ith layer

Di = Depth of the ith layer

$\sum_{i=1}^{n}$ = Summation of n number of layers in the root zone

3.8.3 Consumptive use of water

Consumptive use of water has been calculated as per the method outlined by Dastane [1972] is given below.

$U = \sum u$, and $u = [E_0 \times 0.8] + [M_1 - M_2] + GWC + ER$

where,

$\sum U$ = Total seasonal cu,

u = CU during a given irrigation interval;

E_0 = Evaporation from the U.S.W.B. Class I pan during the interval from 1st sampling to second sampling;

0.8 = A constant to be used with the U.S.W.B. class I evaporimeter;

M_1 = Soil moisture in the profile on the day of sampling.

M_2 = Soil moisture in the profiles on the day of next sampling ;

ER = Effective rainfall during the interval;

GWC = Ground water contribution during the interval;

3.8.4 Effective rainfall

Effective rainfall is that fraction of the total rainfall, which is useful in crop production directly or indirectly. Any rain received after the soil has attained the field capacity down to the rooting zone, becomes ineffective. Hence, rains received during 48 hours after irrigation were not considered. Rainfall received after 48 hours of irrigation till the next irrigation was summed up. This effective rainfall was ~~added to~~ deducted from the cumulative pan evaporation and then, the further irrigations were given.

3.8.5 Water use efficiency

The water use efficiency (WUE) is the yield of marketable produce per unit of water use in consumptive use and therefore, worked out as

$$WUE = \frac{Y}{CU}$$

Where,

Y = Yield of marketable produce (kg/ha)

CU = Consumptive use of water in mm

3.8.6 Consumptive use/day

Consumptive use/day is the water used by the plant/day during its growth period and was therefore, workedout by the formula

$$CU/day = \frac{CU\ (mm)}{Crop\ period\ (days)}$$

Where,

CU = Consumptive use

CU/day = Consumptive use/day

3.8.7 Consumptive use/day

Consumptive use efficiency (CUE) is the yield of marketable produce per unit of water used in evapotranspiration and therefore, worked out to be as

$$CUE = \frac{Y}{ET}$$

where,

Y = Yield of marketable produce (kg per ha)

ET = Evapotranspiration (mm)

3.9 Statistical analysis and interpretation of the data

The data recorded were statistically analysed by the technique of "Analysis of Variance" (Fisher, 1958). The 'F' test of significance was used for testing the "Null Hypothesis" in order to determine, whether the observed treatment effects were real or discernible due to the chance of effects and was calculated as suggested by Cochran and Cox (1967) and Panse and Sukhatme (1967). The appropriate standard error (S.E.±) for each factor was workedout and whenever the treatments were significant, critical difference (C.D.) at 5 per cent probability level was calculated and indicated. The data were analysed by "Split plot design". The statistical analysis was carried out on the computer of the "All India Co-ordinated Pearl Millet Improvement Project", Pune. Morever, suitable graphical illustrations and figures of relevant data are given at appropriate places. The structure of analysis of variance is given in Appendix - B.

3.10 Correlation studies

Correlation (r) values were worked out by using the formula given by Karl Pearson.

$$r = \frac{\sum_{i}^{n} xy - \left(\frac{\sum x \sum y}{n}\right)}{\sqrt{\left[\sum x^2 - \left(\frac{\sum x}{n}\right)^2\right]\left[\sum y - \left(\frac{\sum y}{n}\right)^2\right]}}$$

where,

r = Correlation coefficient

x = Independent variable

y = Dependent variable

3.11 Energy relationship

Energy values for different inputs and outputs were collected from different sources and a detailed analysis of energy utilization is presented. Energy values of different items are presented in Appendix - C.

Experimental Results

4. EXPERIMENTAL RESULTS

4.1 Plant count

Data pertaining to mean plant count per hectare at 15 days from sowing as affected by various treatments are presented in Table 8.

Table 8 : Mean number of plants (000/ha) on 15th day from sowing as affected by different treatments

Treatment	1986-87	1987-88
Irrigation scheduling (IW/CPE ratios)		
1.0	49.21	50.42
0.8	49.30	51.16
0.6	49.11	51.29
0.4	49.35	51.01
S.E. ±	0.47	0.47
C.D. at 5%	-	-
Mulching		
No mulch	49.30	50.97
Mulch	49.18	50.97
S.E. ±	0.30	0.23
C.D. at 5%	-	-
Irrigation layouts		
Ridges and furrows	48.70	50.81
Flat beds	49.78	51.13
S.E. ±	0.30	0.23
C.D. at 5%	-	-
General mean	49.24	50.97

It is seen from the data in Table 8 that mean number of plants/hectare was 49.24 and 50.27 thousand during 1986-87 and 1987-88, respectively. The difference in plant count due to various treatments was found to be nonsignificant during the period of investigation.

4.2 Growth studies

4.2.1 Plant height

Data regarding mean plant height as influenced periodically by the different treatments are presented in Table 9.

The mean plant height was found to be increasing with increase in the age of the crop, upto harvest. In general, the trend in respect of plant height was similar during both the years. The mean plant height at initial and at harvest stages ranged from 37.19 to 299.41 and 66.57 to 241.08 cm during 1986-87 and 1987-88, respectively.

Irrigation scheduling

The plant height was not significantly influenced at initial stages of 30 and 45 days after sowing during 1986-87 and at all the crop growth stages during 1987-88. The irrigation scheduled at 0.8 and 1.0 IW/CPE ratios significantly increased plant height over 0.4 and 0.6 IW/CPE ratios from 60 days after sowing onwards during 1986-87.

Table 9. Mean plant height (cm) as influenced periodically by various treatments

Treatment	1986-87						1987-88					
	Days after sowing						Days after sowing					
	30	45	60	75	90	105	30	45	60	75	90	105
Irrigation scheduling (IW/CPE ratios)												
1.0	38.19	82.64	171.12	232.15	237.20	241.17	66.92	99.15	181.40	239.00	241.87	244.74
0.8	35.78	80.30	163.92	227.16	236.50	238.47	65.81	89.34	180.40	242.56	244.04	245.37
0.6	36.89	77.94	156.34	203.93	215.11	220.05	67.07	98.54	183.45	235.85	237.46	239.18
0.4	37.88	82.29	153.90	201.62	212.55	217.94	66.49	98.92	181.37	232.04	233.99	235.05
S.E. ±	1.02	1.48	2.47	3.02	3.76	3.62	0.92	1.42	2.15	2.91	2.88	2.67
C.D. at 5%	-	-	7.90	9.68	12.04	11.59	-	-	-	-	-	-
Mulching												
No mulch	37.19	81.61	160.88	216.02	224.03	228.54	66.18	100.20	181.42	237.82	239.39	240.81
Mulch	37.18	79.98	161.76	216.41	226.64	230.27	66.97	97.27	181.89	236.90	239.29	241.35
S.E. ±	0.73	0.87	1.22	1.65	2.25	2.26	0.84	0.74	1.67	1.70	1.90	1.82
C.D. at 5%	-	-	-	-	-	-	-	2.13	-	-	-	-
Irrigation layouts												
Ridges and furrows	36.14	80.66	162.84	217.42	224.69	229.17	67.16	99.13	180.97	235.89	238.82	240.37
Flat beds	38.23	80.92	159.81	215.01	225.98	229.66	65.98	98.34	182.34	238.84	239.86	241.79
S.E. ±	0.70	0.87	1.22	1.65	2.25	2.26	0.85	0.74	1.67	1.70	1.90	1.82
C.D. at 5%	-	-	-	-	-	-	-	-	-	-	-	-
General mean	**37.19**	**80.79**	**161.22**	**216.22**	**225.34**	**229.41**	**66.57**	**98.74**	**181.66**	**237.36**	**239.34**	**241.08**

Mulching

The application of mulch did not affect plant height significantly during both the years of experimentation. However, it was more with the application of mulch than no mulch.

Irrigation layouts

The irrigation layouts did not influence significantly the plant height during both the years of experimentation. However, ridges and furrows layout produced comparatively more plant height than that of flat beds.

Interaction

The interaction effects were found to be absent in both the seasons.

4.2.1.1 Growth functions of plant height

4.2.1.1.1 Crop Growth Rate ($\overline{CGR}$)

Data pertaining to mean $\overline{CGR}$ of plant height/plant at an interval of 15 days as influenced by different treatments are presented in Table 10. Data were not statistically analysed. The inferences are drawn from the mean values.

The mean maximum $\overline{CGR}$ values of 4.30 and 4.42 were recorded in 1986-87 and 1987-88, respectively between 45 and 60 days after sowing.

Table 10 : Mean Crop Growth Rate ($\overline{CGR}$) of height as affected by the various treatments (cm).

Treatment	1986-87					1987-88				
	Between days from					Between days from				
	30-45	45-60	60-75	75-90	90-105	30-45	45-60	60-75	75-90	90-105
Irrigation scheduling (IW/CPE ratios)										
1.0	2.38	4.72	3.25	0.33	0.22	1.71	4.39	3.07	0.21	0.18
0.8	2.38	4.46	3.44	0.53	0.12	1.73	4.38	3.32	0.15	0.07
0.6	2.19	4.18	2.54	0.69	0.26	1.68	4.55	2.79	0.08	0.10
0.4	2.36	3.82	2.54	0.60	0.45	1.75	4.36	2.74	0.20	0.08
Mulching										
No mulch	2.36	4.22	2.94	0.47	0.26	1.81	4.33	3.01	0.17	0.08
Mulch	2.28	4.36	2.95	0.61	0.22	1.62	4.51	2.95	0.15	0.14
Irrigation layouts										
Ridges and furrows	2.37	4.38	2.91	0.44	0.24	1.79	4.36	2.95	0.24	0.11
Flat beds	2.28	4.20	2.97	0.63	0.24	1.64	4.48	3.01	0.08	0.11
General mean	**2.33**	**4.30**	**2.94**	**0.54**	**0.24**	**1.72**	**4.42**	**2.98**	**0.16**	**0.11**

Irrigation scheduling

The $\overline{CGR}$ values were maximum during the period between 45-60 days with 1.0 IW/CPE ratio during 1986-87 and with 0.6 IW/CPE ratio during 1987-88. In general, IW/CPE ratios did not show consistency in their effect on $\overline{CGR}$ values.

Mulching

The $\overline{CGR}$ values of height were more or less same for the application of mulch and no mulch treatment.

Irrigation layouts

The irrigation layouts did not show any consistency in their effects on the values of $\overline{CGR}$ during both the years of the experimentation.

4.2.1.1.2 Relative Growth Rate ($\overline{RGR}$)

Data relating to mean $\overline{RGR}$ of height as influenced by various treatments are presented in Table 11. Data were not analysed statistically and hence the results are based on mean values.

The mean maximum $\overline{RGR}$ values of plant height were 0.3616 and 0.2842 during 1986-87 and 1987-88, respectively. The $\overline{RGR}$ values went on decreasing with the advancement of crop age during 1986-87. However, in 1987-88, it was maximum during the period between 45 and 60 days and then declined till the harvest.

Table 11. Mean Relative Growth Rate (RGR) of height in cm per week per plant during different growth periods in various treatments

Treatment	1986-87					1987-88				
	Between days from					Between days from				
	30-45	45-60	60-75	75-90	90-105	30-45	45-60	60-75	75-90	90-105
Irrigation scheduling (IW/CPE ratios)										
1.0	0.3605	0.3290	0.1400	0.0070	0.0063	0.1833	0.2316	0.1285	0.0056	0.0055
0.8	0.3766	0.3329	0.1515	0.0188	0.0039	0.1872	0.2828	0.1380	0.0028	0.0025
0.6	0.3488	0.3240	0.1232	0.0248	0.0105	0.1793	0.2897	0.1171	0.0032	0.0034
0.4	0.3620	0.2920	0.1258	0.0249	0.0117	0.1852	0.2826	0.1148	0.0039	0.0021
Mulching										
No mulch	0.3663	0.3164	0.1374	0.0169	0.0092	0.1933	0.2767	0.1262	0.0092	0.0028
Mulch	0.3571	0.3283	0.1357	0.0215	0.0074	0.1740	0.2918	0.1232	0.0140	0.0120
Irrigation layouts										
Ridges and furrows	0.3742	0.3275	0.1347	0.0150	0.0092	0.1815	0.2806	0.1235	0.0173	0.0030
Flat beds	0.3495	0.3172	0.1383	0.0230	0.0075	0.1860	0.2878	0.1258	0.0020	0.0037
General mean	**0.3616**	**0.3223**	**0.1365**	**0.0192**	**0.0084**	**0.1838**	**0.2842**	**0.1247**	**0.0039**	**0.0034**

Irrigation scheduling

In both the years of the study, the $\overline{RGR}$ values of height were maximum with 0.8 IW/CPE ratio. The $\overline{RGR}$ values of plant height showed a declining trend after the period 30 to 45 days from sowing during 1986-87 and 45 to 60 days from sowing during 1987-88 with irrigation scheduled at different (1.0, 0.8, 0.6 and 0.4) IW/CPE ratios.

Mulching

The application of mulch did not show any pronounced effect on the $\overline{RGR}$ values of height during both the years of study. The values were more or less same, but, showed a declining trend after 45-60 days period during both the years.

Irrigation layouts

Planting on ridges and furrows has given higher values of $\overline{RGR}$ of height during 1986-87, while during 1987-88 flat beds have given superior values.

4.2.2 Functional leaf number

Data related to mean number of functional leaves/plant as affected periodically by different treatments are presented in Table 12.

Data in Table 12 indicates that the mean number of functional leaves/plant increased upto 75 days from sowing during 1986-87

Table 12. Mean number of leaves/plant as affected periodically by different treatments

Treatment	1986-87 Days after sowing						1987-88 Days after sowing					
	30	45	60	75	90	105	30	45	60	75	90	105
Irrigation scheduling (IW/CPE ratios)												
1.0	8.14	10.05	13.51	13.69	13.25	12.61	11.20	11.87	11.84	12.51	13.09	12.96
0.8	7.94	9.94	13.47	13.69	13.35	12.29	10.82	11.69	11.89	12.66	13.11	12.50
0.6	7.87	9.44	13.20	13.61	12.94	12.05	11.42	11.69	11.80	12.44	13.12	12.85
0.4	8.07	9.52	12.98	13.44	13.24	12.10	10.75	11.71	11.84	12.43	13.14	12.49
S.E. ±	0.17	0.17	0.20	0.23	0.25	0.22	0.21	0.24	0.15	0.22	0.07	0.13
C.D. at 5%	-	-	-	-	-	-	-	-	-	-	-	-
Mulching												
No mulch	8.04	9.79	13.32	13.59	13.16	12.15	11.15	12.01	11.87	12.59	13.25	12.74
Mulch	7.97	9.69	13.26	13.62	13.22	12.37	10.95	11.47	11.81	12.42	13.03	12.66
S.E. ±	0.08	0.11	0.13	0.12	0.11	0.13	0.12	0.13	0.09	0.10	0.08	0.11
C.D. at 5%	-	-	-	-	-	-	-	-	-	-	-	-
Irrigation layouts												
Ridges and furrows	7.96	9.85	13.45	13.67	13.29	12.32	11.07	11.88	11.95	12.47	13.09	12.62
Flat beds	8.05	9.62	13.13	13.53	13.10	12.21	11.03	11.60	11.73	12.54	13.19	12.77
S.E. ±	0.08	0.11	0.13	0.12	0.11	0.13	0.12	0.13	0.09	0.10	0.08	0.11
C.D. at 5%	-	-	-	-	-	-	-	-	-	-	-	-
General mean	**8.00**	**9.74**	**13.29**	**13.60**	**13.19**	**12.26**	**11.05**	**11.74**	**11.84**	**12.51**	**13.14**	**12.70**

and upto 90 days from sowing during 1987-88, and then subsequently decreased. The maximum number of leaves/plant was 13.60 and 13.14 at 75 and 90 days and then it decreased to 12.26 and 12.70 at 105 days in 1986-87 and 1987-88, respectively.

Irrigation scheduling

The differences in the mean number of leaves/plant due to irrigation scheduling at different IW/CPE ratios were not found to be significant in both the years of study. However, irrigation scheduling at 1.0 IW/CPE ratio produced more number of leaves than 0.8, 0.6 and 0.4 IW/CPE ratios, at most of the crop growth stages.

Mulching

The mean number of functional leaves/plant was not influenced significantly by the application of mulch at all the crop growth stages during 1986-87 as well as during 1987-88.

Irrigation layouts

The mean number of leaves/plant was not influenced significantly either by planting on ridges and furrows or on flat beds at all the crop growth stages in both the years of experimentation.

Interaction

The interaction effects were found to be absent in both the seaons.

4.2.3 Leaf area/plant

Data pertaining to leaf area/plant as influenced by various treatments are presented in Table 13.

The leaf area/plant increased with the advancement in the age of crop upto 75 and 90 days from sowing in 1986-87 and 1987-88, respectively. The maximum leaf area of 60.05 and 64.53 dm^2/plant was observed on 75 and 90 days from sowing during the year 1986-87 and 1987-88, respectively.

Irrigation scheduling

The leaf area/plant was significantly influenced by the irrigation scheduling at all the growth stages, except at 30 days during 1986-87. The scheduling of irrigation at 1.0 IW/CPE ratio produced significantly more leaf area than 0.8 and 0.6 and 0.4 IW/CPE ratios at all the crop growth stages, except at 30 days during 1986-87 and on 90 and 105 days after sowing during 1987-88. The irrigation scheduled at 0.6 and 0.8 IW/CPE ratios also significantly increased leaf area/plant as compared to 0.4 IW/CPE ratio on 45 and 60 days after sowing in 1986-87. Further, it was observed that irrigation scheduled at 0.8 IW/CPE ratio resulted in production of more leaf area/plant than 0.4 IW/CPE ratio in advanced stages of 90 and 105 days after sowing during 1986-87.

Mulching

The application of mulch produced significantly more

Table 13. Mean leaf area (dm^2)/ plant as affected periodically by different treatments

Treatment	1986-87						1987-88					
	Days after sowing						Days after sowing					
	30	45	60	75	90	105	30	45	60	75	90	105
Irrigation scheduling (IW/CPE ratios)												
1.0	7.63	27.11	57.02	66.20	65.66	64.77	22.19	42.79	59.18	67.44	71.30	70.49
0.8	7.73	25.47	53.81	58.90	58.33	57.35	23.01	40.76	54.78	61.52	64.25	61.50
0.6	7.53	25.79	54.16	58.69	57.96	56.94	22.36	38.85	54.64	60.09	62.11	59.65
0.4	7.52	24.08	50.23	56.42	55.62	54.89	21.94	39.90	54.06	59.80	60.43	57.13
S.E. ±	0.17	0.53	0.67	0.95	0.88	0.83	0.76	2.17	1.53	1.59	1.35	1.36
C.D. at 5%	-	0.81	2.14	3.05	2.82	2.66	-	-	-	-	4.33	4.37
Mulching												
No mulch	7.42	26.62	51.28	58.72	58.04	57.17	22.07	40.55	56.35	62.38	64.72	62.40
Mulch	7.78	24.61	56.33	61.38	60.74	59.80	22.67	40.61	54.99	62.04	64.33	61.99
S.E. ±	0.14	0.48	0.80	0.72	0.71	0.71	0.62	1.31	1.23	0.92	0.93	0.90
C.D. at 5%	-	1.38	2.32	2.07	2.03	2.05	-	-	-	-	-	-
Irrigation layouts												
Ridges and furrows	7.54	25.70	53.61	60.57	59.98	59.15	22.82	40.13	57.30	62.15	64.53	62.01
Flat beds	7.66	25.53	54.01	59.53	58.81	57.82	21.93	41.02	54.04	62.27	64.52	62.38
S.E. ±	0.14	00.48	0.80	0.72	0.71	0.71	0.62	1.31	1.23	0.92	0.93	0.90
C.D. at 5%	-	-	-	-	-	-	-	-	-	-	-	-
General mean	**7.60**	**25.62**	**53.81**	**60.05**	**59.39**	**58.48**	**22.37**	**40.58**	**55.69**	**62.21**	**64.53**	**62.19**

leaf area/plant than that without application of mulch at all the growth stages, except 30 days from sowing during 1986-87. However, leaf area/plant was not significantly influenced due to mulching during 1987-88. The leaf area per plant with and without mulch was almost similar .

Irrigation layouts

Leaf area/plant was not significantly influenced either by planting on ridges and furrows or on flat beds during both the years of investigation.

Interaction

The interaction between irrigation scheduling and mulching was present only 60 days after sowing during 1986-87 which is presented in Table 14.

Table 14 . Mean leaf area (Sq dm)/plant at 60 days after sowing as affected by interaction of irrigation scheduling and mulching in 1986-87

Irrigation scheduling (IW/CPE ratios)	Mulching	
	No Mulch	Mulch
1.0	52.98	61.06
0.8	50.05	57.57
0.6	51.24	57.09
0.4	50.86	49.61
S.E. for comparison of irrigation scheduling		1.61
C.D. at 5%		4.64
S.E. for comparison of mulching		1.32
C.D. at 5%		3.92

The irrigation scheduling at different IW/CPE ratios did not show any effect on leaf area/plant, where mulch was not applied (Table 14). However, irrigation scheduled at 0.4 IW/CPE ratio produced significantly less leaf area/plant than other IW/CPE ratios, where mulch was applied.

The scheduling of irrigation at 0.6, 0.8 and 1.0 IW/CPE ratios in combination with mulch significantly increased leaf area/plant than scheduling irrigation with these IW/CPE ratios with no mulch.

4.2.4 Leaf area index (LAI)

Data regarding leaf area index (LAI) as affected by various treatments are presented in Table 15.

The maximum leaf area index of 3.20 and 3.41 was observed on 75 and 90th day during the year 1986-87 and 1987-88, respectively.

Irrigation scheduling

The leaf area index was not significantly influenced due to irrigation scheduling during initial stages i.e. 30 days after sowing during 1986-87 and upto 60 days after sowing during 1987-88. Irrigation scheduled at 1.0 IW/CPE ratio significantly influenced the LAI as compared to the other IW/CPE ratios from 45 days after sowing onwards in 1986-87, and 75 days after sowing onwards during 1987-88; except irrigation scheduled at 1.0 and 0.8 IW/CPE

Table 15. Mean leaf area index (LAI) as affected by different treatments

Treatment	1986-87						1987-88					
	Days after sowing						Days after sowing					
	30	45	60	75	90	105	30	45	60	75	90	105
Irrigation scheduling (IW/CPE ratios)												
1.0	0.40	1.46	2.98	3.53	3.50	3.45	1.18	2.67	3.18	3.60	3.80	3.75
0.8	0.41	1.36	2.86	3.14	3.11	3.05	1.22	2.17	2.95	3.28	3.43	3.27
0.6	0.40	1.38	2.91	3.13	3.09	3.04	1.19	2.08	2.91	3.20	3.18	3.18
0.4	0.40	1.28	2.68	3.00	2.96	2.93	1.16	2.08	2.88	3.15	3.23	3.04
S.E. ±	0.02	0.02	0.04	0.05	0.05	0.04	0.04	0.27	0.09	0.07	0.09	0.07
C.D. at 5%	-	0.06	0.13	0.16	0.15	0.14	-	-	-	0.24	0.27	0.23
Mulching												
No mulch	0.39	1.43	2.74	3.13	3.09	3.05	1.17	2.38	3.02	3.32	3.42	3.32
Mulch	0.41	1.31	2.98	3.27	3.24	3.19	1.20	2.12	2.95	3.29	3.40	3.30
S.E. ±	0.01	0.02	0.05	0.04	0.04	0.04	0.03	0.14	0.07	0.05	0.06	0.05
C.D. at 5%	-	0.07	0.14	0.11	0.11	0.14	-	-	-	-	-	-
Irrigation layouts												
Ridges and furrows	0.40	1.37	2.87	3.23	3.20	3.15	1.21	2.13	3.05	3.31	3.45	3.30
Flat beds	0.40	1.37	2.85	3.17	3.13	3.08	1.16	2.38	2.91	3.30	3.37	3.32
S.E. ±	0.01	0.02	0.05	0.04	0.04	0.04	0.03	0.14	0.07	0.05	0.06	0.05
C.D. at 5%	-	-	-	-	-	-	-	-	-	-	-	-
General mean	**0.40**	**1.37**	**2.86**	**3.20**	**3.16**	**3.12**	**1.19**	**2.25**	**2.98**	**3.31**	**3.41**	**3.31**

ratios were on par on 60 DAS in 1986-87. Further, it was observed that irrigation scheduled at 0.8 IW/CPE ratio also resulted in more LAI than 0.4 IW/CPE ratio on 45 and 60 DAS during 1986-87 and at 105 DAS during 1987-88. Irrigation scheduled at 0.6 IW/CPE ratio also produced more LAI than 0.4 IW/CPE ratio on 45 and 60 DAS during 1986-87.

Mulching

The application of mulch had produced significantly more LAI at all the crop growth stages, except at 30 DAS during 1986-87, but LAI was not significantly influenced during 1987-88 at any of the crop growth stages.

Irrigation layouts

The LAI was not influenced significantly by planting either on ridges and furrows or on flat beds throughout the crop growth period during both the years of investigation. However, LAI values were slightly higher with planting on ridges and furrows than flat bed planting.

Interaction

The interaction effects between the different factors under study were found to be non significant.

4.2.5 Dry matter per plant

Data pertaining to mean dry matter/plant as affected periodically by the different treatments in both the seasons are presented in Table 16 and graphically shown in Fig.5 and 6.

Table 16. Mean Dry matter per plant (g) as affected by various treatments

Treatment	1986-87							1987-88						
	Days after sowing							Days after sowing						
	30	45	60	75	90	105	At harvest	30	45	60	75	90	105	At harvest
Irrigation scheduling (IW/CPE ratios)														
1.0	16.81	74.15	157.25	215.56	351.87	442.50	461.25	19.81	33.19	102.00	185.00	204.63	281.31	324.69
0.8	16.94	69.21	133.50	200.44	293.75	375.62	410.00	21.88	36.13	80.25	148.81	191.06	276.56	304.94
0.6	16.25	70.40	95.12	189.06	271.56	346.25	376.87	19.00	34.81	81.50	118.50	154.19	226.37	271.50
0.4	16.06	63.22	77.69	167.56	256.87	310.94	366.25	20.25	30.44	75.81	117.25	142.19	214.18	252.50
S.E. ±	0.39	2.54	1.65	10.05	8.28	11.44	5.51	1.13	2.48	3.65	3.97	6.81	6.00	3.51
C.D. at 5%	-	-	5.29	32.17	26.51	36.59	17.63	-	-	11.69	12.72	21.78	19.19	11.22
Mulching														
No mulch	16.06	69.73	113.16	192.53	292.81	358.60	397.19	20.34	33.91	85.12	138.41	173.97	246.44	282.75
Mulch	16.97	68.76	118.62	193.78	294.20	379.06	410.00	20.12	33.37	84.66	146.37	172.06	252.78	294.06
S.E. ±	0.30	1.49	1.51	4.61	6.47	5.11	5.77	0.91	1.35	2.79	3.46	8.20	6.32	6.52
C.D. at 5%	0.88	-	4.32	-	-	14.67	-	-	-	-	-	-	-	-
Irrigation layouts														
Ridges and furrows	16.56	71.22	118.09	195.59	296.72	375.78	408.28	19.69	34.41	85.97	138.56	173.91	247.15	288.19
Flat beds	16.47	67.28	113.69	190.72	290.31	361.87	398.90	20.78	32.87	83.81	146.22	172.12	252.06	288.62
S.E. ±	0.30	1.49	1.51	4.61	6 47	5.11	5.77	0.91	1.35	2.79	3.46	8.20	6.32	6.52
C.D. at 5%	-	-	4.33	-	-	-	-	-	-	-	-	-	-	-
General mean	16.52	69.25	115.89	193.16	293.51	368.83	403.59	20.23	33.64	84.89	142.39	173.02	249.61	288.41

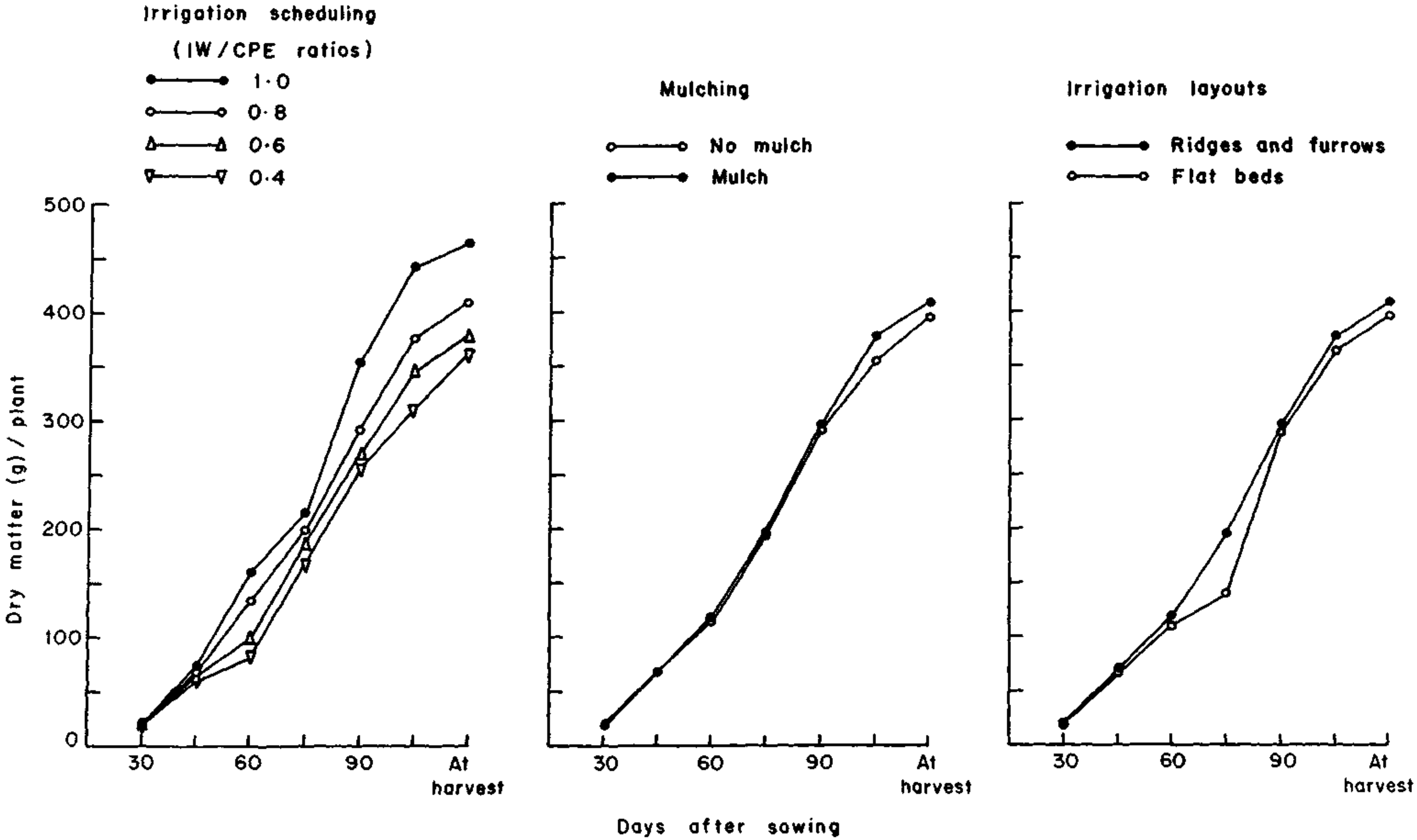


Fig. 5. Mean dry matter (g) per plant as affected by various treatments periodically during 1986-87.

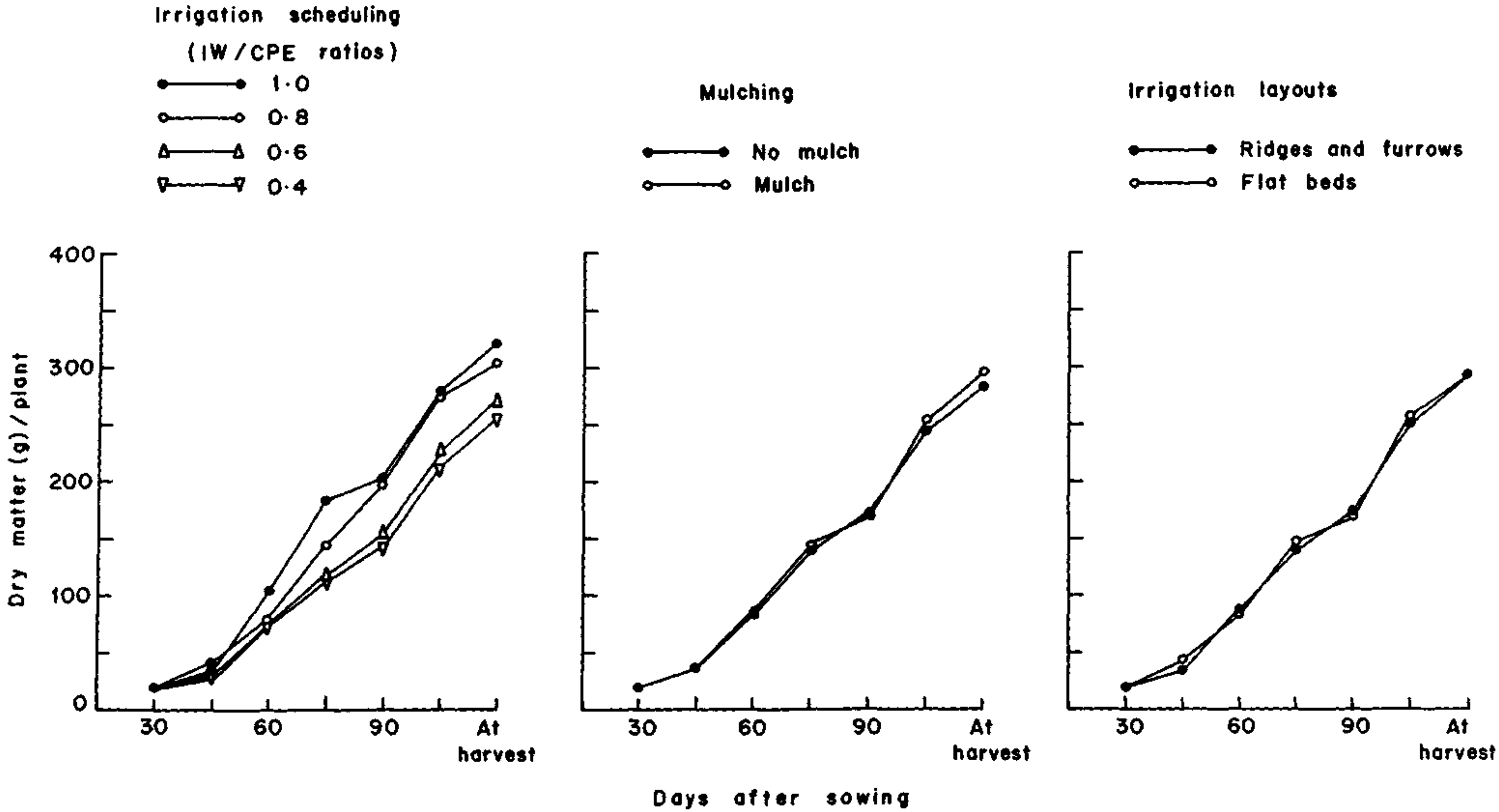


Fig. 6. Mean dry matter (g) per plant as affected by various treatments periodically during 1987-88.

It is observed from the data presented in Table 16 that the mean dry matter/plant increased progressively with increase in the age of the crop from sowing to harvest. It ranged from 16.52 to 403.59 and from 20.23 to 288.41 g/plant on 30th day and at harvest during the year 1986-87 and 1987-88, respectively.

Irrigation scheduling

Irrigation scheduled at 1.0 IW/CPE ratio significantly produced more dry matter/plant than other IW/CPE ratios from 60 days after sowing onwards during both the years, except on 75 DAS during 1986-87 and 90 and 105 DAS during 1987-88, where 0.8 and 1.0 IW/CPE ratios were on par. Irrigation scheduling at 0.8 IW/CPE ratio also accumulated more dry matter/plant than 0.4 and 0.6 IW/CPE ratios from 75 DAS onwards during both the years.

Mulching

Though dry matter/plant increased with the introduction of mulch, it could not attain the level of significance in both the seasons, except at 30, 60 & 105 days from sowing in 1986-87, where dry matter accumulation/plant was significantly more due to application of mulch than no mulch.

Irrigation layouts

The dry matter/plant was not significantly influnced by planting either on ridges and furrows or on flat beds in both the seasons of the experimentation; except at 60 days during 1986-87, where dry matter/plant was significantly more on ridges and furrows than on flat beds.

Interaction

The interaction effects were found to be nonsignificant at all the growth stages in both the seasons.

4.2.5.1 Studies on growth functions of dry matter

The various physiological determinents viz mean Crop Growth Rate ($\overline{CGR}$), mean Relative Growth Rate ($\overline{RGR}$) and mean Net Assimilation Rate ($\overline{NAR}$) were calculated from the data on dry matter/plant and leaf area of functional leaves/plant at different growth stages of maize. The data on these characters were not statistically analysed. Hence, inferences are based on mean values.

4.2.5.1.1 Crop Growth Rate ($\overline{CGR}$)

Data pertaining to mean $\overline{CGR}$ of dry matter in g/plant/day as affected periodically by various treatments are presented in Table 17.

It is seen from the data in Table 17 that the maximum $\overline{CGR}$ values were 6.75 and 5.02 g/plant/day between 75 to 90 and 90 to 105 days from sowing during 1986-87 and 1987-88, respectively, thereafter $\overline{CGR}$ values showed decreased trend during both the years.

Table 17. Mean Crop Growth Rate (CGR) of dry matter in g per day per plant as affected periodically by different treatments.

Treatment	1986-87						1987-88					
	Days between sowing						Days between sowing					
	30-45	45-60	60-75	75-90	90-105	105-H	30-45	45-60	60-75	75-90	90-105	105-H
Irrigation scheduling (IW/CPE ratios)												
1.0	3.82	5.53	3.91	9.09	6.25	1.65	0.90	4.41	5.51	2.73	5.11	2.89
0.8	3.38	4.28	4.46	6.47	5.46	2.89	0.95	3.06	4.56	2.99	5.28	2.30
0.6	3.61	1.65	6.28	5.50	4.97	2.12	1.06	3.00	2.47	2.62	4.89	3.00
0.4	3.14	0.96	5.99	5.95	3.60	3.68	0.73	3.00	2.78	2.65	4.80	2.55
Mulching												
No mulch	3.57	2.89	5.29	6.72	4.48	2.82	0.93	3.47	3.54	2.99	4.67	2.63
Mulch	3.40	3.32	5.03	6.82	5.65	2.06	0.89	3.27	4.11	2.31	5.37	2.75
Irrigation layouts												
Ridges and furrows	3.60	3.12	5.17	6.74	5.27	2.37	0.98	3.43	3.50	2.73	4.87	2.73
Flat beds	3.37	3.09	5.15	6.80	4.87	2.50	0.83	3.31	4.15	2.57	5.17	2.64
General mean	**3.49**	**3.11**	**5.16**	**6.75**	**5.07**	**2.44**	**0.91**	**3.37**	**3.83**	**2.65**	**5.02**	**2.68**

Irrigation scheduling

In the first season the $\overline{CGR}$ values for dry matter were maximum with 1.0 and 0.8 IW/CPE ratios between the period 75-90 days and with 0.6 IW/CPE ratio and 0.4 IW/CPE ratio between the period 60-75 days.

During the second year of the investigation, the 1.0 IW/CPE ratio had given more $\overline{CGR}$ values of dry matter during the period of 60 to 75 days, while 0.8 IW/CPE ratio had given more $\overline{CGR}$ values of dry matter during the period between 90-105 days. However, no definite trend was observed during both the seasons.

4.2.5.1.2 Relative Growth Rate ($\overline{RGR}$)

Data pertaining to mean Relative Growth Rate ($\overline{RGR}$) g/g/week/ plant as affected periodically by different treatments are presented in Table 18.

It is seen from the data in Table 18 that the mean maximum values of $\overline{RGR}$ viz 0.6681 and 0.4315 g/g/week/plant were between the period 30-45 and 45-60 DAS during 1986-87 and 1987-88, respectively. Thereafter, the values decreased till harvest of the crop in both the years,except between 90-105 DAS in 1987-88.

Irrigation scheduling

No definite trend was observed in respect of $\overline{RGR}$ values due to scheduling of irrigation at different IW/CPE ratios during both the years of the study.

Mulching

Application of mulch and no mulch treatment did not produce any distinct difference or trend on mean RGR values during both the years of experimentation.

Table 18. Mean Relative Growth Rate ($\overline{RGR}$) of dry matter in g/g/week/plant during different growth periods in various treatments

Treatment	1986-87						1987-88					
	Between days from						Between days from					
	30-45	45-60	60-75	75-90	90-105	105-Harvest	30-45	45-60	60-75	75-90	90-105	105-Harvest
Irrigation scheduling (IW/CPE ratios)												
1.0	0.6918	0.3504	0.1470	0.2284	0.1068	0.0190	0.2404	0.5235	0.2775	0.0470	0.1484	0.0669
0.8	0.6561	0.3062	0.1894	0.1782	0.1146	0.0408	0.2339	0.2879	0.1165	0.1165	0.1724	0.0455
0.6	0.6834	0.1403	0.3202	0.1688	0.1133	0.0388	0.2822	0.3966	0.1745	0.1227	0.1790	0.0847
0.4	0.6387	0.0961	0.3583	0.1991	0.0891	0.0763	0.1899	0.4253	0.2033	0.0899	0.1910	0.0767
Mulching												
No mulch	0.6844	0.2257	0.2478	0.1955	0.0945	0.0476	0.2383	0.4291	0.2266	0.2284	0.1623	0.0641
Mulch	0.6522	0.2542	0.2288	0.1946	0.1181	0.0366	0.2359	0.4340	0.2552	0.0754	0.1793	0.0705
Irrigation layouts												
Ridges and furrows	0.6800	0.2357	0.2352	0.1943	0.1101	0.0387	0.2602	0.4269	0.2225	0.1060	0.1638	0.0716
Flat beds	0.6560	0.2446	0.2411	0.1958	0.1027	0.0454	0.2137	0.4363	0.2594	0.0760	0.1778	0.0631
General mean	**0.6681**	**0.2400**	**0.2381**	**0.1950**	**0.1065**	**0.0420**	**0.2370**	**0.4315**	**0.2411**	**0.0908**	**0.1708**	**0.0674**

Irrigation layouts

Planting on ridges and furrows in general, showed more values of $\overline{RGR}$ at all the crop growth stages, except initial crop growth stage in both the years.

4.2.5.1.3 Net Assimilation Rate ($\overline{NAR}$)

Data related to mean $\overline{NAR}$ g/dm^2/plant day are presented in Table 19.

Data presented in Table 19 reveals that the mean maximum $\overline{NAR}$ values of 0.2348 and 0.0705 g/dm^2/plant/day were observed between the period 30-45 and 45-60 days after sowing during 1986-87 and 1987-88, respectively.

Irrigation scheduling

Irrigation scheduled at different IW/CPE ratios did not show any consistent effect on mean $\overline{NAR}$ values during both the years of the study.

Mulching

Application of mulch and no mulch treatment did not produce any clear difference on mean $\overline{NAR}$ values during both the years of the experimentation.

Layouts

Planting either on ridges and furrows or on flat beds did

Table 19 : Mean Net Assimilation Rate ($\overline{\text{NAR}}$) of dry matter in g per sq dm leaf area per plant per day as affected periodically by various treatments.

Treatment	1986-87			1987-88			
	Days between sowing			Days between sowing			
	30-45	45-60	60-75	30-45	45-60	60-75	75-90
Irrigation scheduling (IW/CPE ratios)							
1.0	0.2483	0.1373	0.0635	0.0273	0.0952	0.0870	0.0393
0.8	0.2321	0.1128	0.0791	0.0306	0.0644	0.0784	0.0475
0.6	0.2431	0.0431	0.1112	0.0355	0.0647	0.0430	0.0428
0.4	0.2204	0.0270	0.1123	0.0243	0.0643	0.0488	0.0441
Mulching							
No mulch	0.2373	0.0767	0.0962	0.0306	0.0722	0.0596	0.0470
Mulch	0.2323	0.0865	0.0854	0.0289	0.0688	0.0703	0.0365
Irrigation layouts							
Ridges and furrows	0.2428	0.0821	0.0906	0.0319	0.0711	0.0586	0.0431
Flat beds	0.2268	0.0812	0.0907	0.0272	0.0699	0.0714	0.0405
General mean	**0.2348**	**0.0816**	**0.0906**	**0.0297**	**0.0705**	**0.0650**	**0.0418**

not show any difference on mean $\overline{NAR}$ values of crop growth during both the years of study.

4.2.6 Days to 75 per cent silking, number of cobs/plant and per net plot and number of plants/ha.

Data pertaining to days required for 75 per cent silking, mean number of cobs/plant, mean number of cobs/net plot and mean number of plants/ha are presented in Table 20.

4.2.6.1 Days to 75 per cent silking

The mean number of days required for 75 per cent silking was 65.29 and 68.12 in 1986-87 and 1987-88, respectively (Table 20).

Irrigation scheduling

Irrigation scheduled at 0.4 and 0.6 IW/CPE ratios required more number of days for 75 per cent silking than irrigation scheduled at 1.0 IW/CPE ratio during 1986-87. Irrigation scheduled at 0.8 IW/CPE ratio required significantly less number of days for 75 per cent silking than irrigation scheduled at 0.4 IW/CPE ratio during same year.

Mulching

The application of mulch did not show any significant effect on the 75 per cent silking of maize during both the years of study.

Table 20. Mean number of days required for seventy five% silking, number of cobs/plant, Number of cobs/net plot at harvest and number of plants (000/ha) at harvest as affected by different treatments

Treatment	1986-87				1987-88			
	Days of 75% silking	No. of cobs/ plant	No. of cobs/ net plot at har.	No.of plants at har. (000/ha)	Days of 75% silking	No. of cobs/ plants	No. of cobs/ net plot at har.	No. of plants at harvest (000/ha)
Irrigation scheduling (IW/CPE ratios)								
1.0	64.67	1.95	85.56	45.69	66.94	1.71	81.19	46.57
0.8	65.06	1.87	84.12	45.42	67.37	1.71	79.19	46.71
0.6	65.68	1.79	79.56	45.32	68.50	1.69	76.69	47.45
0.4	66.06	1.72	75.31	45.18	69.69	1.59	76.87	46.39
S.E. ±	0.20	0.09	1.88	0.50	0.53	0.02	1.01	0.32
C.D. at 5%	0.66	-	6.04	-	-	-	3.25	-
Mulching								
No mulch	65.37	1.83	80.72	45.51	68.25	1.66	78.03	46.80
Mulch	61.22	1.83	81.56	45.30	68.00	1.69	78.44	46.76
S.E. ±	0.37	0.05	1.59	0.44	0.39	0.03	0.92	0.22
C.D. at 5%	-	-	-	-	-	-	-	-
Irrigation layouts								
Ridges and furrows	65.12	1.82	82.69	44.99	68.03	1.72	78.84	46.76
Flat beds	65.47	1.84	79.69	45.81	68.22	1.64	77.62	46.80
S.E. ±	0.37	0.05	1.59	0.44	0.39	0.03	0.92	0.22
C.D. at 5%	-	-	-	-	-	-	-	-
General mean	**65.29**	**1.83**	**81.14**	**45.40**	**68.12**	**1.68**	**78.23**	**46.78**

Irrigation layouts

The days required for 75 per cent silking of maize were not significant with planting either on ridges and furrows or on flat beds in both the seasons.

Interaction

The interaction effects between different factors under study were found to be nonsignificant during both the years of the study.

4.2.6.2 Number of cobs/plant

The mean number of cobs/plant was 1.83 and 1.68 in 1986-87 and 1987-88, respectively (Table 20).

Irrigation scheduling

The number of cobs/plant was not significantly influenced due to scheduling of irrigation at various IW/CPE ratios during both the years.

Mulching

The number of cobs/plant was not significantly affected due to mulching during both the years of the experimentation.

Irrigation layouts

The planting either on ridges and furrows or on flat beds did not produce any significant effect on the number of cobs/plant in both the seasons. In 1986-87 ridges and furrows showed lower values than flat beds during 1986-87, while in 1987-88 flat beds showed superiority over ridges and furrows, in 1987-88.

Interaction

Interaction effects between different factors under study were found to be absent.

4.2.6.3 Number of cobs/net plot

Data in Table 20 indicates that the mean number of cobs/net plot was 81.14 and 78.23 during 1986-87 and 1987-88, respectively.

Irrigation scheduling

The number of cobs/net plot was significantly more with 1.0 IW/CPE ratio as compared with 0.4 IW/CPE ratio during 1986-87 and lower IW/CPE ratios of 0.4 and 0.6 during 1987-88. Irrigation scheduled at 0.8 IW/CPE ratio also produced significantly more number of cobs/net plot than irrigation scheduled at 0.4 IW/CPE ratio during 1986-87.

Mulching

The application of mulch did not show any significant effect on the number of cobs/net plot, during both the years.

Irrigation layouts

There were no significant differences in the number of cobs/net plot due to planting either on ridges and furrows or on flat beds.

Interaction

The interaction effects between the various factors under study were found to be absent.

4.2.6.4 Number of plants at harvest

The mean number of plants at harvest was 45.40 and 46.78 thousand/ha during 1986-87 and 1987-88, respectively.

Irrigation scheduling

The mean number of plants at harvest was not affected significantly due to irrigation treatments during both the seasons.

Mulching

The number of plants at harvest was not significantly influenced due to mulching during both the years.

Irrigation layouts

Planting either on ridges and furrows or on flat beds did not show any significant effect on number of plants/ha at harvest.

Interaction

The interaction effects were not present in both the seasons.

4.3 Post harvest studies

4.3.1 Yield contributing characters

The data on mean grain weight/plant, cob length, cob girth, grain rows/cob, grain number/row, grain number/cob and 1000 grain weight as influenced by various treatments are presented in Table 21.

4.3.1.1 Grain weight/plant

The mean grain weight/plant of maize was 124.37 and 110.23 g in 1986-87 and 1987-88, respectively.

Irrigation scheduling

The grain weight/plant was significantly increased with the increased levels of IW/CPE ratios. Thus, response was graded and significant.

Mulching

The weight of grain/plant was not significantly influenced due to mulching during both the years of experimentation.

Table 21. Yield components of maize as affected by various treatments

Treatment	1986-87							1987-88						
	Grain wt./ plant(g)	Length of cob (cm)	Girth of cob (cm)	Number of grain rows/cob	Number of grains /row	Number of grains /cob	1000 grain wt.(g)	Grain wt./ plant(g)	Length of cob (cm)	Girth of cob (cm)	Number of grain rows/cob	Number of grains /row	Number of grains /cob	1000 grain wt(g)
Irrigation scheduling (IW/CPE ratios)														
1.0	145.19	18.58	14.55	15.34	40.70	593.75	237.19	123.56	18.71	14.27	15.32	37.37	518.69	207.94
0.8	128.19	17.80	13.79	14.29	38.96	541.56	228.06	116.37	18.14	13.84	14.76	37.57	493.62	206.69
0.6	118.00	17.41	13.41	14.02	38.70	508.12	216.37	106.50	17.68	13.39	14.46	36.41	470.62	200.56
0.4	106.12	17.22	13.13	13.66	36.18	473.12	210.50	94.50	17.20	13.37	14.40	34.54	426.12	193.50
SE ±	1.20	0.11	0.10	0.07	0.39	9.39	2.82	1.18	0.31	0.13	0.15	0.26	2.91	2.05
C.D. at 5%	3.84	0.34	0.32	0.23	1.23	30.05	9.03	3.78	0.99	0.43	0.49	-	9.33	6.58
Mulching														
No mulch	124.25	17.77	13.74	14.24	38.95	526.25	221.69	109.37	17.92	13.94	14.74	36.47	475.69	201.41
Mulch	124.50	17.74	13.70	14.42	38.33	532.03	224.37	111.09	17.94	13.70	14.73	36.48	478.84	202.94
SE ±	0.77	0.12	0.09	0.08	0.27	7.49	2.38	0.80	0.13	0.09	0.12	0.22	2.58	1.35
C.D. at 5%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Irrigation layout														
Ridges & furrows	124.62	17.80	13.78	14.43	38.82	539.28	222.69	110.09	18.00	13.63	14.69	36.44	478.12	202.18
Flat beds	124.12	17.71	13.66	14.22	38.46	520.00	223.37	110.37	17.86	13.81	14.79	36.51	476.40	202.15
SE ±	0.77	0.12	0.09	0.08	0.27	7.49	2.38	0.80	0.13	0.09	0.12	0.22	2.58	1.35
C.D. at 5%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
General mean	124.37	17.75	13.72	14.33	38.64	529.14	223.00	110.23	17.93	13.72	14.74	36.47	477.27	202.17

Irrigation layouts

The grain weight/plant was not significantly affected by the irrigation layouts during both the years of study.

Interaction

Interaction effects were found to be non significant.

4.3.1.2 Length of cob

The mean length per cob was 17.75 and 17.93 cm in 1986-87 and 1987-88, respectively.

Irrigation scheduling

The length of cob was significantly increased with the higher IW/CPE ratios as compared to lower IW/CPE ratios during both the years of study, except 0.8 and 1.0 IW/CPE were on par during 1987-88. The length of cob was also significantly more at 1.0 IW/CPE ratio as compared to 0.4 and 0.6 IW/CPE ratios during 1986-87.

Mulching

The mulching did not significantly influence the mean length of cob in both the seasons of study.

Irrigation layouts

There were no significant differences in the mean length of cob due to irrigation layouts, during both the years. However, in general, planting on ridges and furrows recorded comparatively more cob length than flat bed planting.

Interaction

The interaction effects between different factors under study were not present.

4.3.1.3 Girth of cob

The mean girth of cob was 13.72 cm in both the seasons (Table 21).

Irrigation scheduling

The irrigation scheduling at 1.0 IW/CPE ratio significantly increased girth of cob over lower IW/CPE ratios, during both the years, of experimentation. The girth of cob was also significantly more under 0.8 IW/CPE ratio than 0.4 and 0.6 IW/CPE ratios during both the years.

Mulching

The mulching did not significantly influence the girth of cob during both the years of study. However, it was slightly more under mulching than no mulching.

Irrigation layouts

The girth of cob was not significantly influenced due to irrigation layouts during both the years.

Interaction

Interaction effects were found to be absent in both the years.

4.3.1.4 Number of grain row/cob

The data presented in Table 21 indicates that the mean number of grain rows/cob was 14.33 and 14.74 during 1986-87 and 1987-88, respectively.

Irrigation scheduling

The number of grain rows/cob was significantly increased with increased number of irrigations (IW/CPE ratios) during 1986-87. However, irrigation scheduled at 1.00 IW/CPE ratio significantly increased number of rows/cob as compared to lower IW/CPE ratios during 1987-88.

Mulching

The number of grain rows/cob was not significantly influenced due to mulching during both the years.

Irrigation layouts

The differences in mean number of grain rows/cob were not significantly influenced due to irrigation layouts in both the seasons.

Interaction

The interaction effects between different factors under study were found to be non significant in both the years of study.

4.3.1.5 Number of grains/row

The mean number of grains/row was 38.64 and 36.47 in 1986-87 and 1987-88, respectively.

Irrigation scheduling

Irrigation scheduled at 0.6 and 0.8 and 1.0 IW/CPE ratios were on par but significantly increased number of grains/row as compared to 0.4 IW/CPE ratio during 1986-87. The number of grains/row were not significantly affected due to irrigation scheduling in 1987-88.

Mulching

The number of grains/row was not significantly influenced due to mulching in both the seasons.

Irrigation layouts

The number of grains/row was not significantly affected due to different irrigation layouts during both the years.

Interaction

Interaction effects between different factors under study were found to be non significant.

4.3.1.6 Number of grains per cob

The mean number of grains/cob was 529.14 and 477.27 in 1986-87 and 1987-88, respectively.

Irrigation scheduling

The number of grains/cob was significantly increased with the increase in the number of irrigations (IW/CPE ratios) during both the years of study.

Mulching

No significant effect of mulching was observed on number of grains/cob in both the seasons. However, application of mulch produced slightly more number of grains/cob.

Irrigation layouts

Irrigation layouts did not show any significant differences on the number of grains/cob during both the seasons.

Interaction

Interaction effects were found to be absent.

4.3.1.7 Thousand grain weight

The mean thousand grain weight was 223.00 and 203.17 g in 1986-87 and 1987-88, respectively.

Irrigation scheduling

Irrigation scheduling at 1.0 and 0.8 IW/CPE ratios increased test weight significantly over 0.4 and 0.6 IW/CPE ratios during both the years of experimentation, except 0.6 and 0.8 IW/CPE ratios were on par during 1987-88. Irrigation scheduled at 1.0

IW/CPE ratio also increased thousand grain weight as compared to 0.8 IW/CPE ratio during 1986-87.

Mulching

The differences in thousand grain weight were not significant due to mulch or no mulch treatment in both the seasons. However, mulch proved its superiority over no mulch in both the seasons.

Irrigation layouts

The thousand grain weight was not significantly influenced due to irrigation layouts.

Interaction

Interaction effects between different factors under study were found to be non significant.

4.3.2 Yield

Data pertaining to yield. harvest index and grain production efficiency as influenced by different treatments are presented in Table 22 and graphically depicted in Fig. 7,8 and 9.

4.3.2.1 Grain yield

The data presented in Table 22 reveals that the mean grain yield was 50.43 45.25 and 48.19 q/ha during 1986-87, 1987-88 and when data were pooled, respectively.

Irrigation scheduling

Grain yield was significantly increased with the increased

Table 22. Mean grain and stover yield, harvest index and grain production efficiency of maize as affected by various treatments

Treatment	1986-87				1987-88				Pooled yield (q/ha)	
	Grain yield (q/ha)	Stover yield (q/ha)	Harvest index	Grain production efficiency (kg/ha/day)	Grain yield (q/ha)	Stover yield (q/ha)	Harvest index	Grain production efficiency (kg/ha/day)	Grain	Stover
Irrigation scheduling (IW/CPE ratios)										
1.0	55.72	85.51	39.55	41.27	50.02	72.68	40.64	36.51	52.87	79.10
0.8	53.89	83.73	39.23	39.92	47.75	71.30	40.33	34.85	50.82	77.51
0.6	47.82	77.36	38.19	35.42	45.65	68.52	39.97	33.32	46.74	72.94
0.4	44.30	75.35	37.01	32.81	40.37	66.32	37.86	29.47	42.34	70.83
S.E. ±	0.65	2.03	0.59	0.48	0.48	0.77	0.30	0.35	0.50	1.08
C.D. at 5%	2.07	6.50	-	1.53	1.54	2.47	0.97	1.12	1.49	3.19
Mulching										
No mulch	49.64	78.91	38.59	36.77	45.66	68.75	39.86	33.33	47.65	73.83
Mulch	51.23	82.06	38.40	37.95	46.24	70.66	39.54	33.75	48.73	76.36
S.E. ±	0.49	0.98	0.37	0.36	0.51	0.58	0.29	0.37	0.34	0.57
C.D. at 5%	1.41	2.82	-	1.04	-	1.66	-	-	0.97	1.60
Irrigation layouts										
Ridges and furrows	50.66	79.81	38.82	37.52	46.06	70.25	39.65	33.62	48.36	75.03
Flat beds	50.21	81.16	38.18	37.19	45.83	69.15	39.74	33.45	48.02	75.16
S.E. ±	0.49	0.98	0.37	0.36	0.51	0.58	0.30	0.37	0.34	0.57
C.D. at 5%	-	-	-	-	-	-	-	-	-	-
General mean	**50.43**	**80.48**	**38.50**	**37.35**	**45.95**	**69.70**	**39.70**	**33.54**	**48.19**	**75.09**

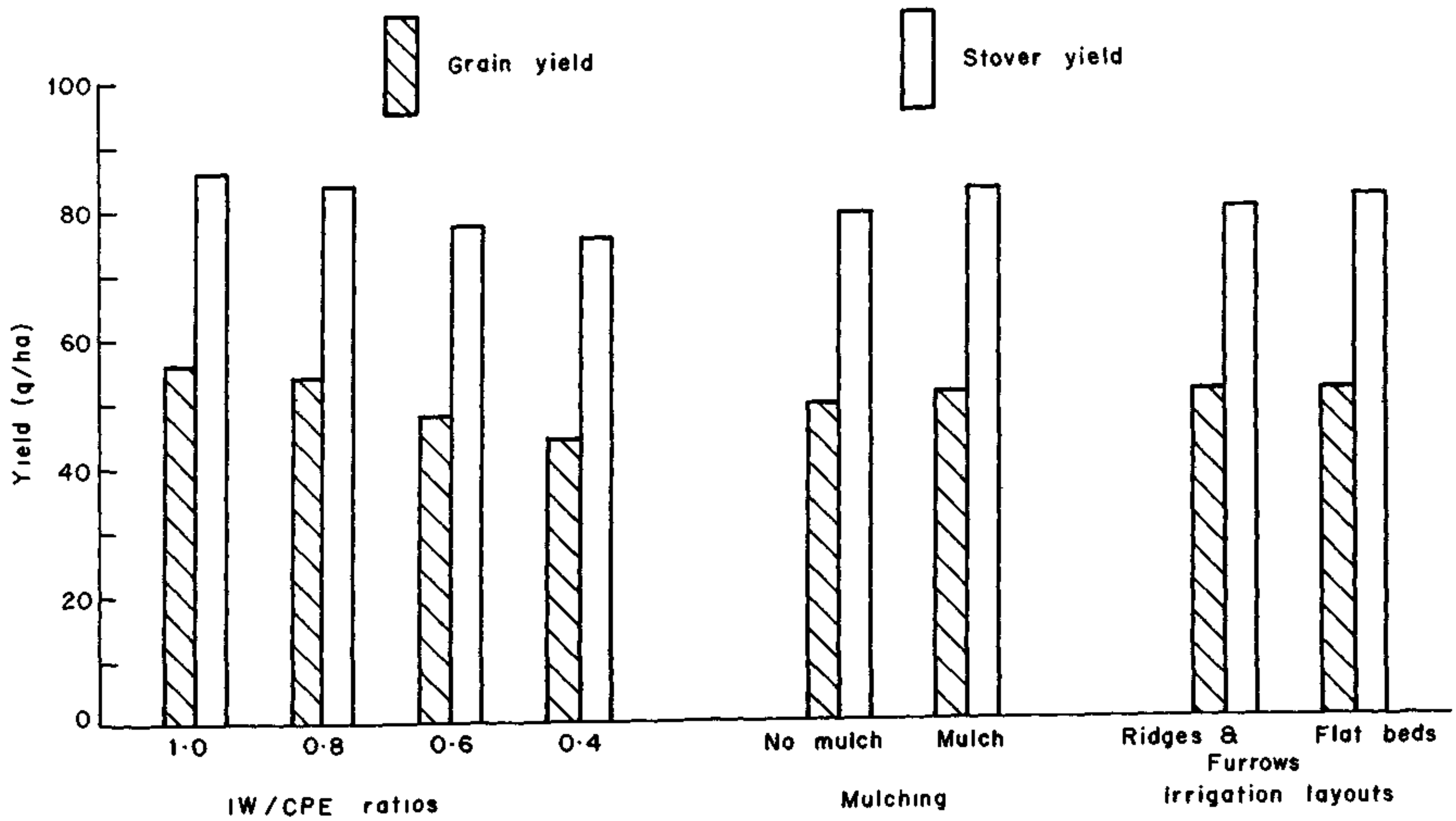


Fig. 7. Mean grain and stover yield (q/ha) as influenced by various treatments during 1986-87.

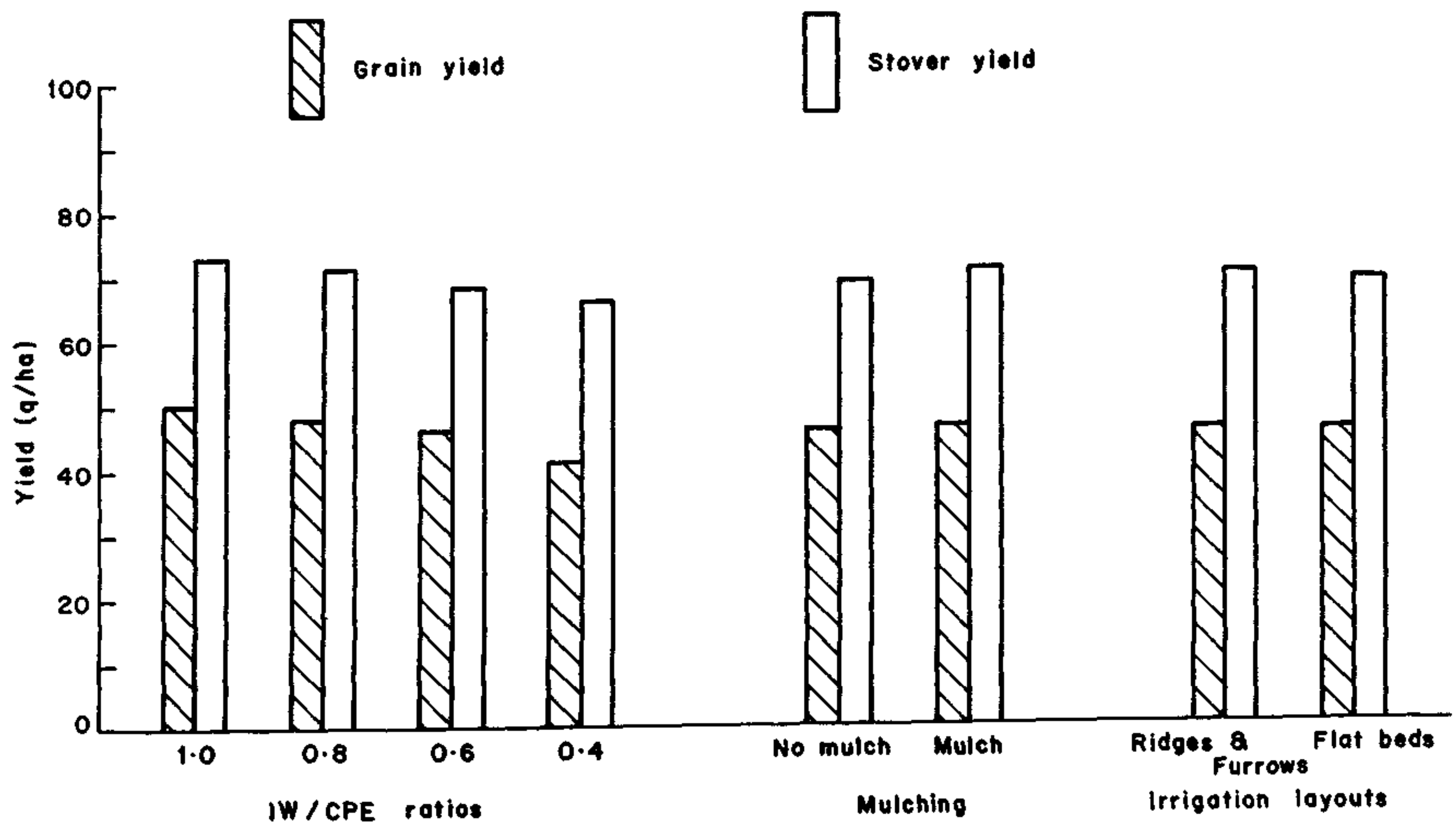


Fig. 8. Mean grain and stover yield (q/ha) as influenced by various treatments during 1987-88.

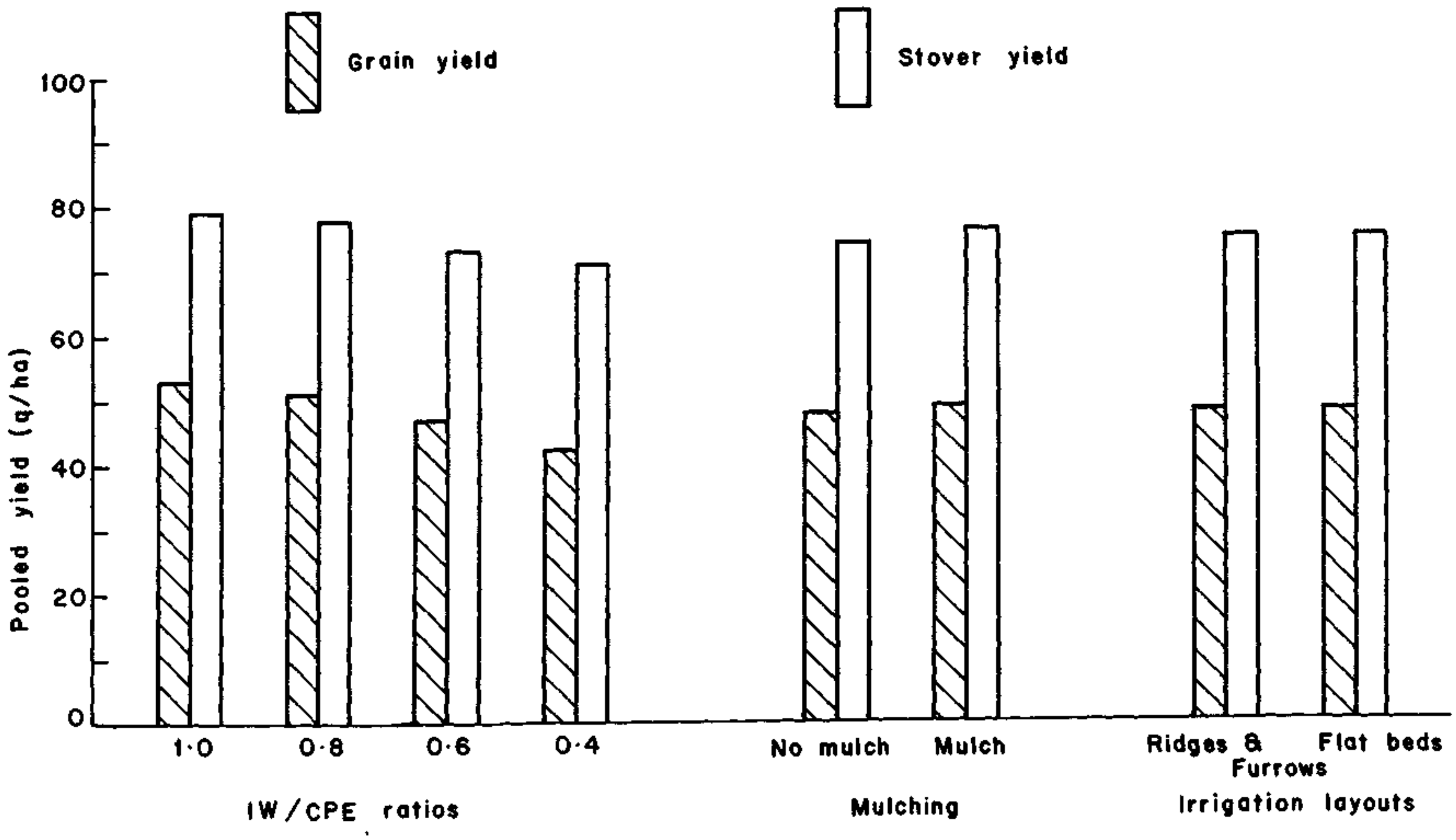


Fig. 9. Pooled grain and stover yield (q/ha) as influenced by various treatments.

number of irrigations (IW/CPE ratios) during both the years of study and when data were pooled, except that 0.8 and 1.0 IW/CPE ratios were on par during 1986-87. The pooled grain yield was increased by 10.39, 20.03 and 24.87 per cent due to irrigation scheduled at 0.6, 0.8 and 1.00 IW/CPE ratios, respectively, over 0.4 IW/CPE ratio.

Mulching

The grain yield was significantly increased due to mulching during 1986-87 and in pooled data. However, it was slightly higher with mulching than no mulch treatment during 1987-88 and in pooled data.

Irrigation layouts

The grain yield of maize was not affected significantly due to different layouts in both the seasons and when data were pooled.

Interaction

The mean grain yield/ha as influenced by interaction of irrigation scheduling and mulching in 1986-87 is presented in Table 23. Other interaction effects were found to be non significant.

Table 23 : Mean grain yield (q/ha) as influenced by the interaction of irrigation scheduling and mulching (1986-87)

Irrigation scheduling (IW/CPE ratios)	Mulching	
	No Mulch	Mulch
1.0	54.86	56.57
0.8	54.25	53.51
0.6	45.32	50.32
0.4	44.12	44.49
S.E. for comparison of irrigation scheduling		0.97
C.D. at 5%		2.81
S.E. for comparison of mulching		0.95
C.D. at 5%		2.86

Irrigation scheduled at 0.8 and 1.0 IW/CPE ratios increased grain yields significantly over 0.4 and 0.6 IW/CPE ratios, under no mulch treatment, whereas grain yield was significantly increased with increased number of irrigations under mulch treatment.

The application of mulch significantly produced more grain yield than no mulch treatment at 0.6 IW/CPE ratio.

4.3.2.2 Stover yield

It is observed from the data presented in Table 22 that the mean stover yield was 80.48, 69.70 and 75.09 q/ha during the year 1986-87, 1987-88 and when data were pooled, respectively.

Irrigation scheduling

Irrigation scheduled at 0.8 and 1.0 IW/CPE ratios significantly increased stover yield as compared to irrigation scheduled at 0.4 and 0.6 IW/CPE ratios, during both the years of study and in pooled data, except 0.8 and 0.6 IW/CPE ratios were found to be on par during 1986-87. The pooled stover yield was increased by 2.98, 9.43 and 11.63 per cent with the irrigation scheduled at 0.6, 0.8 and 1.0 IW/CPE ratios, respectively over 0.4 IW/CPE ratio.

Mulching

The stover yield was significantly more with mulch than no mulch during both the years and when data were pooled. The pooled stover yield increased by 3.44 per cent over no mulch.

Irrigation layouts

The irrigation layouts did not show any significant effect on stover yield of maize in both the years of study and when data were pooled.

Interaction

The interaction effects were found to be absent in both the seasons and when data were pooled.

4.3.2.3 Harvest index

The mean harvest index was 38.50 and 39.70 during 1986-87 and 1987-88, respectively (Table 22).

Irrigation scheduling

The harvest index was not significantly influenced due to irrigation scheduling during 1986-87. However, it was significantly decreased with lower IW/CPE ratio (0.4 IW/CPE) than higher IW/CPE ratios, which were on par with each other during 1987-88.

Mulching

No significant effect of mulch was observed on harvest index in both the seasons under study.

Irrigation layouts

Harvest index was not affected significantly due to different irrigation layouts during both the years.

Interaction

Interaction effects were found to be non significant.

4.3.2.4 Grain production efficiency

It is noticed from the data in Table 22 that the mean grain production efficiency was 37.35 and 33.54 kg/ha/day during the year 1986-87 and 1987-88, respectively.

Irrigation scheduling

The grain production efficiency was significantly increased with increased IW/CPE ratios during both the years of experimentation, except 0.8 and 1.0 IW/CPE ratios were on par in 1986-87.

Mulching

The grain production efficiency was increased significantly, when mulch was introduced as compared to no mulch treatment in 1986-87. However, during 1987-88 mulch had not shown any significant effect on grain production efficiency.

Irrigation layouts

Irrigation layouts did not show significant influence on grain production efficiency in both the seasons.

Interaction

Interaction effects between different factors under study were not found to be significant.

4.4 Response curve

The response to irrigation scheduling was worked out and analysis of variance for the same is presented in Table 24 and predicted grain yield is depicted in Fig. 10.

The response to the irrigation scheduling was found to be linear during both the years and in pooled data. Therefore, optimum irrigation scheduling could not be suggested indicating that higher IW/CPE ratio needs to be tried if unlimited water resources are available for enhancing maize production. The R^2 values (0.9643, 0.9440 and 0.9962) during 1986-87, 1987-88 and for pooled data showed good fit of response equations.

Table 24. Analysis of variance for the irrigation scheduling

1986-87

Source	D.F.	S.S.	M.S.S.	Cal F.	Table F 1%	Table F 5%
Linear	1	81.3255	81.3255	53.8722**	-	18.51
Residual	2	3.0192	1.5096	-	-	-
Total	**3**	**84.3447**	-	-	-	-

1987-88

Source	D.F.	S.S.	M.S.S.	Cal F.	Table F 1%	Table F 5%
Linear	1	48.2100	48.2100	34.18**	-	18.51
Residual	2	2.8213	1.4107	-	-	-
Total	**3**	**51.0313**	-	-	-	-

Pooled

Source	D.F.	S.S.	M.S.S.	Cal F.	Table F 1%	Table F 5%
Linear	1	63.6245	63.6245	83.72**	-	18.51
Residual	2	1.5199	0.7600	-	-	-
Total	**3**	**65.1444**	-	-	-	-

** Highly significant.

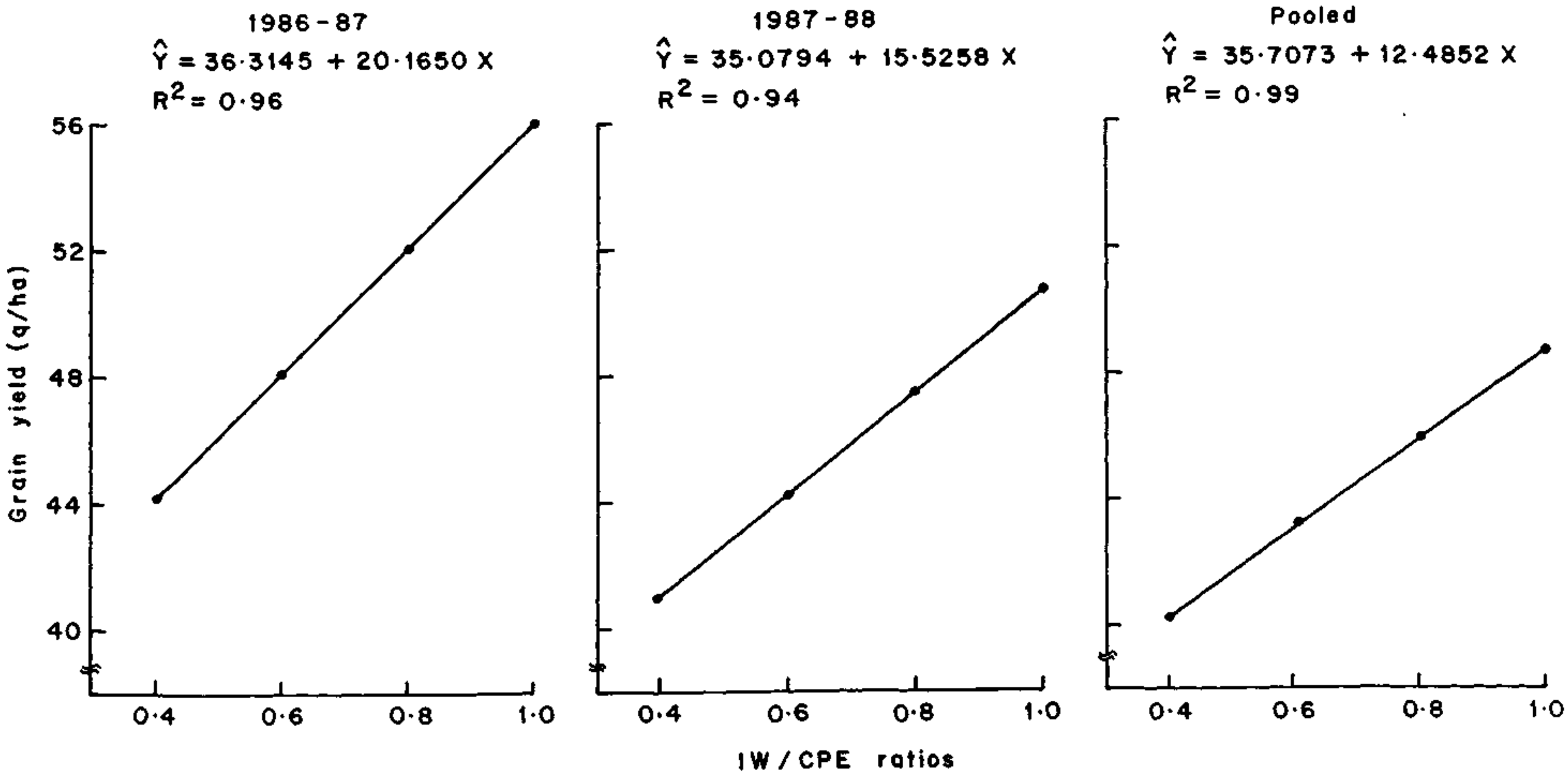


Fig. 10. Irrigation-yield relationship in maize.

4.5 Monetary returns

Data pertaining to mean gross and net monetary returns, cost of cultivation, net monetary returns and benefit cost ratio, as affected by different treatments are presented in Table 25 and depicted in Fig.11,12 and 13.

4.5.1 Gross monetary returns

The mean gross monetary returns were Rs.12,185, 11,988 and 12,087/ha during the year 1986-87 and 1987-88 and from pooled data, respectively.

Irrigation scheduling

The gross monetary returns were significantly increased with increased IW/CPE ratios during both the years of study and in pooled data.

Mulching

The application of mulch gave significantly more gross monetary returns than no mulch in 1986-87 and in pooled data. However, in 1987-88, though mulch had shown more gross monetary returns, yet it had not attained the level of significance.

Irrigation layouts

The gross monetary returns were not significantly influenced due to irrigation layouts during both the seasons as well as when data were pooled.

Table 25. Mean cost of cultivation, gross and net monetary returns per hectare and benefit cost ratio from maize as influenced by different treatmen

Treatment	1986-87				1987-88				Pooled		
	Cost of culti-vation [Rs/ha]	Gross monetary returns [Rs/ha]	Net Monetary returns [Rs/ha]	Benefit cost ratio	Cost of culti-vation [Rs/ha]	Gross monetary returns [Rs/ha]	Net monetary returns [Rs/ha]	Benefit cost ratio	Gross monetary returns [Rs/ha]	Net monetary returns [Rs/ha]	Mean cost of cultivation [Rs/ha]
Irrigation scheduling [IW/CPE ratios]											
1.0	7,102	13,429	6,320	0.89	7,067	12,959	5,892	0.83	13,194	6,106	7,085
0.8	6,984	12,981	5,997	0.87	6,949	12,516	5,563	0.80	12,748	5,780	6,967
0.6	6,866	11,522	4,656	0.67	6,832	11,869	5,035	0.74	11,695	4,845	6,849
0.4	6,631	10,811	4,175	0.63	6,714	10,610	3,896	0.58	10,711	4,036	6,672
S.E. ±	-	145	144	-	-	126	126	-	115	115	-
C.D. at 5%	-	463	459	-	-	402	402	-	337	337	-
Mulching											
No mulch	6,725	12,014	5,290	0.77	6,720	11,876	5,156	0.77	11,945	5,223	6,722
Mulch	7,067	12,357	5,284	0.75	7,061	12,101	5,036	0.71	12,229	5,160	7,064
S.E. ±	-	111	111	-	-	115	115	-	78	78	-
C.D. at 5%	-	319	-	-	-	-	-	-	218	-	-
Irrigation layouts											
Ridges and furrows	6,955	12,193	5,235	0.75	6,950	12,052	5,102	0.73	12,123	5,169	6,952
Flat beds	6,837	12,178	5,338	0.78	6,832	11,924	5,091	0.75	12,051	5,215	6,834
S.E. ±	-	111	111	-	-	115	115	-	78	78	-
C.D. at 5%	-	-	-	-	-	-	-	-	-	-	-
General mean	6,896	12,185	5,287	0.77	6,891	11,988	5,097	0.74	12,087	5,192	6,893

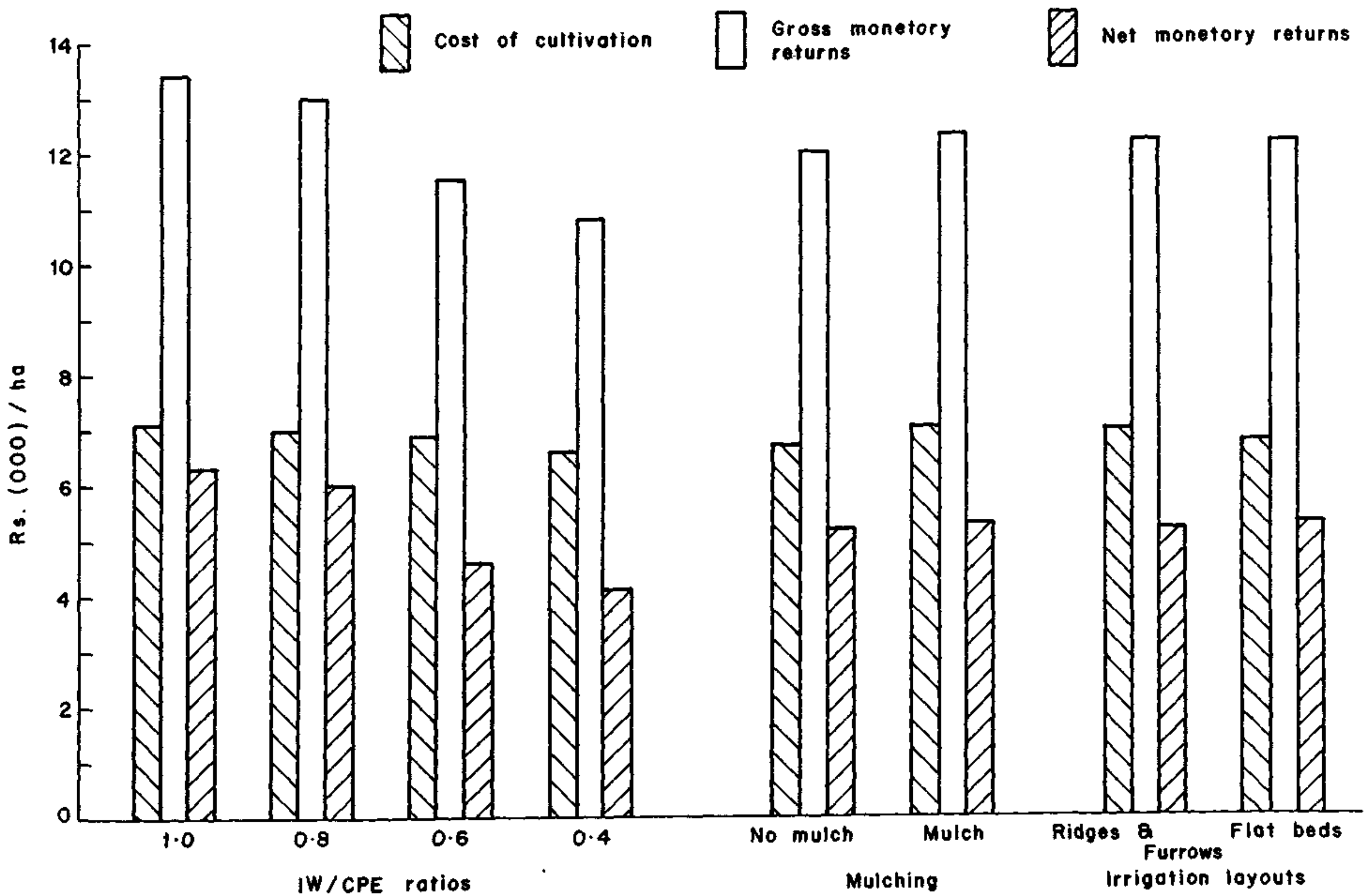


Fig. 11. Mean cost of cultivation, gross and net monetary returns (Rs/ha) as influenced by various treatments during 1986-87.

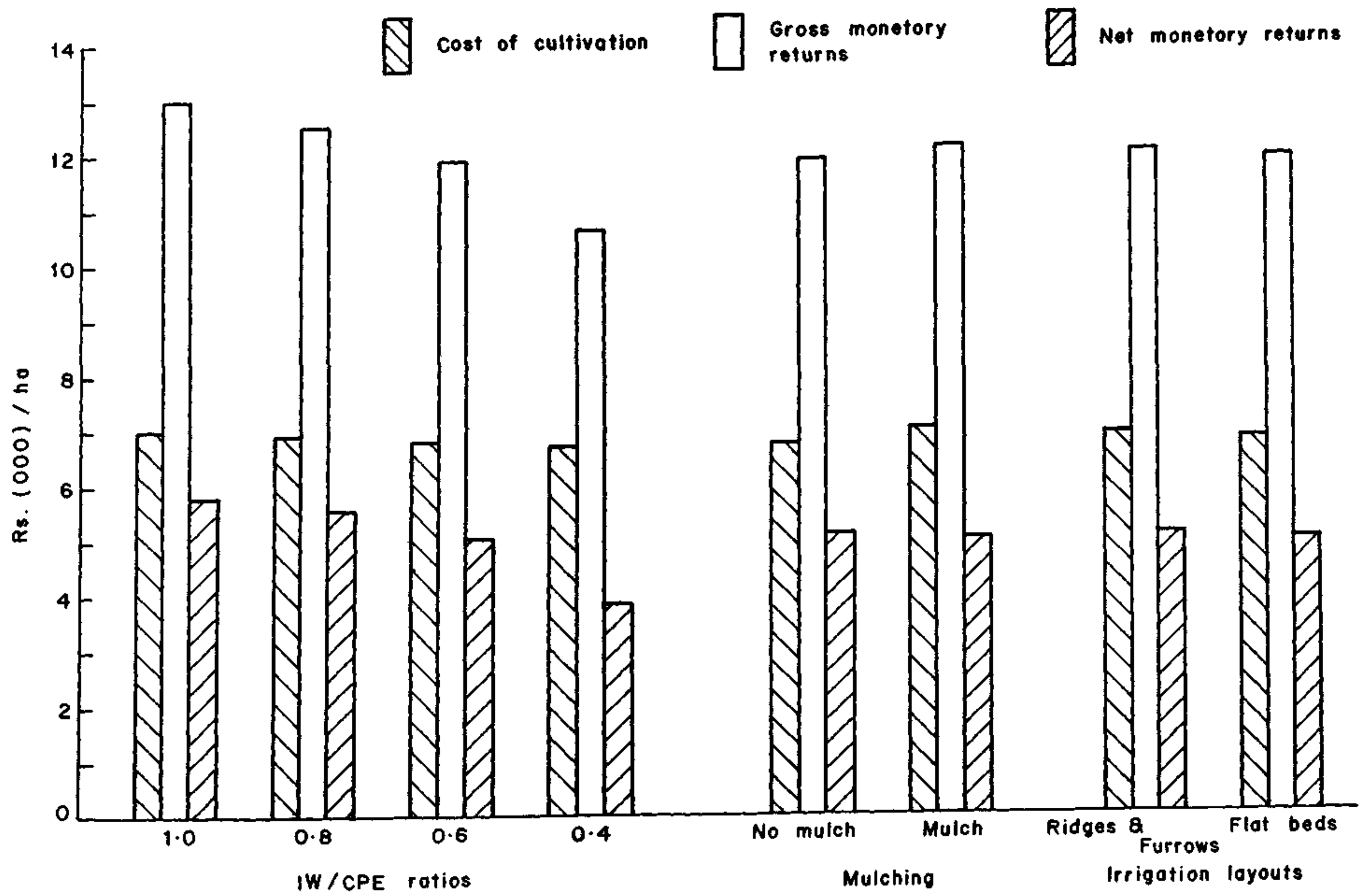


Fig. 12. Mean cost of cultivation, gross and net monetary returns (Rs/ha) as influenced by various treatments during 1987-88.

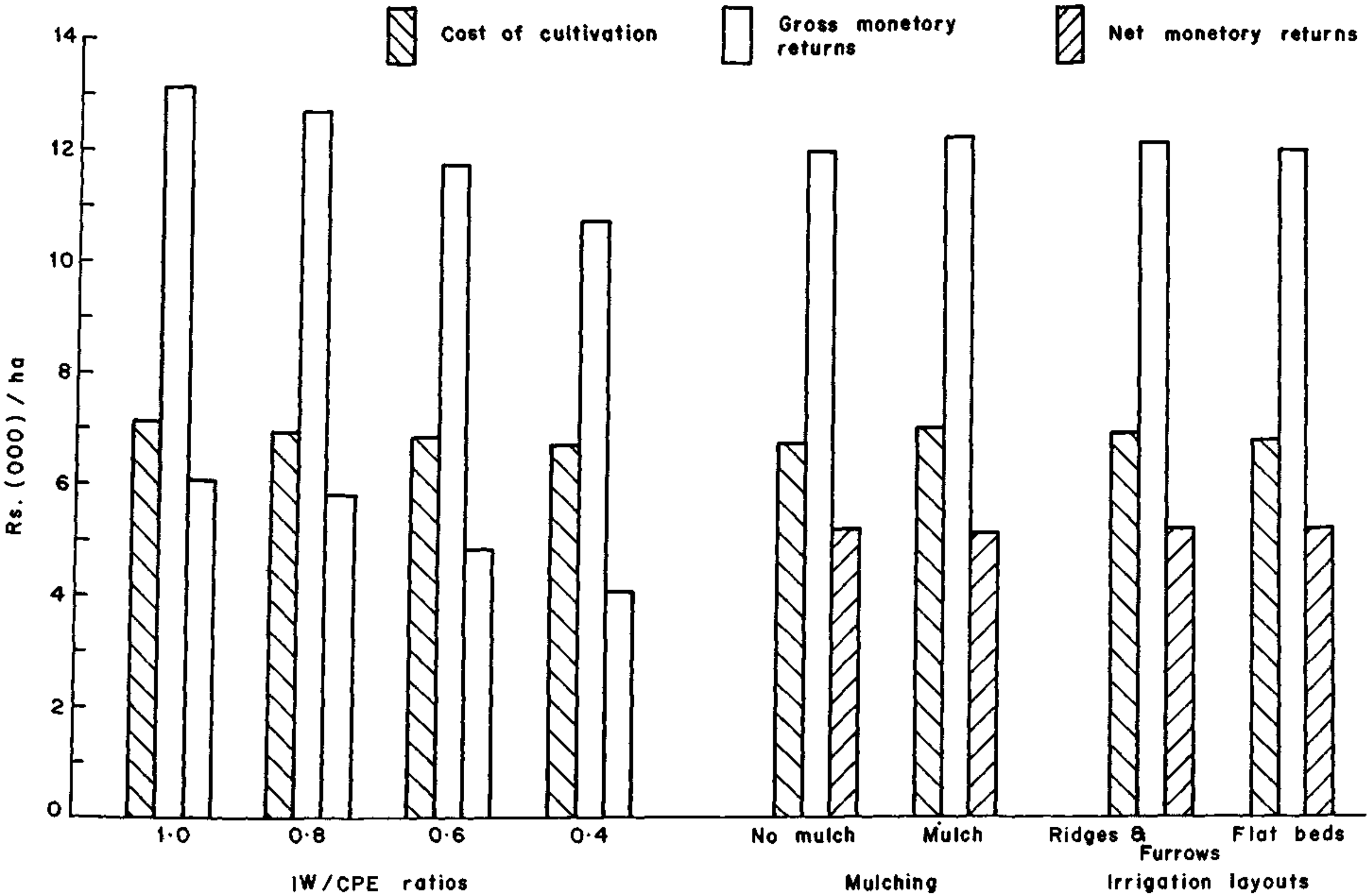


Fig. 13. Mean cost of cultivation and pooled gross and net monetary returns (Rs/ha) as influenced by various treatments.

Interaction

Interaction effects were found to be absent.

4.5.2.2 Cost of cultivation

Data presented in Table 25 on cost of cultivation was not statistically analysed. The inferences are based on mean values. The mean cost of cultivation was Rs.6896 and 6,891 during 1986-87 and 1987-88, respectively (Table 25).

Irrigation scheduling

The cost of cultivation was progressively increased with increased IW/CPE ratios during both the years.

Mulching

The more cost of cultivation was required for mulching than no mulch during both the years.

Irrigation layouts

The cost of cultivation was almost the same in both the years due to planting either on ridges and furrows or on flat beds.

4.5.3 Net monetary returns

The net monetary returns during 1986-87, 1987-88 and when data were pooled were Rs.5,287, 5,097 and 5,192/ha, respectively (Table 25).

Irrigation scheduling

The irrigation scheduled at 0.8 and 1.0 IW/CPE ratios were on par but significantly increased the net monetary returns as compared to lower IW/CPE ratios (0.4 and 0.6) during both the years. However, the net monetary returns were significantly increased with the increase in number of irrigations in pooled data, indicating that it would be advisible to irrigate maize at 1.0 IW/CPE ratio.

Mulching

The net monetary returns/ha were not significantly influenced due to mulching during both the years of study and in pooled data. Thus, the net monetary return/ha were comparable under mulch and no mulch treatment.

Irrigation layouts

The net monetary returns were not affected significantly due to irrigation layouts during both the years and in pooled data.

4.5.4 Benefit cost ratio

The mean benefit cost ratios were 0.77, 0.74 and 0.75 in 1986-87, 1987-88 and when data were averaged over seasons (Table 25).

Irrigation scheduling

The benefit cost ratio was slightly decreased with decrease in the IW/CPE ratios during both the seasons.

Mulching

The mulching with sugarcane trash showed lower benefit cost ratio than no mulching in 1986-87, 1987-88 and in pooled data.

Irrigation layouts

The benefit cost ratio was more when maize was planted on flat beds during both the years.

4.6 Chemical studies

4.6.1 Nitrogen content

Data regarding nitrogen content in stalk, leaves, stover and grain at harvest as affected by different treatments are presented in Table 26.

The data presented in Table 26 reveal that mean N content in stalk, leaves, stover and grain was 0.679, 1.264, 1.067 and 1.721 per cent during 1986-87 and 0.675, 1.256, 0.968 and 1.673 per cent during 1987-88, respectively. The maximum concentration of N was observed in grains during both the years.

Irrigation scheduling

The concentration of N in stalk, leaves, stover and grain at harvest was slightly more with the lower IW/CPE ratios during both the years. However, it had not attained the leavel of significance, during both the seasons.

Table 26 : Mean concentration of nitrogen (%) in different constituents of maize plant

Treatment	1986-87				1987-88			
	Stalk	Leaves	Stover	Grain	Stalk	Leaves	Stover	Grain
Irrigation scheduling IW/CPE ratios)								
1.0	0.641	1.236	1.039	1.702	0.661	1.236	0.958	1.662
0.8	0.658	1.233	1.046	1.714	0.655	1.240	0.947	1.672
0.6	0.676	1.274	1.074	1.735	0.668	1.268	0.968	1.672
0.4	0.720	1.315	1.111	1.736	0.717	1.279	0.998	1.685
S.E. ±	0.021	0.032	0.020	0.028	0.031	0.045	0.029	0.053
C.D. at 5%	-	-	-	-	-	-	-	-
Mulching								
No mulch	0.671	1.260	1.062	1.698	0.674	1.248	0.962	1.678
Mulch	0.676	1.269	1.072	1.744	0.677	1.263	0.973	1.667
S.E. ±	0.022	0.024	0.018	0.029	0.018	0.025	0.016	0.034
C.D. at 5%	-	-	-	-	-	-	-	-
Irrigation layouts								
Ridges and furrows	0.673	1.268	1.069	1.702	0.670	1.267	0.973	1.679
Flat beds	0.673	1.260	1.065	1.741	0.681	1.244	0.962	1.667
S.E. ±	0.022	0.024	0.018	0.029	0.018	0.025	0.016	0.034
C.D. at 5%	-	-	-	-	-	-	-	-
General mean	**0.673**	**1.264**	**1.067**	**1.721**	**0.675**	**1.256**	**0.968**	**1.673**

Mulching

There were no significant differences in N content in stalk, leaves, stover and grain in both the seasons due to application of mulch as compared to no mulch treatment. However, N accumulation was slightly more due to mulching in both the years.

Irrigation layouts

The concentration of N in stalk, leaves, stover and grains was not significantly influenced due to irrigation layouts. However, N accumulation in leaves & stover in 1986-87 and in stalk, leaves, stover and grain in 1987-88 showed a slight improvement, when maize was planted on ridges and furrows.

4.6.2 Phosphorus content

Data regarding P content in stalk, leaves, stover and grains at harvest as affected by different treatments are presented in Table 27.

Data presented in Table 27 reveal that the mean P content in stalk, leaves, stover and grain was 0.407, 0.406, 0.400 and 0.805 per cent in 1986-87 and 0.401, 0.401, 0.400 and 0.773 per cent in 1987-88, respectively.

Irrigation scheduling

The per cent P content in maize plant was not significantly influenced due to scheduling of irrigation in both the seasons. However, with increase in the IW/CPE ratios the P content was slightly decreased in stalk, leaves, stover and grain.

Table 27. Mean concentration of phosphorus (%) in different constituents of maize plant

Treatment	1986-87				1987-88			
	Stalk	Leaves	Stover	Grain	Stalk	Leaves	Stover	Grain
Irrigation scheduling (IW/CPE ratios)								
1.0	0.404	0.404	0.404	0.756	0.400	0.398	0.399	0.706
0.8	0.406	0.405	0.405	0.819	0.401	0.405	0.403	0.763
0.6	0.407	0.407	0.407	0.844	0.401	0.395	0.397	0.806
0.4	0.409	0.406	0.408	0.800	0.403	0.401	0.401	0.819
S.E. ±	0.003	0.003	0.002	0.049	0.003	0.004	0.002	0.052
C.D. at 5%	-	-	-	-	-	-	-	-
Mulching								
No mulch	0.404	0.405	0.404	0.797	0.399	0.401	0.400	0.778
Mulch	0.409	0.406	0.407	0.813	0.403	0.399	0.400	0.769
S.E. ±	0.003	0.002	0.002	0.038	0.001	0.002	0.001	0.045
C.D. at 5%	-	-	-	-	-	-	-	-
Irrigation layouts								
Ridges and furrows	0.408	0.406	0.407	0.803	0.402	0.401	0.401	0.788
Flat beds	0.405	0.405	0.405	0.806	0.400	0.399	0.399	0.759
S.E. ±	0.003	0.002	0.002	0.038	0.001	0.002	0.001	0.045
C.D. at 5%	-	-	-	-	-	-	-	-
General mean	**0.407**	**0.406**	**0.406**	**0.805**	**0.401**	**0.400**	**0.400**	**0.773**

Mulching

The per cent P content in constituent parts of maize plant viz leaves, stalk, stover and grain, was not significantly influenced but it was more with mulch treatment than no mulch during 1986-87 and 1987-88, except in leaves and grain in 1987-88, where it showed reverse trend.

Irrigation layouts

The P content in stalk, leaves, stover and grain was not significantly influenced due to different irrigation layouts. However, P content was slightly more when maize was planted on ridges and furrows.

Interaction

The interaction effects between different factors under study were found to be non significant.

4.7 Nutrient uptake

Data regarding nutrient uptake (viz N and P uptake) by maize as affected by various treatments at harvest are presented in Table 28 and 29 and depicted in Fig. 14, 15 and 16.

4.7.1 N uptake

Data presented in Table 28 shows that the mean uptake of N by grain, stover and total was 86.73, 85.82 and 172.32 kg/ha in 1986-87 and 77.04, 67.41 and 144.44 kg/ha in 1987-88, respectively. The pooled total N uptake was 158.62 kg/ha.

Table 28. Mean uptake of nitrogen (kg/ha) by maize as influenced by various treatments at harvest

Treatment	1986-87			1987-88			Pooled
	Grain	Stover	Total	Grain	Stover	Total	Total N
Irrigation scheduling IW/CPE ratios)							
1.0	94.93	87.92	183.61	83.10	69.65	152.74	168.17
0.8	92.24	87.60	179.81	80.81	67.56	148.37	164.09
0.6	82.88	83.14	165.39	76.22	66.27	142.50	153.94
0.4	76.84	83.64	160.48	68.05	66.16	134.16	148.26
S.E. ±	1.52	1.61	2.48	2.55	1.97	3.14	2.14
C.D. at 5%	4.88	-	7.94	8.16	-	10.04	6.30
Mulching							
No mulch	84.60	83.73	167.85	76.62	66.12	142.72	155.75
Mulch	88.85	87.92	176.79	77.47	68.70	146.17	161.48
S.E. ±	1.68	1.72	2.42	1.81	1.21	2.16	1.59
C.D. at 5%	-	-	6.94	-	-	-	4.49
Irrigation layouts							
Ridges and furrows	85.66	85.09	170.62	77.60	68.27	145.87	158.72
Flat beds	87.79	86.56	174.02	76.48	66.56	143.01	158.52
S.E. ±	1.68	1.72	2.42	1.81	1.21	2.16	1.59
C.D. at 5%	-	-	-	-	-	-	-
General mean	**86.72**	**85.82**	**172.32**	**77.04**	**67.41**	**144.44**	**158.62**

Table 29. Mean uptake of phosphorus (kg/ha) by maize as influenced by various treatments at harvest

Treatment	1986-87			1987-88			Pooled
	Grain	Stover	Total	Grain	Stover	Total	Total P
Irrigation scheduling IW/CPE ratios)							
1.0	42.39	34.53	76.82	35.25	28.99	64.86	70.86
0.8	44.15	33.23	77.36	36.09	28.71	65.42	71.40
0.6	40.36	31.58	71.94	36.85	27.23	64.07	68.01
0.4	39.29	30.74	66.26	32.50	26.60	59.10	62.68
S.E. ±	3.58	0.83	3.48	2.62	0.35	2.30	1.99
C.D. at 5%	-	2.64	-	-	1.10	-	5.87
Mulching							
No mulch	41.41	31.97	71.47	34.97	27.47	62.43	66.96
Mulch	41.68	31.07	74.72	35.37	28.30	64.29	69.52
S.E. ±	2.27	0.46	2.10	2.86	2.26	2.13	1.40
C.D. at 5%	-	-	-	-	0.75	-	-
Irrigation layouts							
Ridges and furrows	40.67	32.14	72.77	35.60	28.17	64.08	68.44
Flat beds	42.42	32.90	73.42	34.75	27.60	62.66	68.04
S.E. ±	2.27	0.46	2.10	2.86	0.26	2.13	1.40
C.D. at 5%	-	-	-	-	-	-	-
General mean	**41.54**	**32.52**	**73.10**	**35.17**	**27.88**	**63.37**	**68.24**

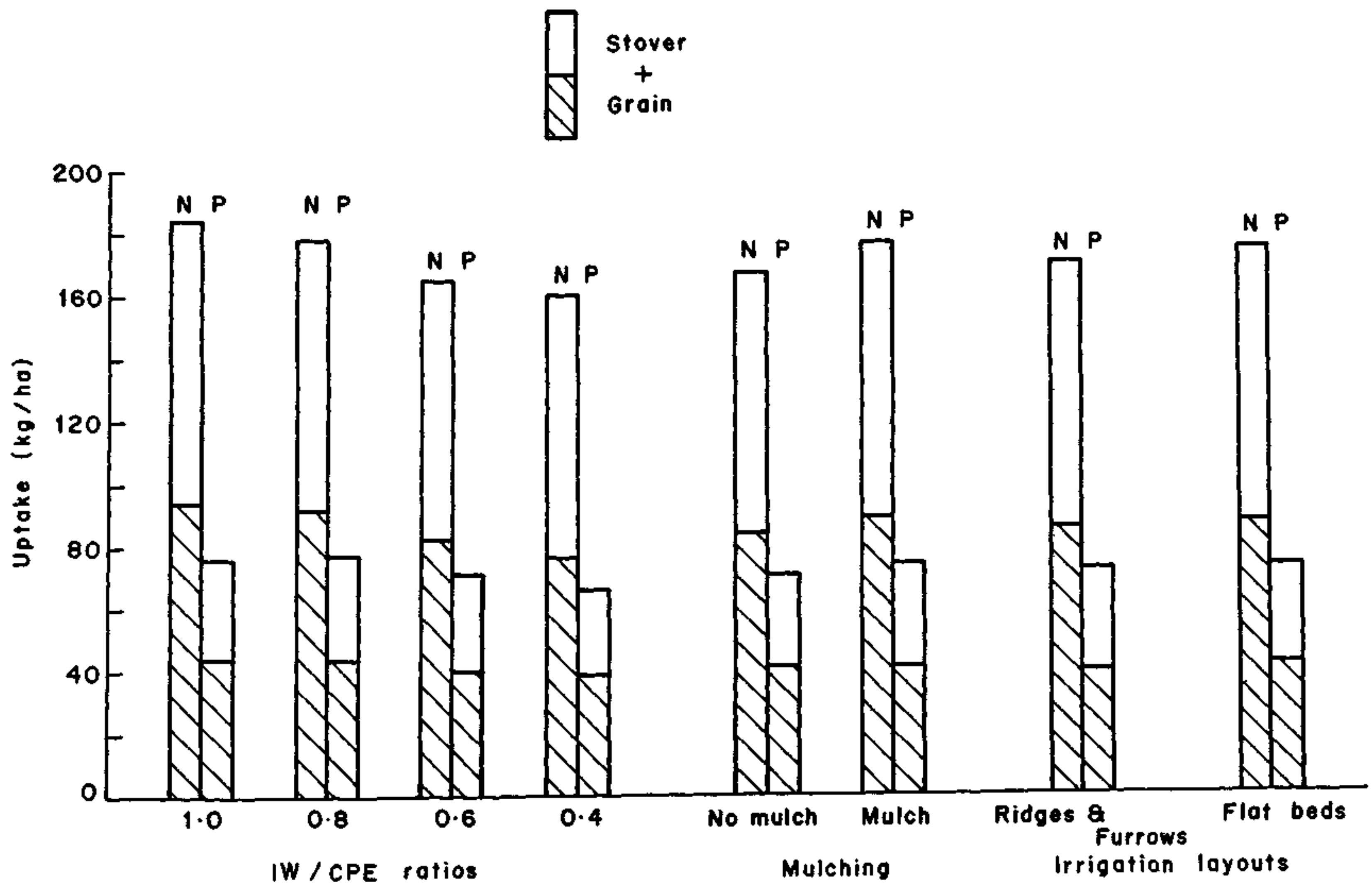


Fig. 14. Mean N and P uptake (kg/ha) by maize grain and stover as influenced by different treatments during 1986-87.

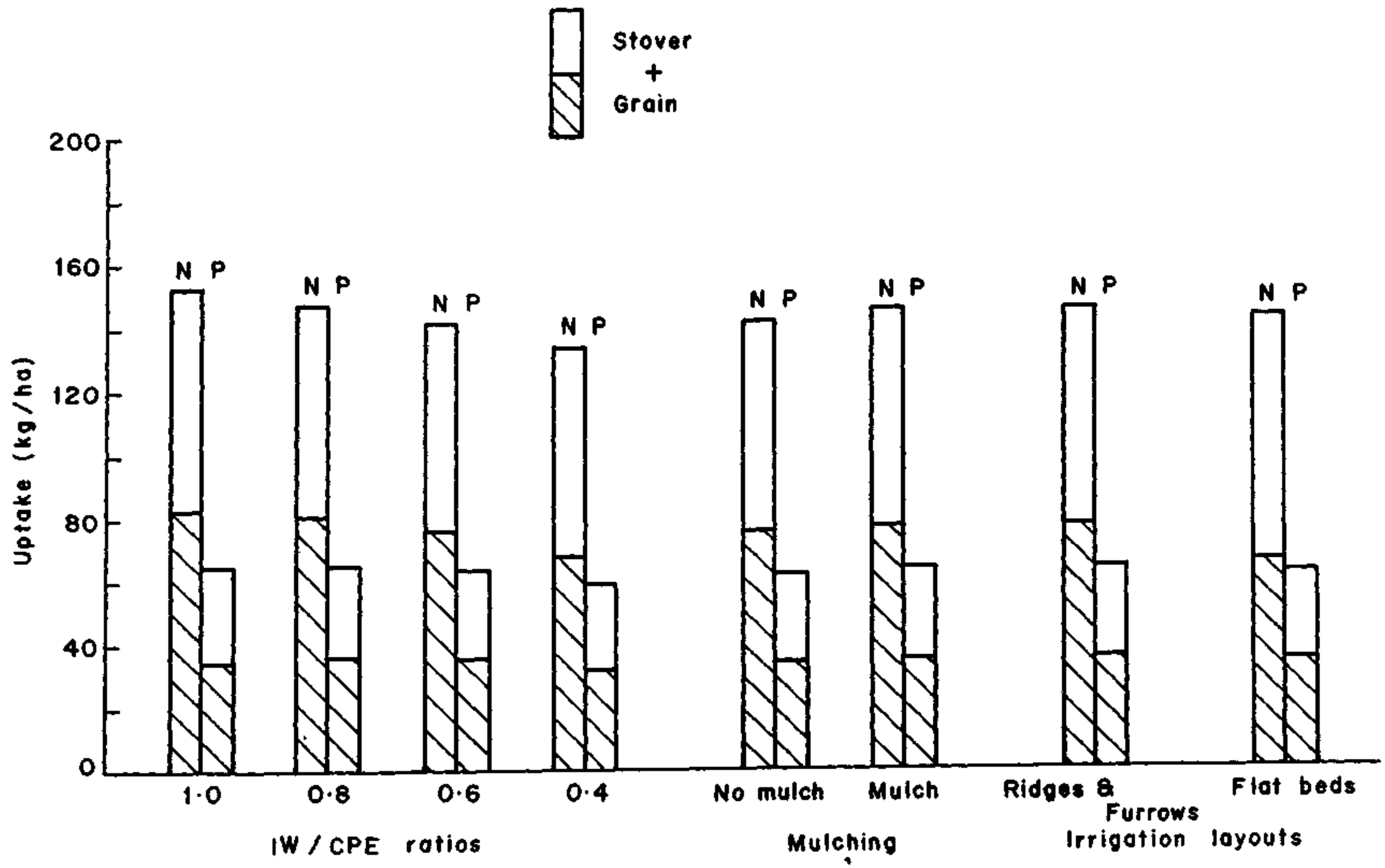


Fig. 15. Mean N and P uptake (kg/ha) by maize grain and stover as influenced by different treatments during 1987-88.

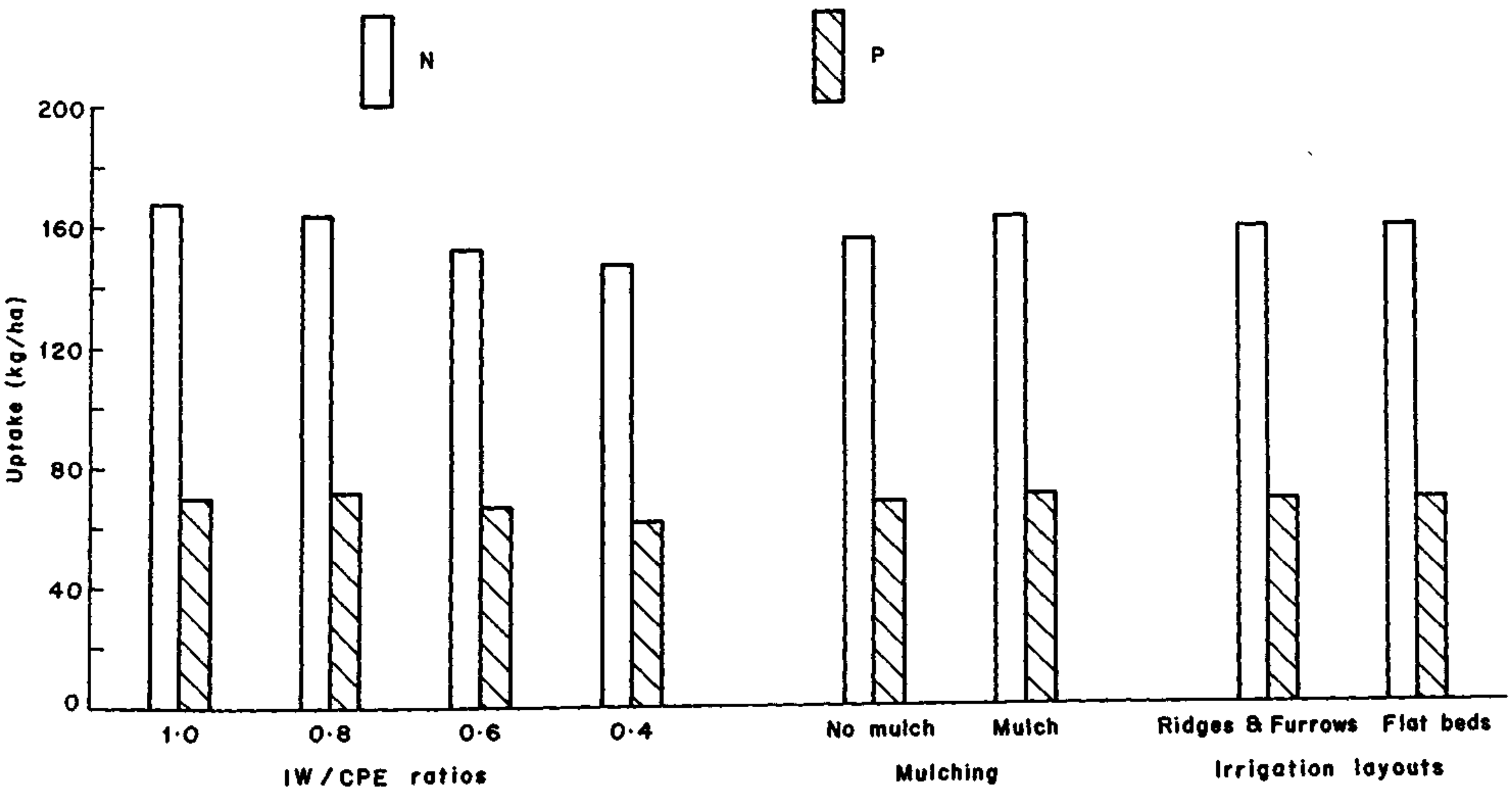


Fig. 16. Pooled total uptake of nitrogen and phosphorus (kg/ha) as influenced by various treatments.

Irrigation scheduling

The irrigation scheduled at 0.8 and 1.0 IW/CPE ratios significantly increased N uptake by grains as compared to 0.4 and 0.6 IW/CPE ratios during both the years, except 0.6 and 0.8 IW/CPE ratios were on par during 1987-88. Irrigation scheduled at 0.6 IW/CPE ratio also significantly increased N uptake by grains over 0.4 IW/CPE ratio durning both the years of study.

Mulching

No significant differences in N uptake by grain due to mulching as compared to no mulching were observed in both the seasons. However, N uptake was slightly higher with mulching.

Irrigation layouts

The N uptake by grain was not influenced significantly by any of the irrigation layouts in 1986-87 and 1987-88.

4.7.1.2 N uptake by stover

Irrigation scheduling

The N uptake by stover was not significantly influenced during both the seasons of experimentation. However, it was gradually increased with increasing number of irrigations.

Mulching

Application of mulch had not shown significant difference on N uptake by stover in 1986-87 and 1987-88 as compared to no mulch.

Irrigation layouts

Planting of maize either on ridges and furrows or on flat beds had not shown any significant difference on N uptake by stover in both the seasons.

Interaction

Interaction effects were found to be absent.

4.7.1.3 Total N uptake

Irrigation scheduling

Irrigation scheduled at 0.8 and 1.00 IW/CPE ratios significantly increased total N uptake as compared to 0.4 and 0.6 IW/CPE ratios during both the years and in pooled data, except 0.6 and 0.8 IW/CPE ratios which were on par during 1987-88 and 0.4 and 0.6 IW/CPE ratios were on par during 1986-87.

Mulching

The total N uptake was increased significantly due to mulching in 1986-87 and when data were pooled, over no mulching. In 1987-88, the differences in total N uptake were nonsignificant with and without mulching, though mulch had shown higher N uptake values.

Irrigation layouts

The total N uptake was not significantly influenced during both the years and when data were pooled.

4.7.2 P uptake

Data regarding P uptake by maize grain, stover and total as influenced by various treatments are presented in Table 29.

It is observed from the data presented in Table 29 that the mean uptake of P by grain, stover and total was 41.54, 32,52 and 73.10 kg/ha in 1986-87 and 35.72 , 27.88 and 63.67 kg/ha in 1987-88, respectively.

4.7.2.1 P uptake by grain

Irrigation scheduling

The P uptake was not significantly affected due to different IW/CPE ratios. However, it was progressively increased with increased IW/CPE ratios upto 0.8 IW/CPE ratio.

Mulching

P uptake by grains was not significantly influenced due to mulching during both the years of study.

Irrigation layouts

Different irrigation layouts did not show any significant differences in P uptake by grains during both the years of experimentation.

Interaction

Interaction effects were found to be non significant.

4.7.2.2 P uptake by stover

Irrigation scheduling

The scheduling of irrigation at 0.8 and 1.0 IW/CPE ratios significantly increased P uptake by stover as compared to 0.4 and 0.6 IW/CPE ratios during both the years, except 0.6 and 0.8 IW/CPE ratios were found to be on par during 1986-87.

Mulching

The P uptake by stover was not significantly influenced due to mulching during both the years.

Irrigation layouts

The different irrigation layouts did not show any significant influence on P uptake by stover during both the years.

Interaction

Interaction effects were found to be absent.

4.7.2.3 Total P uptake

Irrigation scheduling

The total P uptake was not significantly influenced during both the years. However, it was progressively increased with increased IW/CPE ratios upto 0.8 during both the years. Irrigation scheduled at 0.8 and 1.0 IW/CPE ratios significantly increased total P uptake as compared to 0.4 IW/CPE ratio, when data were pooled over season.

Mulching

Mulching did not show any significant difference on total P uptake during both the years of experimentaion.

Irrigation layouts

The total P uptake was not significantly affected due to different layouts during both the years.

Interaction

Interaction effects between different factors under study were found to be nonsignificant.

4.8 Quality study

Data regarding the mean protein content in maize grain and stover, protein production by grain and stover, total protein production and protein production efficiency as affected by various treatments are presented in Table 30 and depicted in Fig. 17 and 18.

4.8.1.1 Protein content

Data presented in Table 30 reveals that the protein content in maize grain and stover was 10.77 and 6.67 per cent during 1986-87 and 10.46 and 6.04 per cent during 1987-88, respectively.

Irrigation scheduling

The percentage of protein in maize grains and stover was increased with decrease in the IW/CPE ratios during both

Table 30. Mean protein content, protein production and protein production efficiency of maize as affected by various treatments

Treatment	1986-87						1987-88					
	Protein per cent		Protein production			Protein Production efficiency (kg/ha/day)	protein per cent		Protein production			Protein Production efficiency (kg/ha/day)
	Grain	Stover	Grain (q/ha)	Stover (q/ha)	Total (q/ha)		Grain	Stover	Grain (q/ha)	Stover (q/ha)	Total (q/ha)	
Irrigation scheduling (IW/CPE ratios)												
1.0	10.65	6.49	5.95	5.63	11.58	8.57	10.39	5.95	5.19	4.32	9.51	6.94
0.8	10.73	6.53	5.77	5.47	11.18	8.28	10.45	5.92	5.05	4.22	9.27	6.77
0.6	10.84	6.71	5.18	5.19	10.37	7.68	10.45	6.05	4.70	4.13	8.89	6.49
0.4	10.05	5.94	4.80	5.22	10.03	7.43	10.53	6.24	4.25	4.13	8.39	6.12
S.E. ±	0.18	0.13	0.10	0.10	0.17	0.12	0.33	0.18	0.17	0.12	0.19	0.14
C.D. at 5%	-	-	0.31	0.34	0.54	0.40	-	-	0.54	-	0.60	0.44
Mulching												
No mulch	10.65	6.64	5.28	5.22	10.50	7.78	10.49	6.01	4.76	4.13	8.92	6.51
Mulch	10.89	6.70	5.57	5.54	11.08	8.21	10.42	6.06	4.84	4.27	9.11	6.65
S.E. ±	0.18	0.11	0.11	0.11	0.14	0.10	0.21	0.10	0.11	0.08	0.14	0.10
C.D. at 5%	-	-	-	0.31	0.40	0.29	-	-	-	-	-	-
Irrigation layouts												
Ridges and furrows	10.64	6.68	5.37	5.31	10.65	7.89	10.49	6.06	4.82	4.25	9.09	6.64
Flat beds	10.90	6.65	5.48	5.45	10.93	8.09	10.42	6.01	4.79	4.16	8.94	6.52
S.E. ±	0.18	0.11	0.11	0.11	0.14	0.10	0.21	0.10	0.11	0.08	0.14	0.10
C.D. at 5%	-	-	-	-	-	-	-	-	-	-	-	-
General mean	10.77	6.67	5.43	5.38	10.79	7.99	10.46	6.04	4.80	4.20	9.02	6.58

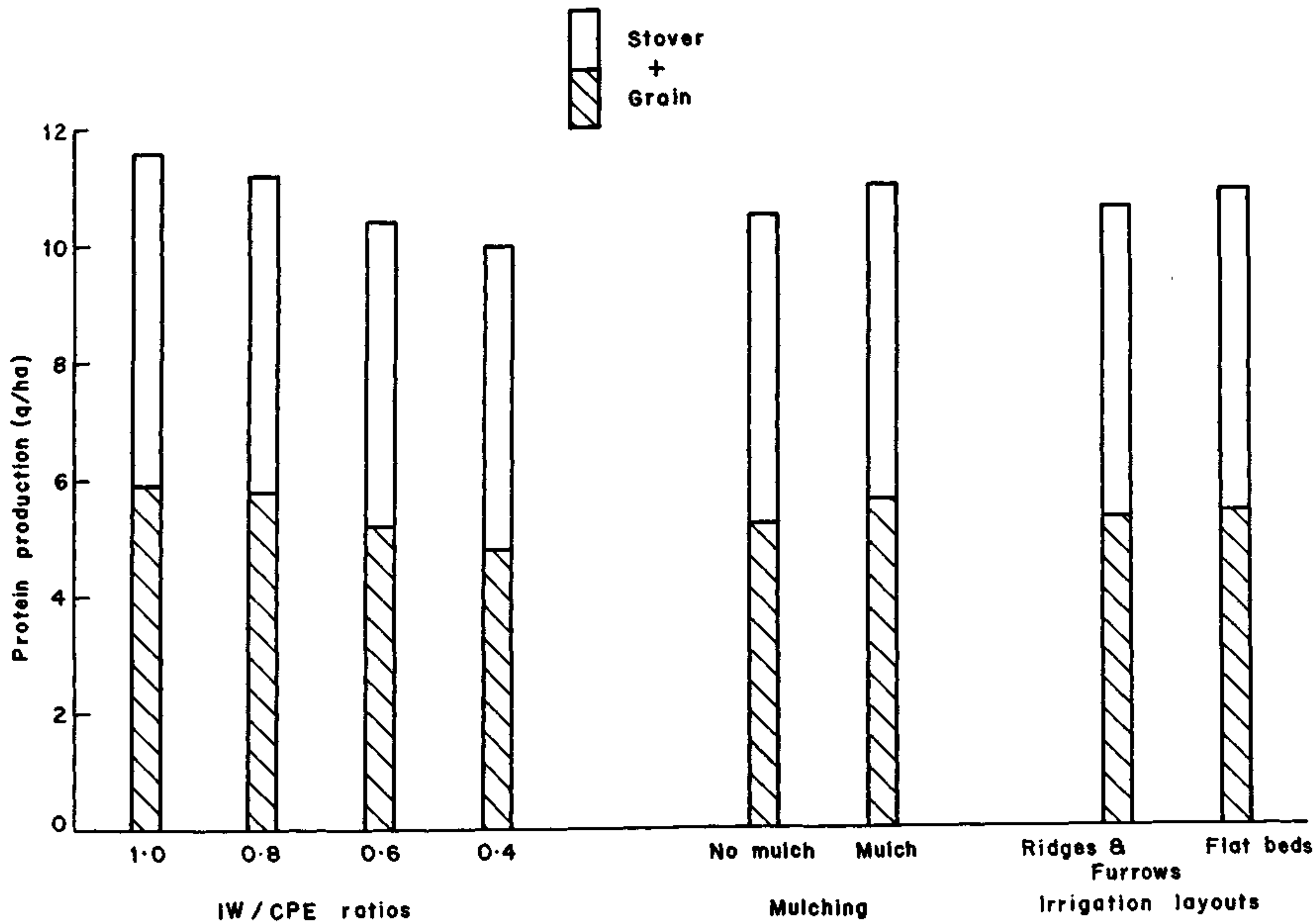


Fig. 17. Mean protein production (q/ha) of maize as affected by various treatments during 1986-87.

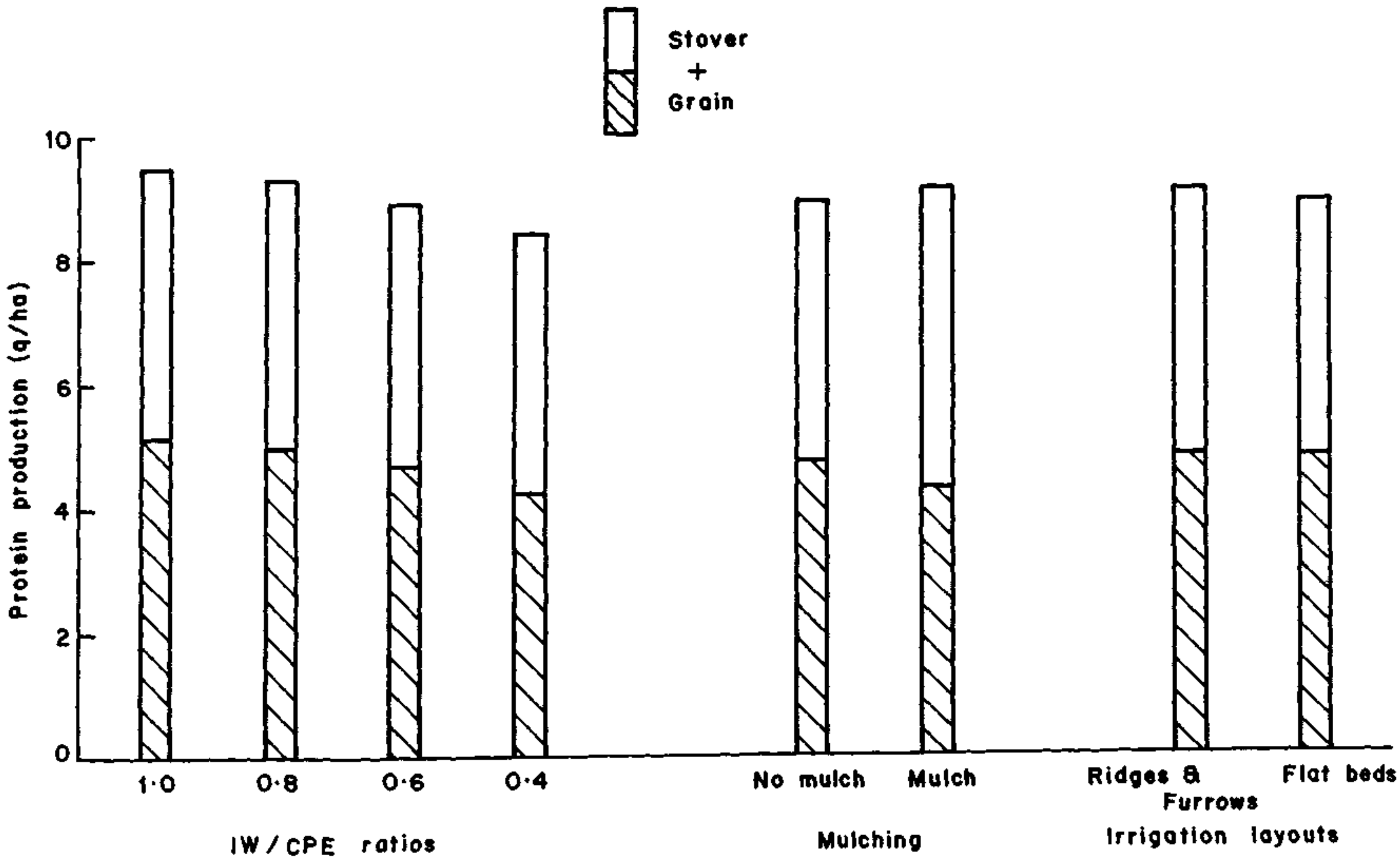


Fig. 18. Mean protein production (q/ha) of maize as affected by various treatments during 1987-88.

the seasons. However, it had not attained the level of significance.

Mulching

No significant differences in protein per cent in grains and stover during both the seasons were observed due to mulching.

Irrigation layouts

The protein content in maize grain and stover was not influenced significantly either due to planting on ridges and furrows or on flat beds in both the seasons.

Interaction

Interaction effects were observed to be non significant.

4.8.2 Protein production

The mean protein production by maize grain, stover and total protein production was 5.43, 5.38 and 10.79 q/ha during 1986-87 and 4.80, 4.20 and 9.02 q/ha during 1987-88, respectively.

Irrigation scheduling

Irrigation scheduled at 1.00 IW/CPE ratio significantly increased protein production by grain, stover and total protein production over 0.4 and 0.6 IW/CPE ratios during both the years, except protein production by grain and stover during 1987-88. Irrigation scheduled at 0.8 IW/CPE ratio also significantly influenced protein production by grain and total protein production over 0.4 and 0.6 IW/CPE ratios during both the years, except 0.6

and 0.8 IW/CPE ratios were on par during 1987-88. The protein production by grain was also significantly more due to irrigation scheduled at 0.6 IW/CPE ratio than 0.4 IW/CPE ratio during 1986-87.

Mulching

The protein production was not significantly influenced during 1987-88. However, protein production by stover and total protein production was significantly more under mulch treatment than no mulch during 1986-87.

Irrigation layouts

The protein production was not affected significantly due to different irrigation layouts during both the years of experimentation.

Interaction

Interaction effects between different factors under study were not present.

4.8.3 Protein production efficiency

Data presented in Table 30 reveals that the mean protein production efficiency was 7.99 and 6.58 kg/ha/day during 1986-87 and 1987-88, respectively.

Irrigation scheduling

Irrigation scheduled at 0.8 and 1.0 IW/CPE ratios significantly increased protein production efficiency as compared to 0.4 and

0.6 IW/CPE ratios during both the years of experimentation, except 0.6 and 0.8 IW/CPE ratios were on par during 1987-88.

Mulching

The protein production efficiency was significantly more with the mulching than no mulching in 1986-87. However, in 1987-88 the protein production efficiency was not influenced significantly due to mulching.

Irrigation layouts

The irrigation layouts did not influence significantly the protein production efficiency during both the seasons.

Interaction

Interaction effects were found to be absent.

4.9 Correlation study in maize

Data regarding correlation coefficient between grain yield (g)/plant and important growth and yield contributing characters in maize are presented in Table 31 and 32 and correlation coefficient between grain yield of maize (q/ha), consumptive use and water use efficiency are presented in Table 33. Data presented in Table 33 shows that the yield components viz dry matter/plant, cob length and grain number/row were positively and highly significantly correlated, whereas cob girth, grain rows/cob and test weight were significantly correlated with grain yield/plant during 1986-87. All the yield components were either highly significantly or

Table 31. Correlation coefficient (r) between grain yield (g) per plant and yield c
1986-87

Character	Grain wt(g)/ plant	Plant ht (cm)	Leaf area (dm²)	Dry matter (g)/ plant	Cob No./ plant	Cob length (cm)	Cob girth (cm)	Grain rows/ cob	(row		
Grain wt. (g)/ plant	1.00	0.39	0.46	0.56**	0.39	0.68**	0.50*	0.53*	0.74**	0.43	0.57*
Plant ht. (cm)		1.00	0.63**	0.82**	0.73**	0.76**	0.76**	0.79**	0.73**	0.80**	0.85**
Leaf area (dm²)			1.00	0.90**	0.53*	0.82**	0.88**	0.93**	0.71**	0.82**	0.84**
Dry matter (g)/ plant				1.00	0.63**	0.96**	0.95**	0.96**	0.82**	0.90**	0.94**
Cob No./ plant					1.00	0.60*	0.63**	0.66**	0.49*	0.62**	0.62**
Cob length (cm)						1.00	0.89**	0.93***	0.34	0.86**	0.90**
Cob girth (cm)							1.00	0.91**	0.82**	0.86**	0.92**
Grain rows/ cob								1.00	0.80**	0.92**	0.89**
Grain No./row									1.00	0.86**	0.82**
Grain No./cob										1.00	0.89**
Test wt.(g)											1.00

* Significant ** Highly significant.

Table 32. Correlation coefficient (r) between grain yield (g) per plant and yield components in maize 1987-88.

Character	Grain wt(g)/ plant	Plant ht. (cm)	Leaf area (dm^2)	Dry matter (g)/ plant	Cob No./ plant	Cob length (cm)	Cob girth (cm)	Grain rows/ cob	Grain No./ row	Grain No./ cob	Test wt (g)
Grain wt. (g)/ plant	1.00	0.78**	0.80**	0.92**	0.31	0.86**	0.80**	0.68**	0.76**	0.87**	0.96**
Plant ht. (cm)		1.00	0.45	0.78**	0.45	0.65**	0.59*	0.30	0.64**	0.54*	0.80**
Leaf area(dm^2)			1.00	0.70**	-0.11	0.66**	0.79**	0.85**	0.35	0.83**	0.62**
Dry matter (g)/plant				1.00	0.48	0.87**	0.72**	0.58*	0.70**	0.77**	0.89**
Cob No./ plant					1.00	0.42	-0.005	-0.25	0.37	0.03	0.43
Cob length (cm)						1.00	0.85**	0.62*	0.73**	0.76**	0.83**
Cob girth (cm)							1.00	0.76**	0.63**	0.78**	0.72**
Grain rows/ cob								1.00	0.33	0.88**	0.54*
Grain No./ row									1.00	0.55*	0.84**
Grain No./ cob										1.00	0.77**
Test wt.(g)											1.00

* Significant ** Highly significant

significantly correlated among themselves, except cob length, grain number/row, grain weight/plant with plant height, leaf area/plant, cob number/plant and grain number/cob.

The growth and yield contributing characters viz plant height, leaf area/plant, dry matter/plant, cob length, cob girth, grain rows/cob, grain numbers/cob and thousand grain weight, were positively and highly significantly correlated to the grain weight/plant, during 1987-88 (Table 32). Most of the yield components were either significantly or highly significantly correlated among themselves during 1987-88. There was a weak correlation between cob number/plant and other characters and it was negatively correlated with leaf area/plant, cob girth and grain rows/cob.

The data presented in Table 33 shows that the consumptive use of water was positively and highly correlated with grain yield whereas water use efficiency was negatively and highly significantly correlated with grain yield during both the years

Highly significant negative correlation was also observed between consumptive use and water use efficiency in both the years.

Table 33 : Correlation coefficient (r) between grain yield, consumptive use and water use efficiency

Character	Grain yield (q/ha)	Consumptive use (mm)	Water use efficiency (kg/ha/mm)
	1986-87		
Grain yield (q/ha)	1.00	0.95 **	- 0.84 **
consumptive use (mm)		1.00	- 0.95 **
Water use efficiency (kg/ha/mm)			1.00
	1987-88		
Grain yield (q/ha)	1.00	0.97**	- 0.96 **
Consumptive use (mm)		1.00	- 0.99 **
Water use efficiency (kg/ha/mm)			1.00

** Highly significant

4.10 Energy balance

Data pertaining to energy input, energy output, energy balance, balance per unit of input and energy use efficiency as incluenced by various treatments are presented in Table 34.

4.10.1 Energy input

The mean energy inputs were 23.36, 23.14 and 23.25

Table 34. Energy balance sheet in maize as influenced by different treatment.

Treatment	1986-87 G calory/ha					1987-88 G calory/ha					Mean G calory/ha				
	Energy input	Energy output	Balance	Balance /unit input	Energy use effici-ency	Energy input	Energy output	Balance	Balance /unit input	Energy use effici-ency	Energy input	Energy output	Balance	Balance /unit input	Energy use effici-ency
Irrigation scheduling (IW/CPE ratios)															
1.0	24.11	19.43	-4.68	-0.19	0.81	23.78	17.43	-6.35	-0.26	0.73	23.95	18.43	-5.52	-0.23	0.77
0.8	23.68	18.80	-4.88	-0.21	0.79	23.76	16.64	-6.72	-0.28	0.71	23.52	17.72	-5.80	-0.25	0.75
0.6	23.26	16.69	-6.58	-0.28	0.72	22.93	15.91	-7.03	-0.30	0.69	23.09	16.31	-6.78	-0.29	0.71
0.4	22.40	15.48	-6.92	-0.31	0.69	22.50	14.10	-8.40	-0.37	0.63	22.46	14.79	-7.67	-0.34	0.66
Mulching															
No mulch	14.21	17.32	3.11	0.22	1.22	13.99	15.92	1.93	0.14	1.14	14.10	16.62	2.52	0.18	1.18
Mulch	32.51	17.88	-14.63	-0.45	0.55	32.29	16.13	-16.16	-0.50	0.50	32.40	17.00	-15.40	-0.48	0.52
Irrigation layouts															
Ridges and furrows	23.44	17.68	-5.76	-0.25	0.75	23.22	16.06	-7.16	-0.31	0.69	23.33	16.87	-6.46	-0.28	0.72
Flat beds	23.29	17.53	-6.16	-0.26	0.75	23.07	15.98	-7.09	0.31	0.69	23.18	16.75	-6.43	-0.28	0.72
General mean	**23.36**	**17.60**	**-5.76**	**-0.25**	**0.75**	**23.14**	**16.02**	**-7.12**	**-0.31**	**0.69**	**23.25**	**16.81**	**-6.44**	**-0.28**	**0.72**

G calories/ha in 1986-87, 1987-88 and in mean data, respectively.

Irrigation scheduling

The energy inputs were maximum with irrigation scheduling at 1.0 IW/CPE ratio and were slightly decreased with decrease in IW/CPE ratio in both the seasons and in mean data.

Mulching

Mulching with sugarcane trash required comparatively double energy inputs than no mulching in both the seasons and in mean data.

Irrigation layouts

Energy inputs were slightly more with planting on ridges and furrows than with flat beds in 1986-87, 1987-88 and in mean data.

4.10.2 Energy output

The data presented in Table 34 reveals that the mean energy outputs were 17.60, 16.02 and 16.81 G calories/ha in 1986-87, 1987-88 and in mean data, respectively.

Irrigation scheduling

The energy output was gradually decreased with decrease in the IW/CPE ratios during both the years and in mean data.

Mulching

The energy output was slightly more with mulching as compared to no mulching during both the seasons and in the mean data.

Irrigation layouts

Planting on ridges and furrows produced comparatively more energy than planting on flat beds in 1986-87, 1987-88 and in mean data.

4.10.3 Energy balance

The mean energy balance was -5.76, -7.12 and -6.44 G calories/ha during 1986-87, 1987-88 and in mean data, respectively.

Irrigation scheduling

The energy balance was negative with the irrigation scheduling at all the IW/CPE ratios in both the seasons and in mean data. Further, the energy balance was negatively increased with decrease in the IW/CPE ratios.

Mulching

Energy balance was positive with no mulching in both the seasons of study and in mean data. However, it was negative with mulching during both the years and in mean data.

Irrigation layouts

The energy balance was negative under different irrigation layouts during both the seasons and in mean data.

4.10.4 Energy balance per unit input and energy use efficiency

The mean energy balance per unit input was -0.25, -0.31 and 0.28, while the energy use efficiency was 0.75, 0.69 and 0.72 during 1986-87, 1987-88 and in mean data, respectively.

Irrigation scheduling

The energy balance and energy use efficiency were progressively increased with the increase in the IW/CPE ratios during both the years and in mean data.

Mulching

The positive energy balance per unit input was observed with no mulch treatment in 1986-87, 1987-88 and in mean data, while there was negative energy balance per unit of input in both the seasons and in mean data. The energy use efficiency was higher with no mulch as compared to mulching during both the years.

Irrigation layouts

The energy balance per unit of input was negative and almost same with ridges and furrows and flat bed layouts during both the seasons and in mean data. No difference was observed in energy use efficiency under different irrigation layouts.

4.11 Soil moisture studies

The data regarding cumulative pan evaporation values, number of irrigations, interval between successive irrigation turns and average irrigation interval for each IW/CPE ratio are presented in Table 35.

Data presented in Table 35 shows that the number of irrigations in 1986-87 were 6, 5, 4 and 2 and in 1987-88 were 4, 3, 2 and 1 for 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios, respectively. The interval between two successive irrigations ranged between 14 to 16 and 13 to 27 days for 1.0 IW/CPE ratio; 18 to 19 & 18 to 30 days for 0.8 IW/CPE ratio, 22 to 26 and 27 to 54 days for 0.6 IW/CPE ratio and 36 to 37 and 67 days for 0.4 IW/CPE ratio during 1986-87 and 1987-88, respectively. The average interval upto last irrigation was 14.66, 18.20, 24 and 36.50 in 1986-87 and 22.00, 28.33, 40.50 and 67.00 days in 1987-88 with 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios, respectively. The average interval during second year of study was higher as compared to first year.

4.11.1 Soil Moisture percentage

Data regarding soil moisture percentage for the two soil layers viz 0-30 and 30-60 cm just before and 48 hours after the application of irrigation are presented in Table 36 and 37 for the year 1986-87 and 1987-88, respectively.

The data on soil moisture percentage were not statistically analysed, as the soil samples for the moisture determination were taken on different dates according to the irrigation schedule based on the IW/CPE ratios.

able 35. Number of irrigations, interval between successive irrigations turns and average interval as per the IW/CPE ratic

rigation heduling /CPE tio]	Number of irrigations [Excluding post sowing common irrigation.	Interval between successive irrigation turns (days)						Period from last irriga- tion to har- vest in days	Average interval upto har- vest in days	Average interval upto last irrigation in days
		A	B	C	D	E	F			
					1986-87					
1.0	6	15	14	14	16	14	15	32	17.14	14.66
0.8	5	18	18	18	19	18	-	29	20.16	18.20
0.6	4	25	23	26	22	-	-	24	24.00	24.00
0.4	2	36	37	-	-	-	-	47	40.00	36.50
					1987-88					
1.0	4	27	32	16	13	-	-	34	24.40	22.00
0.8	3	30	37	18	-	-	-	37	30.50	28.33
0.6	2	54	27	-	-	-	-	42	40.66	40.50
0.4	1	67	-	-	-	-	-	55	61.00	67.00

Table 36. Soil moisture percentages at various soil depths of sowing before and 48 hours after irrigation and at harvest under different IW/CPE ratios during 1986-87

IW/CPE ratios	Sowing depth (cm)	At sowing	Common		First		Second		Third		Fourth		Fifth		Sixth		At Harvest
			B	A	B	A	B	A	B	A	B	A	B	A	B	A	
1.0	0-30	32.40	29.12	35.30	24.82	35.46	25.03	35.33	25.42	35.51	24.98	35.26	25.20	35.26	25.10	34.07	25.47
	30-60	33.15	32.11	35.60	32.90	35.53	32.16	35.36	32.78	35.61	32.25	35.43	32.25	35.33	32.21	34.11	29.12
	0-60	32.77	30.61	35.45	28.86	35.50	28.59	35.34	29.10	35.56	28.61	35.34	28.72	35.29	28.65	34.09	27.29
0.8	0-30	32.40	29.12	35.30	25.06	35.42	25.08	35.31	25.10	35.37	25.13	35.36	25.06	33.62			25.20
	30-60	33.15	32.02	35.60	32.11	35.51	32.17	35.30	32.17	35.61	32.35	35.76	32.61	34.36			29.50
	0-60	32.77	30.57	35.45	28.58	35.46	28.62	35.30	28.63	35.49	28.74	35.56	28.83	33.99			27.35
0.6	0-30	32.41	29.08	35.75	25.10	35.57	25.08	35.63	25.08	35.42	25.05	33.55					25.40
	30-60	33.15	32.16	35.91	32.37	35.65	32.20	35.70	32.16	35.50	32.20	33.66					29.37
	0-60	32.78	30.62	35.83	28.73	35.61	28.64	35.66	28.62	35.46	28.62	33.60					27.38
0.4	0-30	32.35	29.13	35.68	24.93	35.67	25.26	34.77									24.90
	30-60	33.17	32.10	35.67	31.92	35.65	31.87	32.86									28.31
	0-60	32.76	30.61	35.67	28.42	35.66	28.56	33.81									26.60

B - Before A- After

Table 37. Soil moisture percentages at various soil depths of sowing before and 48 hours after irrigation and at harvest under different IW/CPE ratios during 1987-88

IW/CPE ratios	Sowing depth (cm)	At Sowing	Common		First		Second		Third		Fourth		At Harvest
			B	A	B	A	B	A	B	A	B	A	
1.0	0-30	32.65	25.22	35.27	25.47	35.37	25.35	35.45	25.08	35.23	25.22	35.35	25.00
	30-60	33.10	30.87	35.67	32.57	35.43	32.07	35.43	32.17	35.47	32.17	35.47	32.07
	0-60	32.87	28.04	35.47	29.02	35.40	28.71	35.44	28.62	35.35	28.69	35.41	28.53
0.8	0-30	32.62	25.13	35.26	25.46	35.33	25.21	35.28	25.32	35.22			24.70
	30-60	33.13	30.67	35.60	32.13	35.45	32.07	35.30	32.32	35.22			32.30
	0-60	32.87	27.90	35.43	28.79	35.39	28.64	35.29	28.82	35.22			28.50
0.6	0-30	32.70	26.10	35.25	26.36	35.33	25.35	35.41					25.20
	30-60	33.30	30.85	35.57	32.41	35.37	32.26	35.17					32.02
	0-60	33.00	28.47	35.41	29.38	35.35	28.80	35.29					28.61
0.4	0-30	32.62	25.13	35.25	24.92	32.23							25.51
	30-60	33.12	30.82	35.66	32.20	30.37							27.07
	0-60	32.87	27.97	35.45	28.56	31.30							26.29

B - Before A - After

Data presented in Table 36 indicate that during 1986-87, the soil moisture percentage determined just before irrigation (ex cluding common irrigation) in 0-60 cm layer ranged from 28.59 to 29.10, 28.58 to 28.83, 28.62 to 28.73 and 28.56 to 28.42 per cent for 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios, respectively. The soil moisture content at sowing was 32.77, 32.77, 32.78 and 32.76 for 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios, respectively, while at harvest it was 27.29 27.35, 27.38 and 26.60 per cent.

The soil moisture content in 0-60 cm soil depth determined after 48 hours of irrigation, ranged from 34.09 to 35.56, 33.99 to 35.56, 33.60 to 35.66 and 33.81 to 35.66% for 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios, respectively.

In 1987-88 the soil moisture percentage determined just before irrigation (excluding common irrigation) in 0-60 cm layer ranged from 28.69 to 29.02, 28.64 to 28.79, 28.80 to 29.38% for 1.0, 0.8, and 0.6 IW/CPE ratios, respectively, while it was 28.56 per cent for 0.4 IW/CPE ratio (Table 37). The soil moisture percentage at sowing was 32.87, for 1.0 and 0.8 IW/CPE ratios, 33.00 and 32.87 per cent for 0.6 and 0.4 IW/CPE ratios, respectively, while it was 28.53, 28.50, 23.61 and 26.29 per cent for 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios, respectively, at harvest.

The soil moisture content in 0-60 cm depth after 48 hours of irrigation was between 35.44 to 35.35, 35.22 to 35.39 and 35.29 to 35.35% for 1.0, 0.8 and 0.6 IW/CPE ratios, respectively, while it was 31.30 for 0.4 IW/CPE ratio. Thus, it is evident from the data that the soil moisture percentage in 0-60 cm depth of soil 48 hours after irrigation was almost equal to the field capacity of soil which was 36.50 per cent.

4.11.2 Consumptive use of water

The consumptive use of water was computed by summing up the i) soil moisture extracted by the crop from the profile depth (d) ii) Potential evapotranspiration (PET) during 48 hours immediately after each irrigation and iii) effective rainfall.

The contribution of each of the above stated components in the build up of the consumptive use was worked out and the data are presented in Table 38 and 39 for the year 1986-87 and 1987-88, respectively.

4.11.2.1 Soil moisture extracted by the crop

The data on soil moisture extracted by the maize crop from the 0-60 cm soil profile indicates that, from common irrigation to last irrigation, in each irrigation interval, the moisture used by the crop from a particular soil layer was more or less same in the individual treatment in each year. The soil moisture used by the maize crop from 0-30 cm soil layer varied from 30.60 to 35.67, 34.53 to 35.04, 34.84 to 35.76 and 35.29 to 37.94 mm in 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios, respectively during the interval of two successive irrigation in 1986-87. In 1987-88, these values varied from 33.21 to 35.10, 33.21 to 34.32

for 1.0 and 0.8 IW/CPE ratios and 33.51 to 33.68 for 0.6 IW/CPE ratio and it was 34.99 mm for 0.4 IW/CPE ratio.

The soil moisture extracted by the maize crop from 30-60 cm soil layer in 1986-87 varied from 9.03 to 12.06 10.96 to 12.23, 11.62 to 12.41 and 13.10 to 13.15 mm for 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios, respectively. In 1987-88 these values were 10.87 to 11.71, 10.56 to 12.15, 11.09 to 11.53 for 1.0, 0.8 and 0.6 IW/CPE ratios, respectively, while it was 12.14 mm fro 0.4 IW/CPE value.

The soil moisture extracted by the maize crop from 0-30 and 30-60 cm soil layer was summed up together and the values for 0-60 cm layer were computed. Thus, the values for 0-60 cm layer ranged between 52.95 to 58.27, 45.49 to 47.22 46.79 to 48.17 and 58.13 to 58.40 for 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios, respectively during 1986-87. These values varied from 44.08 to 46.55, 43.36 to 46.06, 44.78 to 45.04 mm for 1.0, 0.8 and 0.6 IW/CPE ratios, respectively and 47.14 mm for 0.4 IW/CPE ratio in 1987-88.

The layerwise quantum of mean soil moisture extracted by the maize crop during the period of 2 successive irrigations was also calculated for both the seasons. These values for 0-30 cm layer were 34.77, 34.83, 35.24 and 36.61 mm with 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios, respectively, during 1986-87, while the corresponding values, during 1987-88 were 34.05, 33.63, 33.59 and 34.99 mm, respectively. The values of mean soil moisture extracted by the crop during 1986-87 from 30-60 cm soil layer were 11.14, 11.39, 12.10 and 13.12 mm and in 1987-88 were 11.34, 11.48, 11.31 and 12.14 mm for 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios, respectively.

The layerwise total soil moisture used by the crop from sowing to harvest as workedout in Table 38 and 39 are also presented in Table 40 and depicted in Fig. 19. The layerwise contribution is also expressed in percentages. Data presented in Table 40 reveals that the percentages of soil moisture extracted by the maize crop from 0-30 cm layer were decreased with increase in IW/CPE ratios in 1986-87, while it showed a reverse trend with 30-60 cm layer. In 1987-88, 1.0, 0.8 and 0.6 IW/CPE ratios has extracted more or less same quantity of water from 0-30 cm and 30-60 cm layer, while in 0.4 IW/CPE ratio the values for 0-30 cm were lower and with 30-60 cm layers were higher.

4.11.2.2 Potential Evapotranspiration (PET)

The total number of irrigations applied in 1986-87 were 6, 5, 4 and 2 and in 1987-88 4, 3, 2 and 1 with scheduling of irrigation at 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios, respectively. The PET values were 74.78, 65.52, 57.76 and 32.60 mm with 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios during 1986-87 and corresponding values during 1987-88 were 58.00, 50.40, 37.68 and 27.68 mm. Thus, the PET values were increased with increase in the IW/CPE ratios.

Table 38. Periodical layerwise and total consumptive use (mm) for rabi maize at different treatments in 1986-87

Irrigation interval between	1.0 IW/CPE ratio						0.8 IW/CPE ratio						0.6 IW/CPE ratio						0.4 IW/CPE ratio					
	Soil moisture extracted by crop						Soil moisture extracted by crop						Soil moisture extracted by crop						Soil moisture extracted by crop					
	0-30	30-60	0-60	PET	ER	Total	0-30	30-60	0-60	PET	ER	Total	0-30	30-60	0-60	PET	ER	Total	0-30	30-60	0-60	PET	ER	Total
S-C	11.01	3.80	14.81	7.92	24.32	47.05	11.09	3.94	15.03	7.92	24.32	47.28	11.26	23.46	14.72	7.92	24.32	46.97	10.88	3.75	14.64	7.92	24.32	46.90
C-I	35.50	12.06	47.56	7.04	-	54.60	34.99	12.23	47.22	7.04	-	54.26	35.25	12.41	47.66	7.04	-	54.70	37.94	13.15	51.09	7.04	-	58.13
I-II	35.33	11.84	47.17	10.24	-	47.42	35.04	11.27	46.31	10.64	-	56.95	34.82	11.97	46.80	10.64	-	57.44	35.29	13.10	48.39	10.00	-	58.40
II-III	33.60	9.03	42.63	10.32	-	52.95	34.53	10.96	45.49	10.00	-	55.49	35.76	12.41	48.17	9.52	-	57.69						
III-IV	35.67	11.79	47.47	10.80	-	58.27	34.70	11.44	46.14	8.08	-	54.22	35.16	11.62	46.79	8.64	-	55.43						
IV-V	34.10	11.18	45.28	9.12	-	54.41	34.91	11.05	45.96	8.64	-	54.60												
V-VI	34.44	10.96	45.41	8.64	-	54.05																		
VI/V/IV/II/H	29.15	17.50	46.65	10.40	-	57.05	28.36	17.24	45.60	13.20	-	58.80	27.62	15.04	42.67	14.00	-	56.67	32.88	15.96	48.84	8.64	-	57.48
Mean for successive irrigations.	34.77	11.14	45.58	-	-	-	34.83	11.39	46.22	-	-	-	35.24	12.10	47.35	-	-	-	36.61	13.12	49.74			
Total	248.83	88.19	337.02	74.48	24.32	436.33	214.48	79.11	293.99	65.22	24.32	381.60	179.87	66.91	246.78	57.76	24.32	328.01	116.99	45.96	162.95	33.60	24.32	221.67

Table 39. Periodical layerwise and total consumptive use (mm) for rabi maize at different treatment in 1987-88

Irrigation interval between	1.0 IW/CPE ratio						0.8 IW/CPE ratio						0.6 IW/CPE ratio						0.4 IW/CPE ratio					
	Soil moisture extracted by crop						Soil moisture extracted by crop						Soil moisture extracted by crop						Soil moisture extracted by crop					
	0-30	30-60	0-60	PET	ER	Total	0-30	30-60	0-60	PET	ER	Total	0-30	30-60	0-60	PET	ER	Total	0-30	30-60	0-60	PET	ER	Total
S-C	25.16	7.80	32.17	9.[illegible]	-	42.65	25.38	8.55	33.93	9.68	-	43.61	25.59	7.89	33.48	9.68	-	43.16	25.37	8.06	33.43	9.68	-	43.11
C-1	33.21	10.87	44.08	9.04	45	98.13	33.21	12.15	43.36	9.04	45	99.40	33.51	11.53	45.04	9.04	95	149.08	34.99	12.14	47.14	9.04	95	151.18
I-II	33.97	11.35	45.33	9.84	50	105.17	34.32	11.74	46.06	10.40	50	106.46	33.68	11.09	44.78	8.32	-	53.10						
II-III	35.10	11.44	46.55	7.76	-	54.51	35.37	10.56	44.33	8.96	-	53.29												
III-IV	33.95	11.71	45.66	9.44	-	55.01																		
IV/III/II/I/H	35.08	11.93	47.01	12.24	-	59.15	35.67	10.26	45.93	12.32	-	58.25	34.61	11.05	45.67	10.64	-	56.31	22.70	11.62	34.32	8.96	-	43.28
Mean for successive irrigations	34.05	11.34	45.40	-	-	-	33.63	11.48	44.58	-	-	-	33.59	11.31	-	-	-	-	34.99	12.14	47.14	-	-	-
Total	196.47	65.10	261.57	58.00	95	414.41	161.35	53.26	215.61	50.40	95	361.22	127.39	41.56	168.95	37.68	95	301.86	83.06	31.62	114.69	27.68	95	237.56

Table 40. Total soil moisture use in mm per cent as influenced by various IW/CPE values in 1986-87 - 1987-88

Irrigation treatment	Depth of soil layer (cm)	Total soil moisture use (mm)			
		1986-87		1987-88	
1.0	0-30	248.83	(73.83)	196.47	(75.11)
IW/CPE	30-60	88.19	(26.17)	65.10	(24.89)
ratio	0-60	337.02	(100.00)	261.57	(100.00)
0.6	0-30	214.48	(73.05)	161.95	(75.29)
IW/CPE	30-60	79.11	(26.95)	53.26	(24.71)
ratio	0-60	293.59	(100.00)	215.61	(100.00)
0.6	0-30	179.87	(72.88)	127.39	(75.40)
IW/CPE	30-60	66.91	(27.12)	41.56	(24.60)
ratio	0-60	246.78	(100.00)	168.95	(100.00)
0.4	0-30	116.99	(71.79)	83.06	(72.30)
IW/CPE	30-60	45.96	(28.21)	31.82	(27.70)
ratio	0-60	162.95	(100.00)	114.89	(100.00)

Figures in parenthesis indicate the percentage

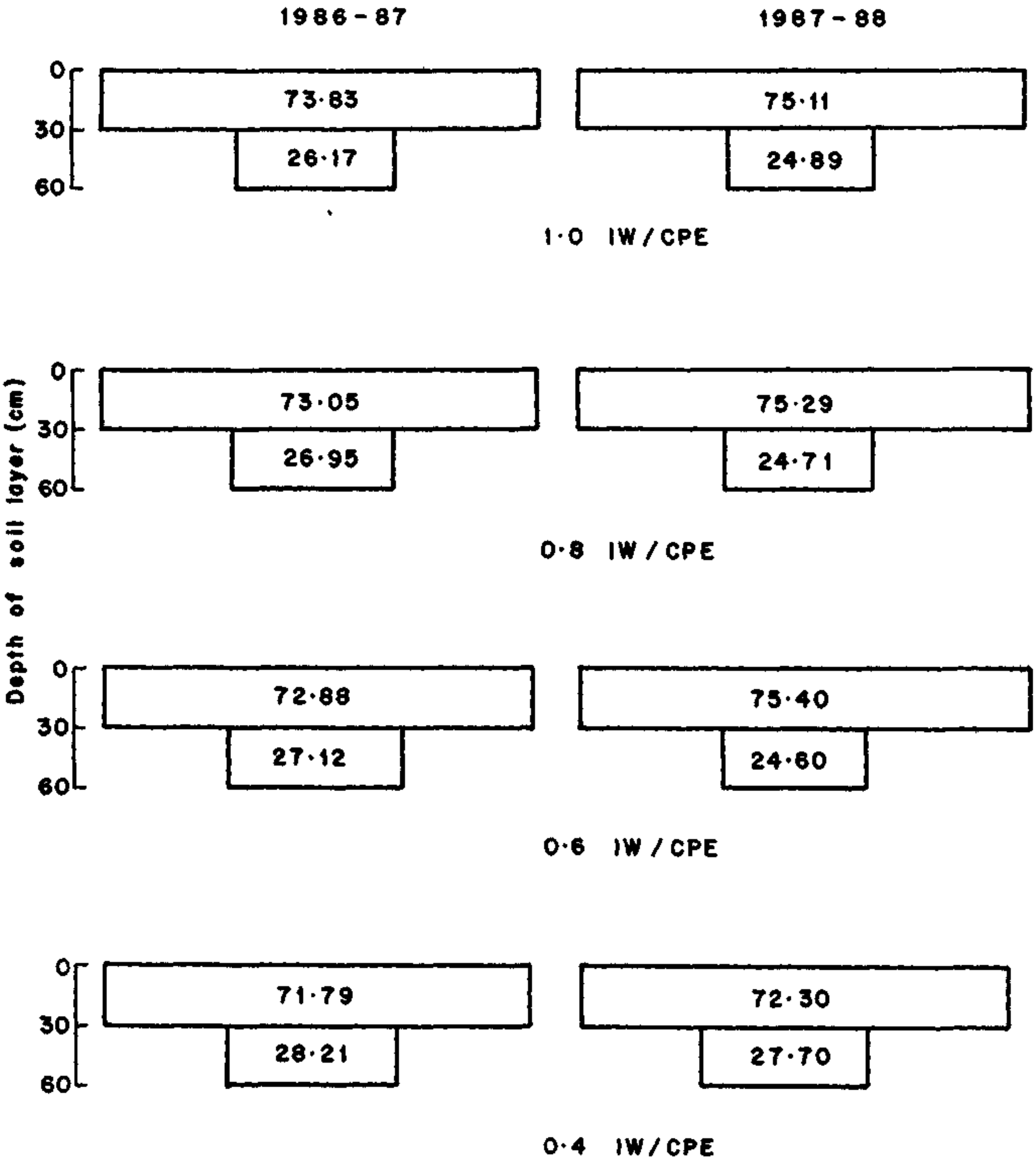


Fig. 19 . Soil moisture extraction in percentages as influenced by irrigation scheduling .

4.11.2.3 Effective Rainfall (ER)

Data presented in Table 3 and 4 indicates that the total quantum of rainfall received during 1986-87 was 110.4 mm and in 1987-88 was 143.8 mm. This rainfall reduced the irrigation requirement of maize. Though the quantum of total rainfall for all the irrigation treatments was same viz 110.4 mm in 1986-87 and 143.8 mm in 1987-88, the effective rainfall was not observed to be equal for all the IW/CPE ratios. It is clear that the fraction of total rainfall had formed a part of consumptive use in different irrigation treatments was not uniform in all the IW/CPE ratios.

4.11.2.4 Consumptive use, pan evaporation and relative evaporanspiration rate

Data on consumptive use of water, pan evaporation and relative evapotranspiration rate for the each successive irrigation interval are presented in Table 41 for the year 1986-87 and 1987-88.

The total consumptive use of water was 436.33, 381.61, 328.93 and 221.67 mm with 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios, respectively, during 1986-87, while it was 414.41, 361.22, 301.66 and 237.55 mm during 1987-88. Thus, with increase in the IW/CPE ratios the total consumptive use of water was also increased in both the seasons. However, the total consumptive use of water during 1986-87 was comparatively higher than 1987-88. The total pan evaporation was 599 and 592.90 mm in 1986-87 and 1987-88,

Table 41. Total and average daily consumptive use of water [Et] total and average daily open pan evaporation [Ep] and relative evapotranspiration rate [Et/Ep] during successive irrigation interval for different irrigation treatments in 1986-87 and 1987-88

Irrigation Treatment	Irrigation interval between	Period in days 1986	Period in days 1987	Total consumptive use of water [mm] [Et] 1986-87	Total consumptive use of water [mm] [Et] 1987-88	Total open pan evaporation [mm] [Ep] 1986-87	Total open pan evaporation [mm] [Ep] 1987-88	Average daily consumptive use [mm] 1986-87	Average daily consumptive use [mm] 1987-88	Average daily open pan evaporation [mm] 1986-87	Average daily open pan evaporation [mm] 1987-88	Relative evapotranspiration rate [Et/Ep] 1986-87	Relative evapotranspiration rate [Et/Ep] 1987-88
1.0 IW/CPE ratio	S-C	15	15	47.06	42.65	49.20	65.10	3.13	2.84	3.28	4.34	0.95	0.65
	C-I	15	28	64.60	98.13	61.20	105.50	3.64	3.50	4.08	3.76	0.89	0.93
	I-II	14	32	57.42	105.17	61.10	111.10	4.10	3.28	4.36	3.47	0.94	0.95
	II-III	14	16	52.95	54.31	60.30	59.00	3.78	3.39	4.30	3.68	0.88	0.92
	III-IV	16	13	58.27	54.88	59.00	59.80	3.64	4.22	3.68	4.60	0.98	0.91
	IV-V/H*	14	34	54.41	59.25	57.80	192.40	3.88	1.74	4.12	5.65	0.94	0.30
	V-VI*	15	-	54.55	-	63.40	-	3.63	-	4.22	-	0.86	-
	VI-H	32	-	57.06	-	187.00	-	1.78	-	5.84	-	0.30	-
	Total	**135**	**137**	**436.33**	**414.41**	**599.00**	**592.90**	**3.23**	**3.02**	**4.43**	**4.32**	**0.72**	**0.70**
0.8 IW/CPE ratio	S-C	15	15	47.28	43.61	49.20	65.10	3.13	2.90	3.28	4.34	0.96	0.66
	C-I	18	30	54.27	99.40	69.90	118.00	3.01	3.31	3.88	3.93	0.77	0.84
	I-II	18	37	56.95	106.77	77.90	126.20	3.16	2.88	4.32	3.41	0.73	0.84
	II-III	18	18	55.49	53.16	73.60	75.70	3.08	2.95	4.08	4.20	0.75	0.70
	III-IV/H**	19	37	54.22	58.26	73.40	207.90	2.85	1.57	3.86	5.61	0.73	0.28
	IV-V	18	-	54.60	-	76.40	-	3.03	-	4.24	-	0.71	-
	V-H**	29	-	58.80	-	178.60	-	2.02	-	6.15	-	0.32	-
	Total	**135**	**137**	**381.61**	**361.22**	**599.00**	**592.90**	**2.82**	**2.64**	**4.43**	**4.32**	**0.63**	**0.61**
0.6 IW/CPE ratio	S-C	15	15	46.97	43.16	49.20	65.10	3.13	2.87	3.28	4.34	0.95	0.66
	C-I	24	53	54.70	149.09	96.30	196.00	2.27	2.81	4.01	3.69	0.56	0.76
	I-II	23	27	57.44	53.10	98.90	100.10	2.49	1.96	4.30	3.70	0.58	0.53
	II-III/H @	26	42	57.69	56.31	99.60	231.70	2.21	1.34	3.83	5.51	0.57	0.24
	III-IV	22	-	55.43	-	99.80	-	2.51	-	4.53	-	0.55	-
	IV-H @	25	-	56.67	-	156.20	-	2.26	-	6.24	-	0.36	-
	Total	**135**	**137**	**328.93**	**301.66**	**599.00**	**592.90**	**2.43**	**2.20**	**4.43**	**4.32**	**0.55**	**0.51**
0.4 IW/CPE ratio	S-C	15	15	46.90	43.13	49.20	65.10	3.12	2.87	3.28	4.34	0.95	0.66
	C-I	37	67	58.13	151.18	152.00	244.20	1.57	2.25	4.10	3.64	0.38	0.61
	I-II/H §	37	55	58.90	43.24	147.40	283.60	1.59	0.78	3.98	5.15	0.39	0.15
	II-H §	46	-	57.48	-	250.40	-	1.24	-	5.44	-	0.22	-
	Total	**135**	**137**	**221.67**	**237.55**	**599.00**	**592.90**	**1.64**	**1.73**	**4.43**	**4.32**	**0.37**	**0.40**

S - Sowing   C - Common irrigation   H - Harvesting

* At 1.0 IW/CPE ratio IV-H for 1987-88 and VI-H for 1986-87

** At 0.8 IW/CPE ratio III-H for 1987-88 and V - H for 1986-87

@ At 0.6 IW/CPE ratio II-H for 1987-88 and IV-H for 1986-87

§ At 0.4 IW/CPE ratio I-H for 1987-88 and II-H for 1986-87 respectively. Similar trend was observed when daily average consumptive use of water was determined on the basis of whole crop growth.

4.11.2.5 Average daily consumptive use and open pan evaporation

The data presented in Table 41 and depicted in Fig.20 indicates that the average daily consumptive use was 3.23, 2.82, 2.43 and 1.64 mm in 1986-87 and 3.02, 2.64, 2.20 and 1.73 mm in 1987-88 with 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios, respectively. Thus, the range of average daily consumptive use was widened in 1986-87 than 1987-88. The average daily pan evaporation in 1986-87 and 1987-88 was 4.43 and 4.32 mm, respectively.

4.11.2.6 Relative evapotranspiration rate

The Et/Ep ratio was 0.72, 0.63, 0.55 and 0.37 during 1986-87 and it was 0.70, 0.61, 0.51 and 0.40 during 1987-88 with 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios, respectively. During both the years of the study the Et/Ep ratio increased with increase in the IW/CPE ratio. The Et/Ep ratio was higher at the begining of the crop growth, then it was gradually decreased, again increased and at latter crop growth stage it was lowest in all the irrigation treatments in between the two successive irrigations in both the seasons.

4.11.3 Consumptive use, consumptive use efficiency and water use efficiency

Data regarding CU, CUE and WUE of maize as influenced by various treatments are presented in Table 42 and depicted in Fig.21 and 22.

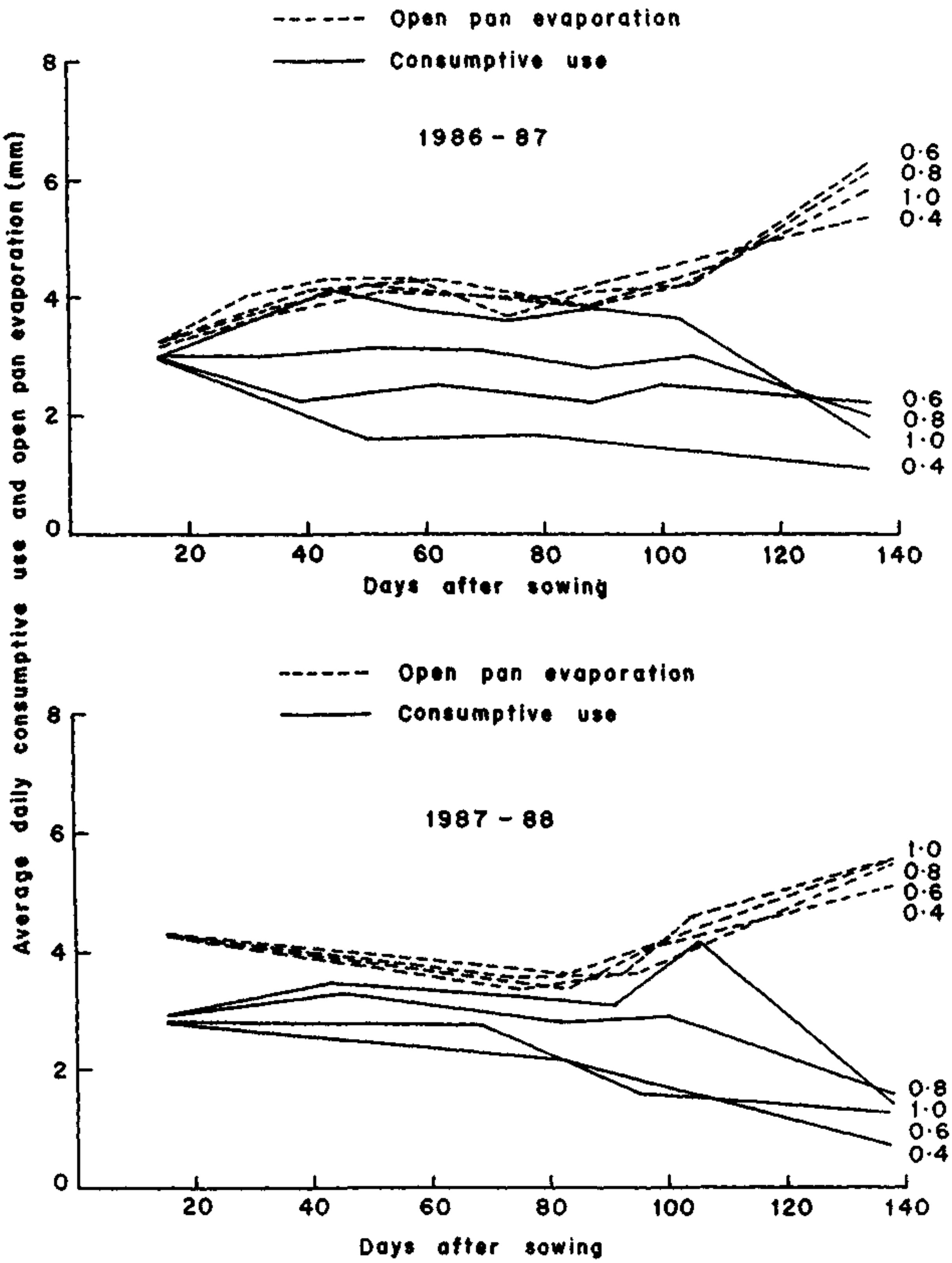


Fig. 20 . Average daily consumptive use and open pan evaporation. (mm).

Table 42. Consumptive use, consumptive use efficiency and water use efficiency of maize as influenced by various treatments

Treatment	1986-87			1987-88		
	CU (mm)	CU efficiency (mm/day)	WUE (kg/ha/mm)	CU (mm)	CU efficiency (mm/day)	WUE (kg/ha/mm)
Irrigation scheduling (IW/CPE ratios)						
1.0	436.33	9.30	12.77	414.41	8.43	12.06
0.8	381.61	8.99	14.11	361.22	8.05	13.39
0.6	328.93	7.98	14.52	301.66	7.70	15.13
0.4	221.67	7.39	19.98	237.56	6.80	16.99
Mulching						
No mulch	339.11	8.55	15.10	325.79	7.80	14.19
Mulch	345.16	8.28	14.38	331.63	7.70	13.77
Irrigation layouts						
Ridges and furrows	338.81	8.46	14.95	324.73	7.77	14.18
Flat beds	345.46	8.38	14.53	332.68	7.73	13.77
General mean	**342.13**	**8.41**	-	**328.70**	**7.75**	-

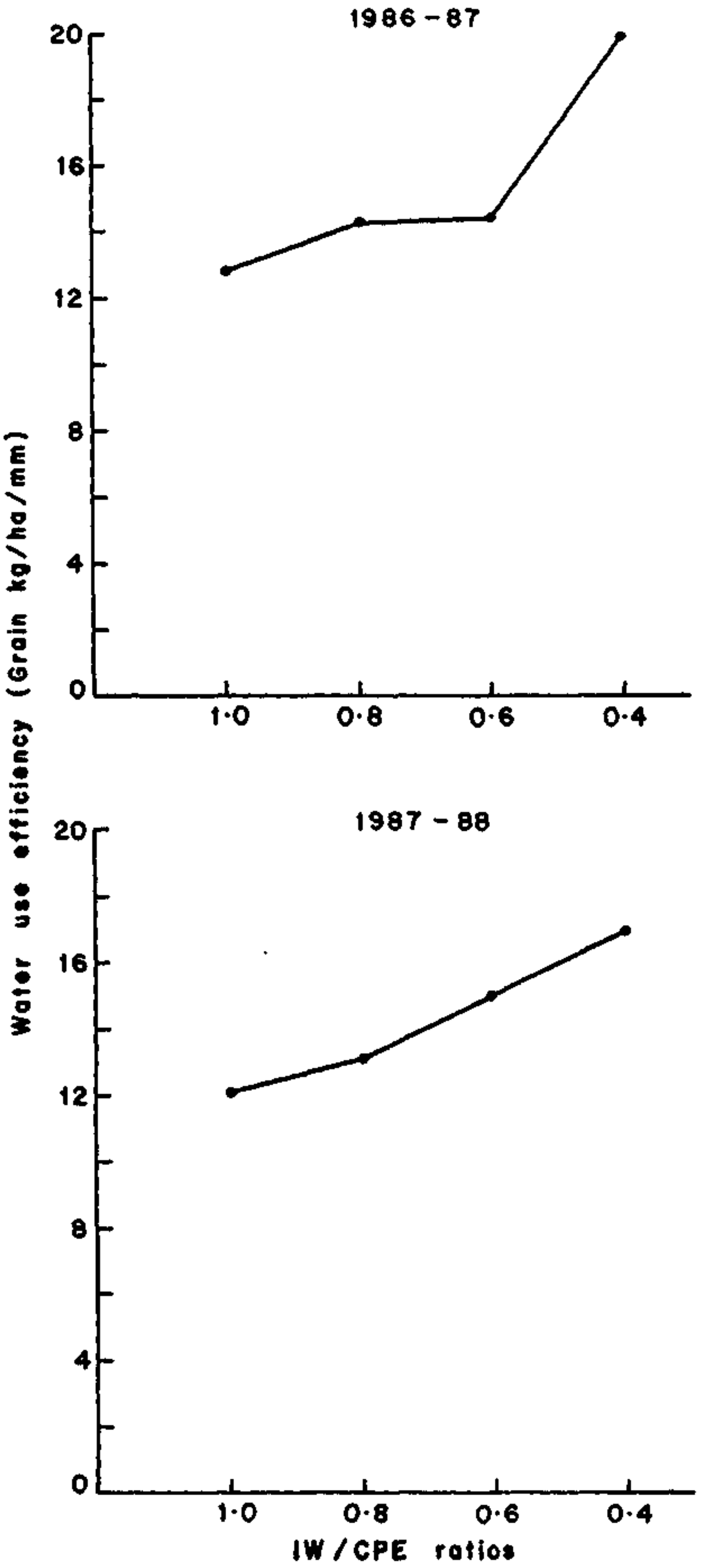


Fig. 21 . Water use efficiency (grain kg/ha/mm) as influenced by different IW/CPE ratios.

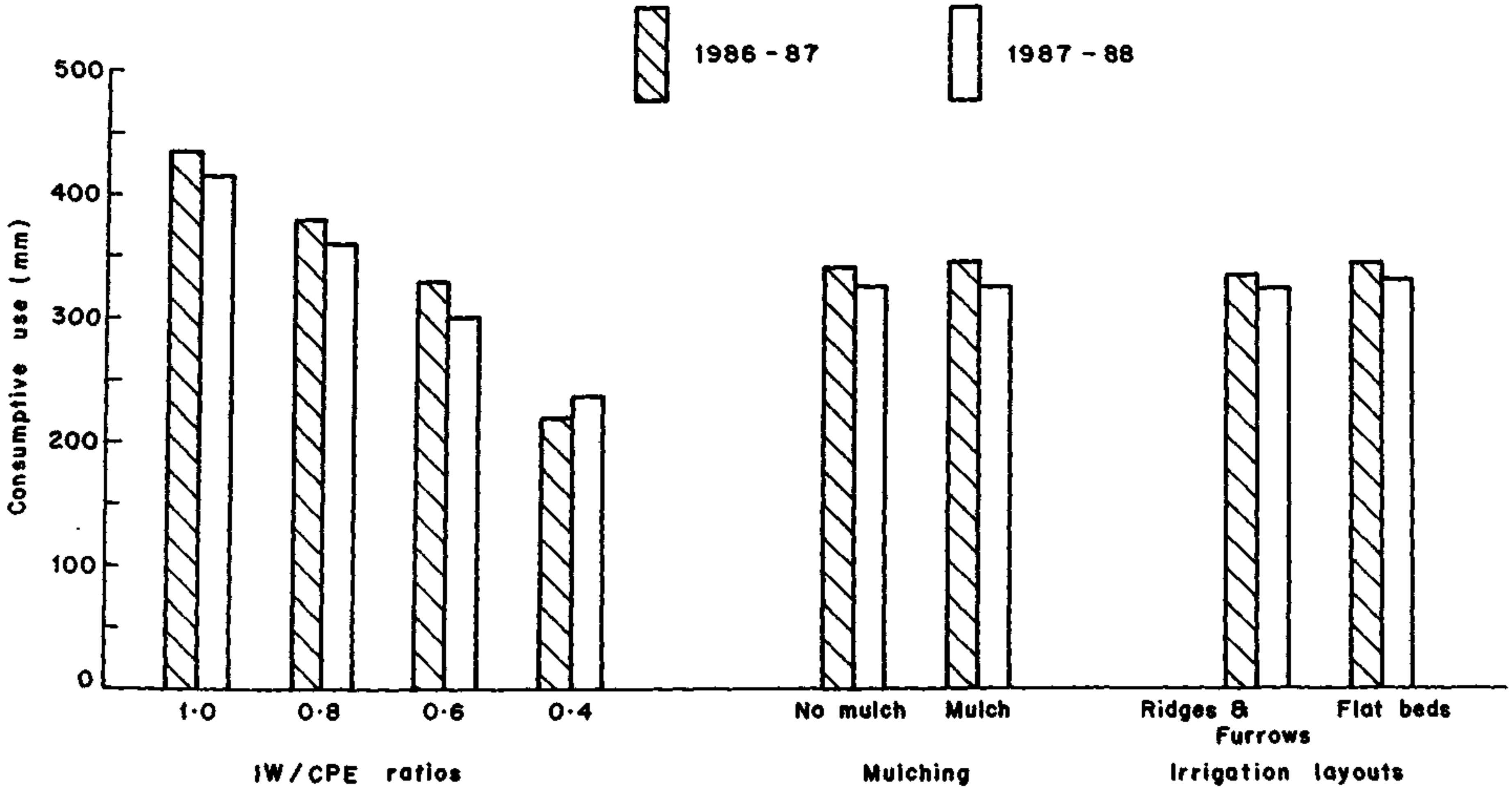


Fig. 22 . Consumptive use of maize as influenced by various treatments during 1986-87 and 1987-88.

The mean CU and CUE of water during 1986-87 and 1987-88 were 342.13, 328.70 mm and 8.41 and 7.75 mm, respectively.

Irrigation scheduling

The CU and CUE of water was increased with increase in IW/CPE ratios in both the years of study. The difference in CU of water between 1.0, 0.8 and 0.6 IW/CPE ratios were more or less constant. However, between 0.6 and 0.4 IW/CPE ratios, the the difference was more widened in both the years. The CUE was gradually decreased, where as WUE progressively increased with increas in IW/CPE ratios during both the years of study.

Mulching

The CU and CUE were slightly more with mulch as compared to no mulch in 1986-87 and 1987-88. But the WUE was more with no mulch than mulch treatment.

Irrigation layouts

The CU of water was higher with flat bed layout in both the years. However, the CUE and WUE were higher under ridges and furrows layout in both the years of the study.

Discussion

5. DISCUSSION

The results of the present investigation on "Studies on the effect of irrigation scheduling and irrigation layouts with and without mulch on growth, yield and quality of maize [*Zea mays* L.] in *rabi* season" conducted during the *rabi* season of 1986-87 and 1987-88 reported in the preceeding chapter are discussed in this chapter.

5.1 Soil, climate and crop development

The analysis of the soil of the experimental plots at the commencement of the present investigation showed, that the soil was clay loam in texture [Table 1]. Studies on the initial status of the nutrient content indicated that the soil was medium in total nitrogen and available phosphorus and fairly rich in available potassium. Thus, the soil was classed as medium in fertility as per the criteria laid down by Muhr et al. [1965]. It was slightly alkaline in reaction [pH 7.8] with a fairly high maximum water holding and field capacity. The soil was well drained and the water table was below 3 metre depth. Hence, the ground water contribution of the soil moisture from the water table to the crop under investigation was nil. Thus, the soil was appropriate for growing maize in *rabi* season.

The mean maximum temperature during the crop growth period ranged between 28.90 to 36.10°c and 26.70 to 37.1°c in 1986-87 and 1987-88, respectively. The mean minimum temperature ranged between 6.82 to 20.30°c and 6.10 to 17.8°c during 1986-87 and 1987-88, respectively.

The mean morning relative humidity ranged between 56 to 94 and 60 to 92 per cent during 1986-87 and 1987-88, respectively. The corresponding percentages for evening humidity were between 18 to 62 and 18 to 64 [Table 3 and 4].

The total precipitation of 110.4 and 143.8 mm was received in 9 and 14 rainy days during 1986-87 and 1987-88, respectively. The showers received immediately after sowing the crop during 1987-88 helped in better germination and good initial crop growth. The precipitation received during 1986-87 was before the common irrigation. Hence, it did not affect the irrigation scheduling. However, the precipitation received during 1987-88 was between 45 and 50 days from sowing. This precipitation helped better initial vegetative crop growth and extending irrigation interval, thereby reducing the irrigation turns.

The daily pan evaporation from the open pan evaporimeter ranged between 3.22 to 6.90 and 3.10 to 7.50 mm during 1986-87 and 1987-88 respectively. The rate of evaporation was higher from the month of February onwards in both the years.

The bright sunshine hours ranged between 5.92 to 10.7 and 2.1 to 10.5 in 1986-87 and 1987-88 respectively. Thus, there was ample bright sunshine in both the years of investigation.

In general, the climatic condition that prevailed during different growth stages of the maize in both the seasons was favourable for the satisfactory growth of the crop. There was no incidence of major pests and diseases, except a mild attack of bacterial blight at cob filling stage during 1987-88.

To have a general idea about nature and development of maize under soil and environmental conditions of Kolhapur, the means of the different growth attributes, yield contributing characters and other attributes were studied. The general means emerged as effects averaged over all the factors under study are presented in Table 43.

Data presented in Table 43 revealed that the maximum growth of maize in terms of plant height was 229.41 and 241.08 cm in 1986-87 and 1987-88, respectively.

The number of functional leaves/plant was 13.60 and 13.14 with a leaf area of 60.05 and 64.53 dm^2/plant during 1986-87 and 1987-88, respectively. The dry matter accumulation/plant was 403.59 g in 1986-87, while it was 288.41 g in 1987-88. The number of days required for 75 per cent silking were 65.29 and 68.12 in 1986-87 and 1987-88, respectively.

The number of cobs/plant was 1.83 and 1.68 and the number of cobs/net plot were 81.14 and 78.23 during 1986-87 and 1987-88, respectively. The number of plants at harvest were

Table 43. Influence of season on the performance of important characters of maize during 1986-87 and 1987-88

	Characters	Mean (maximum) values	
		1986-87	1987-88
1]	Plant height [cm] at 105 days	229.41	241.08
2]	No. of leaves/plant at 75/90 days	13.60	13.14
3]	Leaf area/plant in dm^2 at 75/90 days	60.05	64.53
4]	Dry matter/plant in g at harvest	403.59	288.41
5]	Days of 75 per cent silking	65.29	68.12
6]	Number of cobs/plant	1.83	1.68
7]	Number of cobs/net plot	81.14	78.23
8]	Number of plant [000/ha] at harvest	45.40	46.78
9]	Grain weight/plant [g]	124.37	110.23
10]	Length of cob	17.75	17.93
11]	Girth of cob	13.72	13.72
12]	Number of grain rows/cob	14.33	14.74
13]	Number of grain/cob	529.14	427.27
14]	Number of grains/row	38.64	36.47
15]	Test weight [g]	223.00	202.17
16]	Grain yield [q/ha]	50.43	45.95
17]	Stover yield [q/ha]	80.48	69.70
18]	Nitrogen percentage in constituent parts of maize at harvest.		
	a) Stalk	0.673	0.675
	b) Leaves	1.264	1.256
	c) Stover	1.067	0.968
	d) Grain	1.721	1.673

Table 43. (Contd...)

	Characters	1986-87	1987-88
19]	Phosphorus percentage in the constituent parts of maize at harvest		
	a) Stalk	0.407	0.401
	b) Leaves	0.406	0.400
	c) Stover	0.406	0.400
	d) Grain	0.800	0.773
20]	Uptake of nitrogen (kg/ha) at harvest		
	a) Grain	86.72	77.04
	b) Stover	85.82	67.41
	c) Total	172.32	144.44
21]	Uptake of phosphorus (ka/ha) at harvest		
	a) Grain	41.54	35.17
	b) Stover	32.52	27.88
	c) Total	73.09	63.37
22]	Protein per cent		
	a) Grain	10.77	10.45
	b) Stover	6.67	6.04
23]	Protein production (q/ha)		
	a) Grain	5.43	4.80
	b) Stover	5.38	4.20
	c) Total	10.79	9.01
24]	Energy balance (G calories/ha)		
	a) Energy input	23.36	23.14
	b) Energy output	17.60	16.02
	c) Balance	-5.76	-7.12

45,400 and 46,780/ha during 1986-87 and 1987-88, respectively. Thus, the final plant count/ha during 1986-87 was comparatively less than that of 1987-88. However, the number of cobs/net plot was 81.14 during 1986-87, which was more than that of 1987-88 (78.23). This might be because of the higher number of cobs/ plant during 1986-87 (1.83) than 1987-88 (1.68).

The yield contributing characters viz grain weight/plant, grain number/row, grains/cob and test weight were higher during 1986-87 as compared to 1987-88.

The growth of these characters in early life period of the crop was beneficial for more dry matter production in terms of vegetative part, which consequently formed a base for dry matter accumulation in terms of reproductive parts. All these had reflected on grain and stover yield of maize. The grain and stover yields were 50.43 and 45.95, and 80.48 and 69.70 q/ha during 1986-87 and 1987-88, respectively.

Nitrogen and phosphorus content in the constituent parts of maize viz leaves, stalk, stover and grain showed higher percentages during 1986-87 than 1987-88.

The total uptake of nitrogen was 172.32 and 144.44 kg/ha and that of phosphorus was 73.09 and 63.37 kg/ha in 1986-87 and 1987-88, respectively. The higher values during 1986-87 were because of the higher grain and stover yields and higher N and P concentration in constituent parts.

The protein production during 1986-87 was more [10.79] q/ha than that of 19870-88 [9.01 q/ha]. This was because of the higher protein per cent [6.678] in 1986-87 than that of 1987-88 [6.04].

The energy inputs were more or less the same during both the years of study. However, outputs were slightly higher during 1986-87.

In order to study the nature of growth maize, the plant growth was measured in terms of height, number of functional leaves, leaf area and dry matter accumulation/plant at different stages. Data pertaining to these aspects are presented in Table 44.

It was evident from the data presented in Table 44 that there was gradual increase in growth during the first 30 days. Period between 45 to 60 days was characterised by a fast growth rate and the growth rate slightly declined between 60-75 days. From 90 days onwards, the growth rate slowed down substantially. It was observed from the data that 70, 97 and 89 per cent of height, number of leaves and leaf area/plant were produced by maize plant at the age of 60 days during 1986-87, while the corresponding figures were 98,95 and 96 per cent at the age of 75 days for the year 1987-88.

The rate of dry matter accumulation was slow upto 60 days from sowing during both the years. It was faster between 75

Table 44. Periodical performance of some growth characters of maize plant during 1986-87 and 1987-88

Character		1986-87							1987-88						
		Days after sowing							Days after sowing						
		30	45	60	75	90	105	At harvest	30	45	60	75	90	105	At harvest
1 Plant height (cm)	A	37.19	80.79	161.22	116.22	225.34	229.41	-	66.57	98.74	181.66	237.36	239.34	241.08	-
	B	16.21	35.21	70.27	94.25	98.22	100.00	-	27.61	40.96	75.35	98.46	99.27	100.00	-
2 Mean number of leave/plant	A	8.0	9.74	13.29	13.60	13.19	12.66	-	11.05	11.74	11.84	12.51	13.14	12.70	-
	B	58.82	71.62	97.65	100.00	96.98	88.67	-	84.09	89.34	90.10	95.20	100.00	96.65	-
3 Leaf area (dm^2) plant)	A	7.60	25.62	53.81	60.05	59.39	58.48	-	22.37	40.58	55.69	62.21	64.53	62.19	-
	B	12.65	42.66	89.61	100.00	98.90	97.38	-	34.66	62.88	86.30	96.40	100.00	96.37	-
4 Dry matter (g)/plant	A	16.52	69.25	115.89	193.16	293.51	368.83	403.59	20.23	33.64	84.89	142.39	173.02	249.61	288.41
	B	4.09	17.16	28.71	47.86	72.72	91.38	100.00	7.01	11.66	29.43	49.37	59.99	86.54	100.00

A Absolute value

B Per cent of total value

and 90 days in 1986-87 and then it decreased gradually. However, it increased gradually upto 75 days and was the maximum between 90-105 days and then declined during 1987-88.

In order to study the further nature of plant height and dry matter accumulation in maize, the data on physiological growth attributes needs to be examined. The relevant data on these attributes are presented in Table 45.

It is seen from the data presented in Table 45 that the $\overline{CGR}$ values of height were the maximum between the period of 45-60 days from sowing during both the years under study. Subsequently, the values decreased between 60-75 DAS and then a sudden fall in the values between 90-105 was observed. The $\overline{RGR}$ values during 1986-87 showed a continuous decreasing trend from sowing to harvest and it was maximum between 45-60 days from sowing. However, during 1987-88 the $\overline{RGR}$ values showed sigmoid curve, having the maximum values between 45-60 days.

As regards the $\overline{CGR}$ values of dry matter accumulation, the highest values were between 75-90 and 90-105 days from sowing during 1986-87 and 1987-88, respectively. This was because of the maximum number of leaves, leaf area and leaf area index in the same period by the maize crop.

The $\overline{RGR}$ value of dry matter during 1986-87 was maximum between 30-45 DAS and then suddenly dropped. Further, the

Table 45. $\overline{CGR}$ and $\overline{RGR}$ of height, $\overline{CGR}$, $\overline{RGR}$ and $\overline{NAR}$ of dry matter and LAI between different periods of maize growth in 1986-87 and 1987-88

Period between days after sowing	Year	of height		of dry matter			LAI
		$\overline{CGR}$ cm/day	$\overline{RGR}$ cm/cm/week	$\overline{CGR}$ g/day	$\overline{RGR}$ g/g/week	$\overline{NAR}$ g/dm²/day	
30-45	1986-87	2.33	0.3616	3.49	0.6681	0.2348	0.40
(15)	1987-88	1.72	0.1838	0.91	0.2370	0.0297	1.19
45-60	1986-87	4.30	0.3223	3.11	0.2400	0.0816	1.37
(15)	1987-88	4.42	0.2842	3.37	0.4315	0.0005	2.25
60-75	1986-87	2.94	0.1365	5.16	0.2381	0.0906	2.86
(15)	1987-88	2.98	0.1247	3.83	0.2411	0.0650	2.98
75-90	1986-87	0.54	0.0192	6.75	0.1950	-	3.20
(15)	1987-88	0.16	0.0039	2.65	0.0908	0.0418	3.31
90-105	1986-87	0.24	0.0084	5.07	0.1065	-	3.16
(15)	1987-88	0.11	0.0034	5.02	0.1708	-	3.41
105 to Harvest	1986-87	-	-	2.44	0.0420	-	3.12
	1987-88	-	-	2.68	0.0674	-	3.31

values showed a continuous decrease till the harvest of the crop. However, during 1987-88, the $\overline{\text{RGR}}$ value was maximum between 45-60 and then slowly decreased till the harvest. The $\overline{\text{NAR}}$ was the maximum between 30-45 and 45-60 days from sowing during 1986-87 and 1987-88, respectively. This might be due to the maximum growth of the major growth attributes during this period.

The leaf area index values increased slowly upto 75 and 90 days from sowing during 1986-87 and 1987-88, respectively and then gradually decreased till the harvest. The number of functional leaves/plant were maximum at 75 and 90 days, which led to maximum leaf area exposer for production of photosynthetic activities, which might have reflected in more leaf area index.

In general, considering all the climatological and other factors, both the seasons were favourable to the maize crop.

In this chapter, attempts are made to discuss the effects and relation of different growth and yield contributing characters, yield, monetary benefit, uptake, nutrient balance, energy balance, consumptive use, water use efficiency of maize with the scheduling of irrigation, mulching and irrigation layouts. The discussion has been broadly classified in 3 categories as follows :

a] Studies on irrigation scheduling

b] Mulching

c] Irrigation layouts

5.2 Studies on irrigation scheduling

Irrigation plays an important role in cultivation of rabi crops. Though sufficient water is available at the initial stage of the rabi crop, yet it faces acute shortage in latter growth stages. In Maharashtra, hardly 98,200 ha area is under rabi maize cultivation which is concentrated in Deccan canal area, where the main source of irrigation is either well or canal water. The limited availability of irrigation water restricts the area under planting of maize as well as adversly affect its growth and production.

Many research workers have suggested the scheduling of irrigation to maize at the critical growth stages and also the number of irrigations to be applied. Lal and Saini [1985], Rai, et al. [1985], Anonymous [1985-86], Pathak and Mathur [1987], Alam [1988], Puste and Kumar [1988] and Singh and Singh [1988] suggested the critical stages at which the irrigation should be given to maize crop, while Nair [1972], Bajwa, et al.[1988] and Singh [1988] had given the total number of irrigations to be given to maize throughout the crop growth.

The most suitable and practicable approach of scheduling irrigation based on the ratio of a fixed amount of irrigation water [IW] to pan evaporation has also been suggested for the maize crop. As this approach is based on cumulative pan evaporation, the consumptive use efficiency in both these approaches viz growth stage and IW/CPE ratio can therefore, be compared to find out, whether the irrigation water could be saved by IW/CPE ratio. Michael [1978] had observed close relationship between the consumptive use by crop and the rate of evaporation from a well located evaporimeter/evaporation pan. Saving of irrigation water during rabi season is a prime need for increasing area under maize crop.

The various weather parameters viz temperature, rainfall and humidity in this area during the last 10 years and soil depths were considered for fixing the IW/CPE ratios for maize crop [Table 2]. The rainfall situation during the last 10 years in this area would show, that sufficient rains are received in the month of October and November, but the rainfall receded after December to March. Considering both the parameters, therefore, the IW/CPE ratios were therefore, kept as 1.0 [60 mm], 0.8 [75 mm], 0.6 [100 mm] and 0.4 [150 mm]. The irrigations were scheduled as per these ratios after giving a common irrigation on 15th day from sowing till physiological maturity of maize as specified by Berger [1962], who suggested 35-40 per cent of grain moisture at physiological maturity i.e. approximately 100-100 days from sowing. The ratios were kept constant throughout the crop growth period and depth of irrigation water was kept 60 mm for all these treatments.

The plant height remained unaffected during 1987-88. However, it was significantly more with 1.0 and 0.8 IW/CPE ratios, than

0.4 and 0.6 IW/CPE ratios from 60 days onwards during 1986-87 [Table 9]. The availability of sufficient soil moisture both during vegetative and reproductive stages might have enhanced the plant height with 1.0 and 0.8 IW/CPE ratios. These results are in conformity with the findings of Titev [1969] and Borole [1973].

The growth analysis viz $\overline{CGR}$ and $\overline{RGR}$ of plant height showed considerable variation. The values for $\overline{CGR}$ and $\overline{RGR}$ of height were more or less similar for irrigation scheduling at 1.0 and 0.8 IW/CPE ratios. Similar trend was observed for 0.6 and 0.4 IW/CPE ratios [Table 10 and 11].

The number of functional leaves/plant were not significantly influenced due to irrigation scheduling at different IW/CPE ratios during both the years. However, the irrigation scheduled at 1.0 IW/CPE ratio showed favourable influence on production of functional leaves/plant due to better soil moisture availability [Table 12].

The leaf area/plant was significantly more under 1.0 IW/CPE ratio than IW/CPE ratios during advanced crop growth stages during both the years [Table 13]. The increase in leaf area with this ratio was due to increase in leaf number/plant and leaf expansion. Leaf area has been considered as a reliable index of crop response to irrigation scheduling. The increase in leaf area with higher IW/CPE ratios was found to be useful in utilizing the radient energy more efficiently thereby increasing synthesis of carbohydrates. Therefore, the general vigour of the plant irrigated with higher IW/CPE ratios was increased. Similar results were reported by Titev [1969] and Borole [1973].

The leaf area index was also significantly more with 1.0 IW/CPE ratio during advanced crop growth stages [75 days onwards] during both the years [Table 15]. The production of more leaf area with 1.0 IW/CPE ratio might have increased leaf area index. Increase in leaf area index with increase in IW/CPE ratio/irrigation was also reported by Borole [1973].

Periodical dry matter accumulation/plant in general was significantly increased due to scheduling of irrigation at 1.0 IW/CPE ratio after 60 days from sowing in 1986-87 and 90 days from sowing in 1987-88 [Table 16]. The dry matter accumulation/ plant is largely a function of photosynthetic surface of leaf, which was favourably influenced by the scheduling of irrigation at 1.0 IW/CPE ratio. Irrigation scheduled at 0.8 IW/CPE ratio also accumulated more dry matter/plant, than 0.4 and 0.6 IW/CPE ratios from 75 days onwards during both the years. The production of more dry matter with 1.0 and 0.8 IW/CPE ratios was attributed to the increased plant height and leaf number, leaf area and leaf area index due to the better soil moisture availability and absorption of more plant nutrients resulting in vigorous plant growth. There results coroborate the findings of Borole [1973], Zaborský [1969] and Subramanian et al. [1987].

The photosynthetic efficiency as measured by $\overline{CGR}$ was more with scheduling of irrigation at 1.0 IW/CPE ratio upto 105 days after sowing in 1986-87 and upto 90 DAS during 1987-88 [Table 17]. In general, the $\overline{RGR}$ and $\overline{NAR}$ values showed decreased trend with advancement in the age of the crop, during both the years, except the period between 30-45 days during 1986-87. No definite trend was observed due to irrigation scheduling at different IW/CPE ratios.

Silking is an indication that the plant is entering the reporductive stage from its vegeta tive stage. The number of days required for the 75 per cent silking were significantly more with scheduling of irrigation at 0.4 and 0.6 IW/CPE ratios than 1.0 and 0.8 IW/CPE ratios during 1986-87. This might be due to less irrigation water supplied which forced the plant to continue its vegetative crop growth stage and delay silking. The results of silking were nonsignificant during 1987-88, trend noticed was as that of 1986-87. Gaikwad [1975] also observed earlier 50% tasselling, flowering and silking in higher level of irrigation as compared with those in lower level. Similar results are reported by Borole [1973] and Sharma and Upadhyay [1973].

Cob is an economical part of maize plant. The number of cobs/plant was beneficially increased with increase in IW/CPE ratio during both the seasons [Table 20]. The number of cobs/net plot was significantly more with 1.0 IW/CPE ratio as compared with 0.4 IW/CPE ratio during 1986-87, and lower IW/CPE ratios in 1987-88. Irrigation scheduled at 0.8 IW/CPE ratio also produced more number of cobs/net plot than 0.4 IW/CPE ratio during 1986-87. This was because of the higher number of cobs/plant with 1.0 and 0.8 IW/CPE ratios. Puste [1988] and Puste and Kumar [1988] also recorded maximum number of cobs/ha, when irrigation was given at all the critical crop growth stages. The final plant count/ha was not affected significantly due to different IW/CPE ratios during both the years.

The important yield contributing characters viz grain weight/plant, cob length and girth, number of grain rows/cob, number of grains/row and per cob and 1000 grain weight were significantly increased, when irrigation was scheduled at 1.00 IW/CPE ratio as compared to 0.8, 0.6 and 0.4 IW/CPE ratios during both the years [Table 21]. The increase in yield contributing characters with 1.0 IW/CPE ratio was attributed to the better soil moisture situation at different crop growth stages. This may be attributed to the substantial improvement in growth, practicularly in terms of leaf area, leaf area index and dry matter accumulation/plant leading to formation of more number of grains/plant and test weight. The significant increase in the weight of grains/plant, 1000 grain weight under 1.00 IW/CPE ratio, may also attributed to the better soil moisture situation for vegetative and reproductive growth resulting in better development of grains. These results co-ordinate with the findings of Petrunin [1967], Borole [1973], Nadanam and Morachan [1974], Pathak and Mathur [1987], Bajwa [1988] and Puste and Kumar [1988].

The grain yield was significantly increased with the increased number of irrigation [IW/CPE ratios] during both the years of study and when data were pooled, except 0.8 and 1.0 IW/CPE ratios were on par during 1986-87 [Table 22]. The pooled grain yield increased by 24.87, 20.03 and 10.39 per cent due to irrigation scheduling at 1.0, 0.8 and 0.6 IW/CPE ratios as compared to 0.4 IW/CPE ratio, respectively. The increase in grain yield with scheduling of irrigation at 1.00 IW/CPE ratio was mainly attributed to an increase in the functional leaves, leaf area, dry matter accumulation, cob number/plant, cob number/net plot and important yield contributing characters viz grain weight/plant, cob length and girth, number of grain rows/cob, number of grains/row and per cob, and 1000 grain weight than the lower IW/CPE ratios. It would be, therefore, advisible to irrigate maize with 1.0 IW/CPE ratio to obtain higher grain yield. Similar results of scheduling irrigation at higher IW/CPE ratio or more frequent irrigations were obtained by Petrunin [1967], Zaborskey [1969] Na danam and Morchan [1974], Miranda and Fuentes [1978], Pathak and Mathur [1978], Anonymous [1981-83], Aujla [1987], Roy and Tripathi [1987], Bajwa [1988], Puste [1988], and Puste and Kumar [1988].

Irrigation scheduled at 0.8 and 1.00 IW/CPE ratios significantly increased stover yield as compared to irrigation scheduled at 0.4 and 0.6 IW/CPE ratios during both the years [Table 22]. The pooled stover yield was increased by 11.63, 9.43 and 2.98 per cent with 1.0, 0.8 and 0.6 IW/CPE ratios, respectively, over 0.4 IW/CPE ratio. The increase in stover yield was mainly attributed to the increase in plant height, number of functional leaves, dry matter accumulation and cob number/plant and cob/net plot. These findings are in conformity with the results obtained by Singh and Sharma [1968], Slepicka [1969], Borole [1973], Nandanam and Morchan [1974], Verma and Singh [1976], Kotoria et al. [1981], Rajput [1983-85], Mohamed [1985], Patel et al.[1985] and Bajwa [1988].

Harvest index was significantly lower with 0.4 IW/CPE ratio during 1987-88. This was attributed to more biological yields, rather than economical yield under this IW/CPE ratio.

The grain production efficiency was significantly increased with increased IW/CPE ratios during both the years of experimentation, except that the 0.8 and 1.0 IW/CPE ratios were on par in 1986-87 [Table 22]. This was attributed to more grain production under higher IW/CPE ratios.

The response to the irrigation scheduling was found to be linear during both the years and in pooled data. Therefore, optimum irrigation scheduling could not be suggested indicating higher IW/CPE ratios needs to be tried if unlimited irrigation resources are available for enhancing the maize production. values showed good fit of response equations.

The gross monetary returns were significantly increased with increase in IW/CPE ratios during both the years and when data were pooled over season. Similar trend was observed for the cost of cultivation. The pooled gross monetary returns of Rs.13,194/ha were obtained with scheduling of irrigation at 1.0 IW/CPE ratio [5 irrigations] as against Rs.12,748, 11,695 and 10,711/ha with 0.8 [4 irrigations], 0.6 [3 irrigations] and 0.4 [2 irrigations] IW/CPE ratios, respectively.

The irrigation scheduled at 1.0 and 0.8 IW/CPE ratios significantly increased the net profit as compared to 0.4 and 0.6 IW/CPE ratios during both the years. However, pooled net profit was significantly increased with increased levels of IW/CPE ratios [Table 25]. The net profit was increased by 51.28, 43.21 and 20.04 per cent with 1.0, 0.8 and 0.6 IW/CPE ratios, respectively as compared to 0.4 IW/CPE ratio. The increase in the monetary returns with increase in IW/CPE ratios was attributed to higher grain and stover yields. Rai and Singh [1985] obtained a net profit of Rs.5565/ha with 5 irrigations and an additional net profit of Rs.2,652/ha with maize than growing wheat crop. Singh and Singh [1986] obtained a net profit of Rs.8,435/ha by growing maize with 4 irrigations and an additional net profit of Rs.1,146/ha than growing wheat crop.

The nitrogen and phosphorus content in stalk, leaves, stover and grain at harvest were not significantly influenced due to different IW/CPE ratios. However, it showed a slight improvement with decreased IW/CPE ratios. The decreased N and P in grain and stover with increased IW/CPE ratios might be owing to reduced No_3 content in soil under high bulk density or compacted soil condition and also dilution effect of irrigation water on soil N and P content [Table 27 and 28].

Irrigation scheduling at 0.8 and 1.0 IW/CPE ratio significantly increased N uptake by grain and total N uptake as compared to 0.4 and 0.6 IW/CPE ratios during both the years of study and total pooled N uptake, except 0.4 and 0.6 IW/CPE ratios were on par during 1986-87 and 0.6 and 0.8 IW/CPE ratios were on par during 1987-88. The increase in N uptake with higher IW/CPE ratios was mainly attributed to the higher grain and biological yields. Similar results were reported by Malik [1973]. Irrigation scheduled at 0.6 IW/CPE ratio also produced significantly more N uptake by grain during both the years of study and pooled N uptake than 0.4 IW/CPE ratio. However, N uptake by stover was not significantly influenced during both the years.

The P uptake by grain and total P uptake was not significantly influenced due to different IW/CPE ratios during both the years

[Table 29]. However, scheduling of irrigation at 0.8 and 1.0 IW/CPE ratios significantly increased P uptake by stover as compared to 0.4 and 0.6 IW/CPE ratios during both the years, except 0.6 and 0.8 IW/CPE ratios were found to be on par in 1986-87. The increase in plant height, leaf area and dry matter production with higher IW/CPE ratios [0.8 and 1.0 IW/CPE ratios] resulted in increas ed stover yield and consequently higher P uptake. These results are in conformity with the finding of Malik [1973]. Irrigation scheduled at 0.8 and 1.0 IW/CPE ratios also significantly increased pooled total P uptake as compared to 0.4 IW/CPE ratio. This was attributed to the higher grain and stover yield with higher IW/ CPE ratios.

The protein per cent in grain and stover was increased with decreased IW/CPE ratios in both the seasons. With increase in irrigation frequencies [IW/CPE ratios] might have diluted the nitrogen content in grain resulting in lower protein content. Similar results were obtained by Kotoria et al. [1981].

5.3 Effect of irrigation on soil moisture

The number of irrigations required during the crop growth period were 6,5,4 and 2 during 1986-87 and 4,3,2 and 1 during 1987-88 with 1.0,0·8,0.6 and 0.4 IW/CPE ratios, respectively. Thus, the number of irrigations required during 1987-88 were comparatively less because of 95 mm of effective rainfall received during crop growth period. Due to the effective rainfall, an average interval between two successive irrigation increased during 1987-88 as compared to 1986-87 [Table 25].

The total amount of water applied for 1.0, 0.8, 0.6 and 0.4 IW/CPE ratios was 504.32 and 455.00, 444.32 and 395.0, 384.00 and 335.00 and 264.32 and 275.00 mm during 1986-87 and 1987-88, respectively. The effective rainfall received was 24.32 and 95.00 mm during 1986-87 and 1987-88, respectively.

The highest consumptive use of water viz 436.33 and 414.41 mm was observed with the scheduling of irrigation at 1.0 IW/CPE ratio during 1986-87 and 1987-88, respectively, whereas the lowest values were with 0.4 IW/CPE ratio. Thus, with the increase in IW/CPE ratios, the consumptive use of water also increased. Similar results were recorded by Rana and Malik [1981]. Also consumptive use of water due to scheduling of irrigation at 1.0 IW/CPE ratio was 49 & 42per cent more during 1986-87 and 1987-88, respectively, than scheduling of irrigation at 0.4 IW/CPE ratio owing to wet regimes maintained due to frequent irrigations providing wet surface for large periods and consequently greater would be the loss due to evaporation. More frequently irrigated crop had profuse vegetative growth so as to supply more water due to more transpiration, therefore, more soil moisture has been taken up by the crop resulting in more consumptive use.

The water use efficiency was the highest viz 19.98 and 16.99 grain kg/ha/mm with scheduling of irrigation at 0.4 IW/CPE ratio, whereas it was the lowest viz 12.77 and 12.06 grain kg/ha/mm under irrigation scheduled at 1.0 IW/CPE ratio during 1986-87 and 1987-88, respectively. The highest CU of water resulted in lower WUE under adequate irrigation management, whereas reverse was true with limited irrigation management in which case lesser amount of available soil moisture was more efficiently utilized. These results are in accordance with the findings of Miranda and Fuentes [1978], Reddy et al. [1979], Patel et al. [1985] and Roy and Tripathi [1987].

The daily pan evaporation value [4.43] was higher during 1986-87 than in 1987-88 [4.32]. Thus, the total pan evaporation of 599.00 mm was recorded during 1986-87 as against 592.00 mm in 1987-88 with the total crop growth period of 135 and 137 days, respectively. The crop growth period was extended by 2 days in 1987-88 because of low pan evaporation owing to low temperature.

The daily consumptive use of water was also the highest with scheduling of irrigation at 1.0 IW/CPE ratio as compared to lower IW/CPE ratios during both the years, except 0.4 IW/CPE ratio, where it was more during 1987-88 than in 1986-87. This might be due to higher relative evapotranspiration rate with higher IW/CPE ratios than the lower IW/CPE ratios.

Data presented in Table 40 revealed that the moisture extracted from 0-30 cm soil layer ranged between 71.79 to 73.83

per cent during 1986-87 and 72.30 to 75.11 per cent during 1987-88. However, moisture extracted from 30-60 cm layer was slightly increased with decrease in the IW/CPE ratios. This might be due to effective roots in 0-30 cm soil layer due to frequent irrigations under higher IW/CPE ratios and deep root development in 30-60 cm soil layer with lower IW/CPE ratios, because of stress condition.

5.3 Effect of mulching

The growth of maize as measured in terms of height, number of functional leaves, leaf area, leaf area index, dry matter accumulation and days to 75 per cent silking was favourably influenced due to mulching. The plant height was not influenced due to mulching over no mulch treatment at any of the growth stages during both the seasons. However, application of mulch recorded slightly more plant height than no mulch. The growth functions on plant height viz $\overline{CGR}$ and $\overline{RGR}$ did not show any definite trend with mulch and no mulch treatment [Table 9,10 and 11].

The number of functional leaves per plant was not significantly influenced, at all the growth stages in both the seasons. However, the application of mulch had shown its superiority over no mulch for number of functional leaves per plant after 75 days from sowing during 1986-87. The canopy coverage in terms of leaf area/plant and leaf area index were significantly more with the application of mulch than no mulch at all the growth stages, except at 30 DAS during 1986-87 [Table 12, 13 and 15]. The mulching might have conserved more soil moisture which may be utilized more efficiently by plant and resulted in more leaf area and leaf area index. Similar results have been reported by Chowdhary and Chatterjee [1967], Choudhary and Prihar [1974], Balaswamy et al. [1986] and Shekour et al. [1987].

Mulching treatment had accumulated significantly more dry matter/plant than no mulch at 30,60 and 105 DAS during 1986-87. The marked improvement in root development under mulching might have extracted more soil moisture and increased the dry matter production. Increased dry matter production due to mulching was also reported by Tamlin et al. [1973], Okigbo [1981], Balaswamy et al. [1986] and Shekour et al. [1987].

The growth functions on dry matter viz $\overline{CGR}$, $\overline{RGR}$ and and $\overline{NAR}$ did not show any definite trend under mulch and no mulch treatment during both the years.

Mulching did not show significant impact on seventy five per cent silking over no mulch during both the seasons. However, it was slightly early with mulch during 1986-87. Okigbo [1981] also observed less number of days for silking under mulching treatment.

The number of cobs/plant and number of cobs/net plot at harvest were not significantly incluenced due to mulching during both the seasons.

The various yield components viz length and girth of cob, number of grains/row and/cob, number of grain rows/cob and test weight were not markedly influenced due to mulching in both the seasons [Table 21]. The soil of the experimental field was of vertisol in nature having 1 metre depth, which might have conserved sufficient moisture even under no mulch treatment resulting in nullifying the effect of mulch on these characters during 1986-87 and 95 mm of effective rainfall received during 1987-88 might have nullified the effect of mulching during this year.

The grain and stover yields were significantly increased due to mulching during both the seasons and when data were pooled, except the grain yield in 1987-88. The pooled grain and stover yields were increased by 2.47 and 3.44 per cent due to application of mulch over no mulch [Table 22]. Though the yield components did not increase significantly, they showed a favourable improvement under mulching because of more moisture storage and its extraction, which might have reflected in significant increase in grain and stover yields. Similar results were also reported by Rajput and Singh [1970], Bansal et al. [1971], Um rani et al. [1973], Tamlin [1973], Lal [1974], Olson and Horton [1975], Bhan [1976], Khera et al. [1976], Dahiya and Singh [1977], Prihar et al. [1979], Reddy et al. [1979], Bhan and Khan [1980], Okigbo [1981], Balaswamy et al. [1986] and Shekour et al. [1988].

Mulch had produced significantly more gross monetary returns during 1986-87 and when data were pooled than no mulch

[Table 25]. This was ascribed to the increased grain and stover yields under mulch treatments. However, the net profit was not influenced due to mulching.

Nitrogen and phosphorus content in the constituent parts of maize were not significantly influenced due to mulching in both the seasons. However, mulch had shown higher concentration of N and P than no mulch. The absorption of more N and P under mulch treatment due to better moisture situtation might have increased their concentration in constituent parts.

Mulching had resulted in favourably higher uptake of N and P by grain and stover during both the years of study and in pooled data. The total N uptake was significantly increased due to mulching in 1986-87 and when data were pooled over no mulching [Table 28]. This was ascribed to more N content in grain and stover and their higher yields under mulched plots might have increased nitrogen uptake. Khera et al. [1976] also obtained significantly increased green and dry forage yields and uptake of N and P with mulching.

The protein per cent, protein production and protein production efficiency were favourably improved under mulch than no mulch during both the years. The protein production by stover and total protein production and protein production efficiency were significantly increased under mulched treatment than no mulch during 1986-87. This might be attributed to higher grain and stover yields with mulch.

The consumptive use of water was more under mulching viz 345.16 and 331.63 mm during 1986-87 and 1987-88, respectively. This may be due to storage of more soil water under mulching might have resulted in more vegetative growth and more transpiration. Therefore, more soil moisture might have been extracted by the crop resulting in more CU, whereas the consumptive use efficiency and water use efficiency were more under no mulch treatment. Thus, reverse was true under no mulch treatment, where lesser amount of available soil moisture was more efficiently utilized resulting in more CUE.

5.4 Effect of irrigation layouts

The growth attributes viz plant height, number of functional leaves, leaf area, leaf area index and dry matter accumulation/ plant were not significantly influenced either due to planting on ridges and furrows or on flat beds [Table 9, 12, 13, 15 and 16]. However, these growth attributes were favourably improved under ridges and furrows. This may be ascribed to more moisture conservation and its subsequent availability for better crop development.

The values of growth functions on plant height and dry matter viz $\overline{CGR}$ and $\overline{RGR}$ were comparatively more with planting on ridges and furrows, than on flat beds [Table 10, 11, 17, 18 and 19]. This may be due to production of more height and dry matter/plant under ridges and furrow layout.

The number of leaves/plant, leaf area/plant and leaf area index were in general more with ridge planting than flat bed planting. The better root development under ridges and furrows due to proper soil aeration may have resulted in availability of more moisture and nutrients to the plant. Similar results were obtained by Bhinder and Sawhney [1985].

Dry matter production though not affected significantly due to different irrigation layouts, it showed favourable improvement under ridges and furrows layout during both the years [Table 16]. The dry matter production is a result of photosynthetic activity, which was thus favourably influenced due to planting of maize on ridges and furrows.

The photosynthetic efficiency of leaves as measured by $\overline{\text{NAR}}$ values were, in general, higher with planting on ridges and furrows as compared to flat bed planting [Table 19].

The significant difference in days to 75 per cent silking, number of cobs/plant, number cobs/net plot and number of plants at harvest were not observed between the irrigation layouts during both the seasons [Table 20].

The important yield components viz grain weight/plant, length and girth of cob, number of grain rows/cob, number of grains/cob and/row and 1000 grain weight were not significantly influenced due to different irrigation layouts. However, planting of maize on ridges and furrows showed favourable influence on these yield components, which may be attributed to the better availability of moisture and nutrients due to better aeration under ridges and furrows.

The grain and stover yields were not significantly influenced due to different irrigation layouts. However, planting of maize on ridges and furrows showed slight improvement in grain and stover yields. The consistent favourable influence of ridges and furrows planting on growth and yield contributing characters might have reflected in favourable influence on yields [Table 22].

The cost of cultivation, gross and net monetary returns were not significantly influenced due to different irrigation layouts. The cost benefit ratio was more under flat bed planting than ridges and furrows during both the years of experimentation because of low cost required for the preparation of flat beds. These results are in conformity with the findings of Singh et al. [1984], Anonoymous [1985] and Eckert [1988].

The concentration of N and P in the constituent parts of maize was not significantly influenced due to different irrigation layouts [Table 26 and 27]. However, there was more concentration of N & P in the constituent parts of the plant with planting on ridges and furrows, than on flat beds. The absorption of more nutrients due to better physical soil conditions viz soil aeration, bulk density etc. might have resulted in more concentration of the nutrients in the constituent parts of maize planted on ridges and furrows.

The uptake on N and P, protein content, protein production and protein production efficiency were not significantly influenced due to different irrigation layouts during both the years of study. No definite trend was also recorded for these characters [Table 29].

5.5 Effect of interaction

In the foregoing sections of this chapter an attempt has been made to discuss the effect of individual factor under study. The picture, however, would not be clear unless relationships between factors involved in the study are discussed. In general, it was observed that the effect of interaction was not clearly brought out in both the seasons. The interaction effects were found to be absent in respect of growth attributes, yield contributing characters and yield and qualitative aspects, except leaf area/plant and grain yield as affected by the interaction of irrigation scheduling and mulching during 1986-87. The scheduling of irrigation at 0.4 IW/CPE ratio produced significantly less leaf area per plant than 1.0, 0.8 and 0.6 IW/CPE ratios where mulch was not applied. Similarly, scheduling of irrigation at 0.6, 0.8 and 1.0 IW/CPE ratios in combination with mulch significantly increased leaf area per plant than in combination with no mulch.

Irrigation scheduled at 0.8 and 1.0 IW/CPE ratios increased grain yield significantly over 0.4 and 0.6 IW/CPE ratios, under no mulch treatment, whereas grain yield was significantly increased with increased number of irrigation under mulch treatment. Application of mulch significantly produced more grain yield, than no mulch treatment at 0.6 IW/CPE ratio [Table 23]. The quantum of conserved moisture might have more effectively utilized under mulch treatment at 0.6 IW/CPE ratio, than higher IW/CPE ratios, resulting in increased grain yield.

5.6 Correlation study

The important yield components viz dry matter/plant, cob length and grain numbers/row were highly significantly correlated, whereas cob girth, grain rows/cob and test weight were significantly correlated with grain yield/plant [Table 31]. Therefore, it would be rewarding to lay emphasis on dry matter/plant, cob length and grain numbers/row in selection programme for improving maize grain yield. All the yield components were either highly significantly or significantly correlated among themselves, except cob length, grain number/line, grain weight/plant with plant height, leaf area/plant, cob number/plant and grain number/cob.

The growth and yield contributing characters viz plant height, leaf area/plant, dry matter/plant, cob length, cob girth, grain rows/cob, grain numbers/cob and thousand grain weight, were highly significantly correlated to the grain weight/plant during 1987-88 [Table 32]. Therefore, simultaneously selection of these characters must be adopted to achieve substantial yield improvement in maize. Most of the yield components were either significantly or highly significantly correlated among themselves. These results are in agreement with the findings of Muthukrishnan and Subramanian [1980] and Subramanian et al. [1981]. Further, it was observed from the data in Table 32, that there was a weak correlation between cob number/plant and other characters which was negatively correlated with leaf area/plant, cob girth and grain rows/cob.

The consumptive use of water was positively and highly significantly correlated with grain yield, whereas water use efficiency was negatively and highly significantly correlated with grain yield during both the years [Table 33].

Highly significant negative correlation was also observed in between consumptive use and water use efficiency in both the years, indicating that increase in CU resulted in lower WUE.

5.7 Energy relationship

5.7.1 Effect of irrigation scheduling

The energy inputs were maximum with irrigation scheduled at 1.0 IW/CPE ratio and were slightly decreased with decrease in IW/CPE ratio in both the seasons and in mean data [Table 34]. This could be assigned to more frequencies of irrigation with 1.0 IW/CPE ratio. The energy output was gradually decreased with decrease in IW/CPE ratios during both the seasons and in mean data. This might be due to decreased grain and stover yield with irrigation scheduled at lower IW/CPE ratios. Further, the energy balance was negative with irrigation scheduling at all the IW/CPE ratios. However, energy balance and energy use efficiency were progressively increased with increase in IW/CPE ratios during both the years and in mean data.

5.7.2 Effect of mulching

The energy inputs were comparatively double with mulching with sugarcane trash over no mulch. This might be due to higher energy inputs required for the application of mulch. But the energy output showed slightly higher values with mulching due to higher biomass production. The energy balance and energy use efficiency was positive with no mulching, whereas it was negative with mulching.

5.7.3 Effect of irrigation layouts

The energy inputs as well as energy outputs were slightly more with planting on ridges and furrows than on flat beds. This might be due to more energy inputs required for preparation of ridges and furrows. The energy balance and energy balance/unit input were negative under both the irrigation layouts during both the seasons and in mean data.

Summary & Conclusion

6. SUMMARY AND CONCLUSION

The present agronomic investigation, the results of which have been reported and discussed in the preceding chapters, was planned with a view to findout the best IW/CPE ratio for scheduling irrigation to maize, to study the effect of mulch on moisture conservation and to findout the suitable irrigation layout, which will be useful for water saving in Kolhapur region.

The present investigation was conducted at the Shahu Agricultural School Farm of the Gramsevak Training Centre, Kolhapur during rabi season of 1986-87 and 1987-88 on the same site with the same randomization of treatments.

The soil of the experimental field was clayloam in texture, medium in total nitrogen and available phosphorus and fairly rich in available potassium and slightly alkaline in reaction. The moisture at 1/3 and 15 bar was 36.50 and 37.10 and 20.80 and 21.10 per cent at 0-30 and 30-60 cm soil depth, respectively. The bulk densities at these depths were 1.13 and 1.19 g/cc, respectively.

The experiment was laidout in split plot design, replicated four times. The gross and net plot sizes were 6.0 x 4.5 and 4.5 x 3.0 m^2, respectively. There were 16 treatment combinations formed due to 4 IW/CPE ratios viz 1.0, 0.8, 0.6 and 0.4 tried in main plots and combination of two mulching treatments viz no mulch and mulch and two irrigation layouts viz ridges and furrows and flat beds in sub plots were under studies.

The maize was dibbled at 75 x 25 cm spacing on 21st October, 1986 and 23rd October, 1987 with 2 seed/hill. Nitrogen [120 kg/ha] was given in 3 split doses and phosphorus [80 kg/ha] in 2 equal split doses.

In general, the season was favourable during the entire period of crop growth. The total precipitation received during the crop growth period was 110.4 and 143.8 mm in 1986-87 and 1987-88, respectively.

Besides the yield data, periodical observations on growth and yield components were recorded at 15 days interval from 30th day after sowing, till the harvest of the crop. The monetary returns, cost of cultivation and net monetary returns were workedout. The uptake of N and P was recorded and the quality of maize on the basis of protein content was determined.

Soil moisture contents before and after each irrigation were determined. Consumptive use of water, consumptive use and water use efficiences were determined. Correlation studies between yield/plant and important growth and yield contributing characters and between grain yield/ha and consumptive use of water and water use efficiency were worked out. The energy relationships were studied. Some of the important findings that emerged from this investigation are summerised below.

6.1 Effect of irrigation scheduling

The important growth attributes viz plant height, number of functional leaves/plant showed a favourable influence of scheduling of irrigation at 1.0 and 0.8 IW/CPE ratios, while the leaf area/plant, leaf area index and dry matter accumulation/plant were significantly more under 1.0 and 0.8 IW/CPE ratios than 0.4 and 0.6 IW/CPE ratios.

The days to seventy five per cent silking were significantly less with scheduling of irrigation at 1.0 IW/CPE ratio than 0.6 and 0.4 IW/CPE ratios. The number of cobs/net plot were significantly more with 1.0 and 0.8 IW/CPE ratios, compared to 0.4 IW/CPE ratio.

The important yield contributing characters viz grain yield/plant, length and girth of cob, number of rows/cob, number of grains/row and/cob and 1000 grain weight were significantly increased with scheduling of irrigation at 1.0 IW/CPE ratios, than lower IW/CPE ratios during both the seasons.

The grain and stover yields of maize were significantly more with scheduling of irrigation at 1.0 and 0.8 IW/CPE ratios over 0.6 and 0.4 IW/CPE ratios during both the years of experimentation and when data were pooled. The pooled grain yield was increased by 10.39, 20.03 and 24.87 per cent with 0.6, 0.8 and 1.0 IW/CPE ratios, respectively over 0.4 IW/CPE ratio.

The harvest index and grain production efficiency were significantly increased with increased IW/CPE ratios.

The response to irrigation scheduling was found to be linear during both the years and in pooled data.

The gross and net monetary returns were significantly more with scheduling of irrigation at 1.0 IW/CPE ratio as compared to lower IW/CPE ratios, during both the years of study and when data were pooled over season, suggesting suitability of this ratio for irrigation scheduling.

The uptake of nitrogen by grain and total N uptake and P uptake by stover was significantly higher with scheduling of irrigation at 1.0 and 0.8 IW/CPE ratios than lower IW/CPE ratios. The pooled total N uptake also showed similar trend.

The protein production by grain and stover and total protein production and protein production efficiency were significantly higher with scheduling of irrigation at 1.0 and 0.8 IW/CPE ratios as compare to 0.6 and 0.4 IW/CPE ratios, during both the years of experimentation.

The energy inputs and outputs were maximum with scheduling of irrigation at 1.0 IW/CPE ratio and decreased with decrease in IW/CPE ratios. The energy balance was negative with all the IW/CPE ratios.

The daily and total consumptive use of water was the highest with the scheduling of irrigation at 1.0 IW/CPE ratio during both the years of study. But reverse was true for the consumptive use of water and water use efficiencies.

6.2 Effect of mulching

The important growth attributes viz plant height, number of functional leaves and leaf area/plant, leaf area index and dry matter accumulation/plant were favourably influenced due to application of mulch during both the years of study. However, significant differences in leaf area/plant were observed during 1986-87.

The days to 75 per cent silking, number of cobs/plant and/net plot number of plants/ha at harvest and yield contributing characters were not influenced due to mulching, in both the seasons. However, it had shown its superiority over no mulch.

The grain and stover yields and grain production efficiencies were significantly increased by mulching in both the years of experimentation and in pooled data, except grain yield during 1987-88, not affected.

Mulching significantly increased gross monetary returns than no mulch treatment.

The total N uptake, total protein production and protein production efficiencies were significantly increased under mulched treatment than no mulch.

The consumptive use of water by maize was higher under mulching than no mulch, but the consumptive use and water use efficiencies were more under no mulch.

The energy inputs were markedly more with mulch treatment than no mulch. The energy balance and energy use efficiency were positive with no mulch, whereas, it was negative with mulch.

6.3 Effect of irrigation layouts

The important growth attributes viz plant height, number of functional leaves and leaf area/plant, leaf area index and dry matter accumulation/plant showed favourable improvement with planting on ridges and furrows over flat bed planting.

The days to 75 per cent silking, number of cobs/plant, number of cobs/net plot and number of plants at harvest were not significantly influenced due to both the irrigation layouts.

The important yield contributing characters, grain and stover yields, harvest index, cost of cultivation, gross and net monetary returns were not significantly influenced, due to different irrigation layouts. However, ridges and furrows layout showed its superiority over flat beds.

The uptake of N and P, protein content, protein production and protein production efficiency were not significantly incluenced due to different irrigation layouts.

6.4 Correlation study

The grain yield/plant was highly significantly correlated with dry matter/plant, cob length and grain number/row, whereas it was significantly correlated with cob girth, grain rows/cob and test weight during 1986-87.

The consumptive use of water was positively and highly significantly correlated with grain yield, whereas water use efficiency was negatively and highly significantly correlated with grain yield. A highly significant negative correlation was also observed between consumptive use and water use efficiency.

6.5 Interaction effects

The interaction effects between different factors under study were found to be nonsignificant for all the characters, except leaf area/plant and grain yield/ha, which were significantly affected by interaction between irrigation scheduling and mulching.

6.6 Conclusions

1. The scheduling of irrigation at 0.8 and 1.0 IW/CPE ratios significantly increased growth and yield contributing characters and grain and stover yields as compared to 0.4 and 0.6 IW/CPE ratios.

2. The gross and net monetary returns were significantly more with scheduling of irrigation at 1.0 IW/CPE ratio. It would be, therefore, advisable to irrigate maize with 1.0 IW/CPE ratio during rabi season in Kolhapur region to obtain more monetary advantage.

3. The irrigation scheduled at 0.8 and 1.0 IW/CPE ratios significantly increased N uptake by grain, total N uptake and P uptake by stover as compared to 0.4 and 0.6 IW/CPE ratios. The energy inputs and outputs showed increasing trend with increased IW/CPE ratios.

4. The consumptive use of water was the highest with the scheduling of irrigation at 1.0 IW/CPE ratio, whereas water use efficiency was the lowest, while it was the highest with 0.4 IW/CPE ratio.

5. The application of mulch significantly increased grain and stover yields, total protein production and protein

production efficiency as compared to no mulch. The consumptive use of water was also more with mulching.

6. The growth and yield contributing characters and grain and stover yields were not significantly influenced due to different irrigation layouts. However, yield components and yields showed slight improvement, when maize was planted on ridges and furrows.

7. The grain yield/plant was positively and highly significantly correlated with dry matter/plant, cob length and grain number/row, whereas it was significantly correlated with cob girth, grain rows/cob and thousand grain weight during both the years. Therefore, due emphasis should be given for simultaneous selection of these characters for substantial yield improvement in maize.

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Appendices

8. APPENDICES

Appendix-A

Following prices were considered for calculating cost of cultivation

Sr. No.	Particulars	Rates [Rs] 1986-87	Rates [Rs] 1987-88
1.	Man and Woman	10.0/day	10.0/day
2.	Tractor [Rs/ha]	250.00	250.00
3.	Certified seed of maize [Rs/kg]	6.00	6.00
4.	Nitrogen [Rs/kg]	4.63	5.30
5.	Phosphorus [Rs/kg]	5.78	5.62
6.	Endosulfan [Rs/litre]	45.00	52.00
7.	Nuvacron [Rs/litre]	212.00	220.00
8.	Dithane M-45 [Rs/kg]	-	78.00
9.	Irrigation [inclusive of application charges] [Rs/turn]	75.00	75.00
10.	Mulch [Rs/ton]	10.00	10.00
11.	Supervision charges @ 10 per cent on production cost.		
12.	Interest on working capital @ 14 per cent for half life period of the crop.		
13.	Hire charges on implements Rs.100/crop/year.		
14.	Land rent Rs 500/crop/year.		

Appendix - B

STRUCTURE OF ANALYSIS OF VARIANCE

Sr.NO.	Source of variation	Degrees of freedom
1.	Replications	3
2.	Main plot [IW/CPE ratios]	3
3.	Error [a]	9
4.	Sub-plots [Mulching]	1
5.	Main x sub-plots	3
6.	Sub-sub plots [Irrigation layouts]	1
7.	Main x sub-sub plots	3
8.	Sub x sub-sub plots	1
9.	Main x sub x sub-plots	3
10.	Error [b]	36
	Total	**63**

Appendix - C

ENERGY VALUES OF INPUTS AND OUTPUTS

Sr.No.	Input or Output items	Energy M Cal/unit
A]	**Inputs :**	
1.	One bullock unit [Extra feed energy for working day]	22.40/bullock pair/day*
2.	One man-day	3.90/man-day*
3.	Fixed energy for bullock operated farms in the form of bullocks and related equipments.	7,600/ha*
4.	Fertilizers	
	Nitrogen [Urea]	6.60/kg*
	Phosphorus [Single super phosphate]	0.40/kg*
5.	Irrigation	71.10/cm ha of water*
6.	Seed [Maize]	8.53/kg*
7.	Pesticides	
	Endosulfan 35 EC	24.25/litre***
	Nuvacron	24.25/litre***
	Dithane M-45	24.25/litre***
8.	Mulch	3.66/kg*
B]	**Outputs :**	
1]	Grain	3.42/kg**
2]	Byproducts	4.40/q*

Source : * Gupta et al [1984] ** Gopalan et al. [1982]
*** Pimental [1980] *** Pimental et al. [1973]
* Sajanpawar [1983]

Vita

9. VITA

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of
DOCTOR OF PHILOSOPHY [Agriculture]
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Biographical information

-Personal : Born at Asad, Taluka Khanapur, District Sangli on June 7, 1950; son of Shri S.B. Jadhav, Asad, married Mangala Shinde on March 27, 1976; daughter Arati and son Rahul.

-Educational : Attended secondary school at Chinchani [Ambak], Khanapur, Sangli. Received the Bachelor of Science [Agriculture] degree with first class with Hons. in 1971 and Master of Science [Agriculture] degree in Agronomy in first class with distinction in 1973 from the Mahatma Phule Krishi Vidyapeeth, Rahuri - 413 722. Completed Ph.D. Course work of 49 credits with 3.69 C.G.P.A. out of 4 at the I.A.R.I., New Delhi in Agronomy. Selected to attend the 12th International course on Potato Production, Storage and Processing at Wageningon, The Netherlands from April to July, 1983].

-Professional : 1973 to 1980 Assistant Professor of Agronomy, College of Agriculture, Kolhapur, 1980-1984 Students Welfare Officer, College of Agriculture, Kolhapur. April, 1984 to Sept. 1984 Jr.Agronomist, All India Co-ordinated Project on Oilseeds [Safflower], Solapur; Sept. 1984 to April, 1986 deputed for Ph.D. degree course work in Agronomy at the I.A.R.I., New Delhi; April, 1986 onwards till this day, Assistant Professor of Agronomy, Gramsevak Training Centre, Kolhapur. Attended Summer Institute on Agro-meteorology [June 6-26, 1976], Teachers' Training in Agril. Meteorology [May to July, 1980] at the I.M.D., Pune; Course on Training Methods and Teaching in Rural Development for Principals of C.T.C., G.T.C's and P.R.T.C.'s [March 21-26, 1988] at M.I.DA, Pune. Member of Maharashtra Journal of Agriculture, Pune. Published 2 popular articles in Marathi in reputed journals & 4 popular articles through Marathi Newspapers. Attended 3 special N.S.S. camps.