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Drip fertigation study in spring maize (*Zea mays* L.)

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■ **ABSTRACT :** Drip system can control the rate of water application to achieve application efficiency as high as 92-95%. It is also excellent for soil with higher infiltration rates. In conventional way of nutrient management, the P and K are applied as basal. However, the demand for these two macro-nutrients remains high during the entire growing season. Splitting of K was more beneficial than applying full K at time of planting in soybean. Maize is one of the crop that responses well to phosphatic fertilizers in almost all the soil types. Phosphorus plays vital role in plant nutrition. The deficiency of phosphorus in soil severely limits root and shoot growth and thereby affecting the yield. The experiment consisting of 3 irrigation regimes (100% CPE, 80% CPE and 60% CPE), 2 fertilizer dose (75% RDF and 100% RDF), 2 PK splitting (equal and 70/30) along with 2 control treatments (flood IW: CPE 0.8 with mulch and flood IW:CPE 1.0) was laid out in Split Plot Design with three replications. From findings of present investigation based on cob weight without husk it can be inferred that spring maize in sandy loam soil should be irrigated at 80% CPE. It should be fertilized at 90:45:30 N, P_2O_5, K_2O kg/ha with PK application as 70% upto tasseling and 30% thereafter.

■ **KEY WORDS :** CPE, RDF, PK, LAI, NPK

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Maize (*Zea mays* L.) is the most versatile crop with wider adaptability in varied ecologies. It is an important cereal crop for food, feed and fodder. It is a miracle crop with the highest genetic yield potential among the cereals and also known as 'Queen of cereals' (Kanaan *et al.*, 2013). Worldwide, maize is cultivated on 177 million hectare area with total production of 967 million tonnes at a productivity of 5.46t/ha. In India, maize is cultivated on 9.43 million hectare area, with production and productivity of 24.4 million tonnes and 2.58 t/ha, respectively. Maize is grown mainly as a rainfed crop during *Kharif* season with only 22.8% area under irrigated conditions. It can also be grown successfully during *Rabi* and spring seasons in different parts of India for various purposes including grain, fodder, green cobs, sweet corn, baby corn, pop corn, and ethanol and oil production with the available suitable varieties. During initial phase, temperatures are low to moderate till knee high stage and starts rising thereafter. During reproductive phase, crop experiences quite hot weather. Therefore, during spring season, irrigation is a must to harness good yield of the maize. In Indian agriculture, water is becoming a scarce natural resource particularly due to changing climate. It has been proved by studies that drip and sprinkler methods of irrigation helps to save water and improve water use efficiency. Moisture stress (drought) is considered to be the primary limiting factor affecting maize production; therefore, shortages and uneven distribution of water availability restrict crop growth. Surface flood is the most common method of irrigation application to maize, having very poor efficiency. Mulch provides a better soil environment, maintains soil temperature, increases soil porosity and water infiltration rate during intensive rain and controls runoff and erosion as well as suppresses the weed growth. Supply of water to the plant with correct quantity at the correct time without creating any hazardous effect to the soil-plant environment is considered to be proper irrigation. Therefore, efficient method of irrigation is the key factor for successful irrigated farming system. One of the best methods to increase the efficiency and the uniformity of irrigation is the use of micro irrigation techniques. Drip system can control the rate of water application to achieve application efficiency as high as 92-95%. It is also excellent for soil with higher infiltration rates. Unlike surface and sprinkler irrigation, the drip system can keep the soil water content always near the field capacity without creating any moisture deficit to crop. Drip irrigation system is also designed to apply only the required amount of water. Therefore, it minimizes the water losses from runoff, percolation and seepage. Drip irrigation conserves 50-70% water besides increasing productivity across crops. Most importantly, fertilizer can be injected to the irrigation water which is commonly known as fertigation. Drip fertigation improves crop productivity by 60-100% (Sritharan, 2010). The drier soil surface associated with drip irrigation system also offers the advantages of smaller evaporative water losses; higher infiltration rates for natural precipitation, thereby reducing runoff and erosion besides improving trafficability (Brown *et al.*, 1991). In drip system, only limited amount of water is applied per irrigation however the watering is done frequently to maintain good soil moisture in the root zone. For higher efficiency of the applied water, its optimum time and depth of application is a pre-requisite (Narayanamoorthy, 2005). Application of right amount of water at right time is the key to obtain higher water and crop productivity. It is quite easy with the drip irrigation system. Maize has been found to respond differently to drip irrigation scheduling. Yazar *et al.* (2002) obtained the highest average corn yield (11920kg/ha) from the full irrigation treatment (100% CPE) with 6 days interval. Singh *et al.* (2015) concluded that the IW: CPE ratio 0.90 was found optimum the spring maize (*Zea mays* L.) for applying drip irrigation. Salah and Mohamad (2008) observed that irrigation applied at 0.80 and 0.60 ET consistently resulted in lower yields than the 1.00 ET in maize, with average yield reduction for 0.80 and 0.60 ET relative to 1.00 ET was 33 and 64%, respectively. Maize is a C_4 plant and a heavy feeder of nutrients especially nitrogen thus has a fast growing rate. The rapid growth of maize in the early stages is associated with its need for a liberal dressing of readily available nutrients at the very early stage, but a vast majority of Indian farmers cannot afford adequate application of this crucial nutrient. Therefore, nutrient supply is one of the most important factors that determines the growth and development of crop. Hence, optimization of nutrient availability/dose during the crop growth needs priority in corn production. Though, the use of higher dose of nitrogen increases yield but it impaired the protein quality. Many studies indicated that use of chemical fertilizers might form the major contributing factor for higher agricultural production but its continuous application may have some deleterious effects on soil quality which in turn reflects on crop yield. The beneficial effects of fertilizers can be increased by the use of appropriate placement of fertilizer, especially when the spacing between rows is wide. In case of broadcasting of fertilizers, nutrients (particularly P and K) are exposed to great area of soil; hence, more fixations take place than the band placement. In well-drained soils, phosphate ions normally do not move very far from their place of application. A significantly better method of increasing the availability of phosphorus is band fertilization, where the fertilizer is placed in the direct vicinity of roots. In drip systems, the fertilizers are applied directly to the root zone in confined area thus enhance its availability to roots. In conventional way of nutrient management, the P and K are applied as basal. However, the demand for these two macro-nutrients remains high during the entire growing season. Splitting of K was more beneficial than applying full K at time of planting in soybean. Maize is one of the crop that responses well to phosphatic fertilizers in almost all the soil types. Phosphorus plays vital role in plant nutrition. The deficiency of phosphorus in soil severely limits root and shoot growth and thereby affecting the yield. Potassium application hasten silking in corn, but did not shorten the total production cycle thus gave scope for longer period of grain filling and higher yield (Chauhan, 2010). The research work done so far on drip fertilized maize is scanty. It is, therefore, necessary to find out precise package of fertigation management to achieve higher production of maize and also to work out drip irrigation system to maximize water use efficiency. Hence, the present study is undertaken on drip irrigated maize during spring season for green cobs targeting the following objectives:- (i) To work out optimum CPE based irrigation schedule for drip irrigated spring maize (ii) To study the effect of NPK doses and PK scheduling on growth and productivity of maize (iii) To study the moisture dynamics, nutrient uptake and economics under different treatments (iv) To compare the performance of drip fertilized maize with surface flood method with and without mulch.

METHODOLOGY

A field experiment was conducted during spring 2016. A detailed account of the materials used and techniques followed during experimentation is given in this chapter.

Experimental site:

The field experiment was conducted during the spring season, 2016 at the Bhagwant University Farm Ajmer Rajasthan. Ajmer is situated at 26.44^0 N latitude, 74.5-63^0 E longitude and altitude of 480m above mean sea level in the foot hill range of the Himalayas.

Climate of the region :

The climate of the region is broadly humid subtropical with cool winter and hot dry summers. During summer season, the maximum temperature exceeds 40^{0}C during June while in winters the minimum temperature touches 0^{0}C during January. The monsoon onsets in the 3rd week of June and ends by the middle of September. Frost is expected from late December to middle of February. The mean relative humidity remains almost 80-90% from mid January to end of February and then it steadily decreases to 50% by the first week of May and remains so till mid June. During spring season, the evaporation rates remain high and often exceed 10mm/day particularly during the month of May. The mean annual rainfall is about 1450mm of which 80 to 90% is received during the wet season.

The mean weekly maximum temperature during March to May 2016 ranged from 26.9 to 41.1^{0}C whereas the mean weekly minimum temperature ranged from 12.7

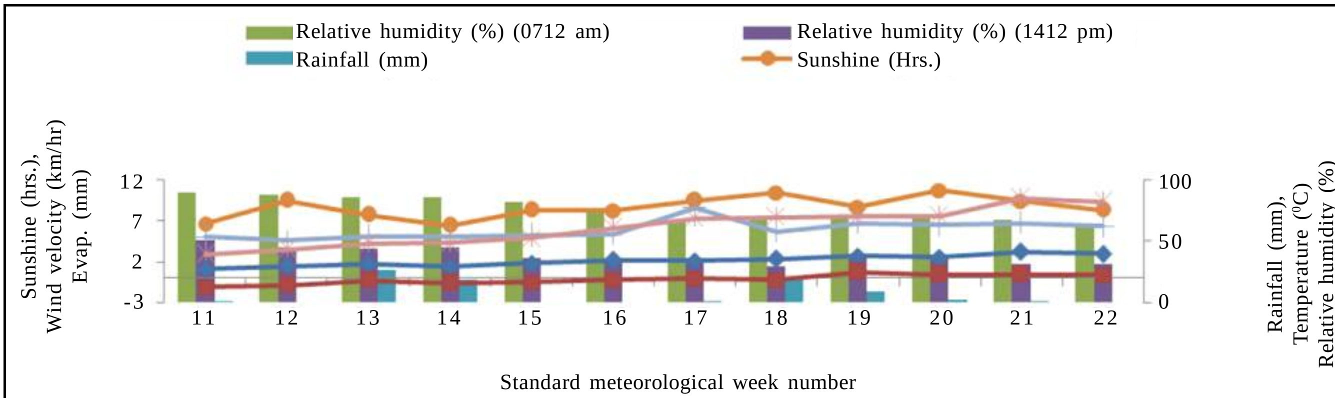

Fig. A : Weekly weather parameters during the crop period at B.U Farm Ajmer

Table A : Physico- chemical characteristics of experimental soil

Soil properties	Value	Method used
Soil texture	Sandy loam	Hydrometer method (Deshpande *et al*., 1971)
Bulk density (Mg/m^3)	1.46	Core method (Richards, 1954)
Basic infiltration rate (cm/hr)	1.30	Double ring infiltrometer
pH (1:2.5 soil : water suspension)	7.97	Beckman Glass Electrode pH meter (Jackson, 1973)
Organic carbon (%)	0.034	Modified Walkley-Black method (Jackson, 1973)
Available nitrogen (kg/ha)	184.20	Alkaline $KMnO_4$ (Subbiah and Asija, 1956)
Available phosphorus (kg/ha)	30.26	Olsen's method (Olsen *et al*., 1954)
Available potassium (kg/ha)	252.68	Flame Photometric (Jackson, 1973)

to 24.5^{0}C. The mean minimum relative humidity varied from 29 to 51% whereas, mean maximum relative humidity varied from 63 to 90%. The mean sunshine varied from 6.6 to 10.7 hours per day during the crop growing season. The total rainfall received during the crop season was 75.5mm out of which the maximum was received in the month of May.

Experimental details :

The experiment was laid out in Split plot design with two control treatments having three replications. The treatments were consisted of three levels of drip irrigation scheduling based on CPE loss, two levels of fertilizer dose and two different P and K fertilizer application schedule. The control treatments were surface flood irrigation with and without mulch. The details of the treatments are as follows:- (i) Factor A:-Drip irrigation schedule:- (a) 60% CPE (b) 80% CPE (c) 100% CPE (ii) Factor B:- NPK dose (a) 90: 45: 30kg NPK /ha (75% RDF) (b) 120: 60: 40kg NPK/ha (iii) Factor C:-PK fertilizer application schedule:- (a) In equal splits during the entire growth period (b) 70% till teaseling and 30% thereafter (iv) Control plots:- (a) Flood surface irrigation at IW:CPE 1.0 without mulch (b) Flood surface irrigation at IW:CPE 0.80 with mulch.

Field preparation:

The field was prepared by three cross harrowing with the tractor mounted disc harrow and three planking for pulverization. Thereafter, the field was leveled with

Table B : Treatment combinations

Symbols	Treatments
T_1	60% CPE with 75% recommended fertilizer dose and PK in equal splits
T_2	60% CPE with 75% recommended fertilizer dose and PK in 70/30 splits
T_3	60% CPE with 100% recommended fertilizer dose and PK in equal splits
T_4	60% CPE with 100% recommended fertilizer dose and PK in 70/30 splits
T_5	80% CPE with 75% recommended fertilizer dose and PK in equal splits
T_6	80% CPE with 75% recommended fertilizer dose and PK in 70/30 splits
T_7	80% CPE with 100% recommended fertilizer dose and PK in equal splits
T_8	80% CPE with 100% recommended fertilizer dose and PK in 70/30 splits
T_9	100% CPE with 75% recommended fertilizer dose and PK in equal splits
T_{10}	100% CPE with 75% recommended fertilizer dose and PK in 70/30 splits
T_{11}	100% CPE with 100% recommended fertilizer dose and PK in equal splits
T_{12}	100% CPE with 100% recommended fertilizer dose and PK in 70/30 splits
T_{13}	Flood irrigation at IW:CPE ratio 1.0
T_{14}	Flood irrigation at IW:CPE ratio 0.80 with mulch

Table C : Details of experiment

Particulars	Description
Site of experiment	Bhagwant University Farm Crop Research Center, Ajmer
Experimental design	Split plot design with drip irrigation schedule and NPK dose in main and PK application schedule in sub plots with two controls *i.e.* surface flood un mulched and mulched
Crop	Maize
Total number of treatments	(3 × 2 × 2) + 2 = 14
Number of replications	3
Total number of plots	42
Variety	Pragati (composite)
Plot size	4.0 m x 3.0 m = 12 m^2
Spacing	Row to row = 60cm Plant to plant =20cm
Sowing method	Flat planting
NPK sources	NPK mixture (12:32:16) MoP (0:0:60) Urea (46: 0: 0) Water soluble fertilizers i.e. NPK (18: 18: 18) and urea phosphate (17: 44:0)
Mulch	Fine rice straw @ 6.0 t/ha was applied immediately after sowing of maize crop.

leveler and layout was made.

Fertilizer application:

In drip treatments, the fertilizers were applied in 9 equal splits at weekly interval including basal. Urea, and water soluble fertilizers were used for drip treatments. For surface flood, the NPK were applied through urea, NPK mixture and MoP. Half dose of N and total P&K were applied as basal and remaining N in two equal splits at knee high and tasseling stages.

Variety :

Maize composite variety **"**Pragati" was used for the study. It is an early maturing composite with yellow colour grains.

Sowing :

The furrows were opened manually with the help of furrow opener at the distance of 60cm. Two seeds were planted in the furrows at a seed to seed distance of 20cm. At 20 DAS, thinning was done to maintain the plant to plant distance at 20cm.

Irrigation application:

In control plots, flood irrigation was applied as per treatment based on IW: CPE ratio. In drip treatments irrigation was scheduled accordingly to the treatment through the drip system based on the pan evaporation values from USWB Open Pan Evaporimete installed at Crop Research Center of Bhagwant University Ajmer. The irrigation frequency in drip treatments was scheduled at 2 days interval and online drippers had the discharge rate of 1 LPH.

Pest management:

Two insecticides spraying of monocrotophos 36% SL were done in the crops in order to control insects.

Harvesting :

The cobs from net plot area were separated from stalks manually and the plants were cut close to the ground with the help of sickle.

Observations and sampling procedure:

Growth parameters :

The observations on growth and development parameters such as plant height, leaf area, dry matter accumulation, etc. were recorded at knee high, teaseling and harvesting stages.

Plant height :

Four plants were selected randomly and tagged in each net plot from 2^{nd} and 4^{th} row. The plant height of these plants was measured with the help of meter scale. The values were averaged and expressed in cm. The plant height before tasseling was measured from the ground surface to the tip of the newly emerged leaf, whereas after tasseling, it was recorded from ground surface to the ligule of the upper most fully opened leaf.

Number of green leaves/plant:

The total number of fully expanded leaves was counted from the tagged plants marked for height observation. Average number of leaves/ plant was computed by dividing the total number of leaves by four.

Dry matter accumulation :

Two plants from sampled row were selected and cut just above the ground level with the help of sickle. These cut plants were allowed to sundry for 48 hours. After sun drying, these plants were dried in the oven at $65\pm5^{0}C$ temperature for 48-72 hours or till the samples attained a constant weight and then dry matter yield was calculated and reported as t/ha.

Leaf area index (LAI) :

All the leaves from the plants harvested for dry matter yield were removed. There length and width was measured with the help of scale. A correction factor with the help of graph paper was found out to convert leaf length and width to obtain area of leaf. It was multiplied by the number of leaves per plant to get leaf area per plant. LAI was calculated by dividing the leaf area per plant by the land area occupied by a plant.

Plant moisture content:

Fresh and oven dry weight of the maize plants was taken at knee height, tasseling and harvesting stage. After that, % plant moisture content was calculated as fallow:

$$\text{Plant moisture content (\%)} = \frac{\text{Fresh weight - Dry weight}}{\text{Fresh weight}} \times 100$$

Root parameters :

Root dry weight density :

To get the root dry weight density, firstly dry weight of roots was taken of each treatment. After that, weight of the roots were divided by volume of the core and expressed in mg/cc

Root volume density :

Root of maize plant was taken by each plot from sampled row with the help of core. Then these roots were thoroughly washed in running water to remove all the dust. After that volume of root from each treatment was taken by placing the root in 1 lit beaker filled with water. Replaced volume of water was reported as volume of the root. After that, to calculate the root volume density, root volume was divided by volume of the core and expressed in mm^3/cc.

Yield and yield attributing characters:

Cob with husk yield :

All the cobs from the net plot area were harvested at green cob stage and weighed without removing husk. It provided cobs weight with husk. The value was expressed on hectare basis.

Cob without husk yield :

After recording the weight of cobs with husk, the husk was removed and the weight of cobs without husk was recorded and expressed on hectare basis.

Stover yield :

After plucking the cobs, the plants were cut just above the soil surface and weighed in each net plot. It was expressed on hectare basis.

Biological yield :

The stover yield and green cobs with husk yield form each net plot were summed up to obtain biological yield and reported as kg/ha.

Weight per cob with husk :

From the net plot produce, five green cobs with husk were selected randomly for recording yield attributes. Weight of these cobs was recorded and expressed as weight per cob with husk.

Weight per cob without husk :

The husk of the above five cobs was removed and weight of cobs without husk was recorded and expressed as weight per cob without husk.

Husk weight/cob:

It was calculated by subtracting green cob weight with husk to the green cob weight without husk and reported as husk weight per cob.

Cob length :

Five cobs were randomly selected from each net plot. The husk was removed and length was measured with the help of foot scale. The average cob length was expressed in cm.

Cob girth :

The cobs selected for measuring cob length were also used for recording cob girth. A fine thread was used to record cob girth at three places *i.e.* top, middle and bottom of cob. The average value was reported in cm.

Number of grain rows/cob :

Number of grain rows of randomly selected five cobs was counted and average of this was recorded as number of grain rows/cob.

Number of grains/row :

The cobs selected for recording number of grain rows/ cob, were used for counting number of grains per row. Number of grains in five rows of five selected cobs was counted and divided by the total number of rows. The average value was reported as number of grains/ row.

Hundred grains weight :

A sample of 100 grains was taken from the harvested produce of the five plants from each net plot and their fresh weight was recorded and expressed as gram.

Plant Analysis :

Nutrient concentration (NPK) in plant:

The plant samples of maize crop were collected from each plot at knee high, tasseling and harvesting stages and kept for sun drying for 2-3 days. Then these samples were kept in drier at 72 ± 2^0C for complete drying. Dried plant samples were ground to fine powder and were analyzed for nitrogen, phosphorus and potassium (Jackson, 1973). Nitrogen was analyzed through Modified micro Kjeldhal method. Phosphorus was analyzed through wet digestion molybdophosphoric acid method. The potassium content in plant was analyzed through Flame emission spectophotometery method.

NPK uptake :

The uptake of nitrogen, phosphorus and potassium was determined at knee high, tasseling and harvest stages. It was obtained by multiplying respective nutrient concentration and dry matter yield. The NPK uptake by maize plant from each treatment was calculated as follows:

$$\text{Nitrogen uptake by maize}\left(\frac{\text{kg}}{\text{ha}}\right) = \frac{\text{N content in plant sample (\%) x Dry matter yield}\left(\frac{\text{kg}}{\text{ha}}\right)}{100}$$

$$\text{Phosphorus uptake by maize}\left(\frac{\text{kg}}{\text{ha}}\right) = \frac{\text{P content in plant sample (\%) x Dry matter yield}\left(\frac{\text{kg}}{\text{ha}}\right)}{100}$$

$$\text{Potassium uptake by maize}\left(\frac{\text{kg}}{\text{ha}}\right) = \frac{\text{K content in plant sample (\%) x Dry matter yield}\left(\frac{\text{kg}}{\text{ha}}\right)}{100}$$

Water use parameters:

Irrigation water use efficiency (IWUE):

The depth of irrigation applied to each treatment was measured. Total of all the irrigations applied in each treatment was summed upto get total depth of irrigation in each moisture regime. The irrigation water use efficiency (kg/ha-mm) was calculated by using the following formula :

IWUE= Y/U

where, Y= Yield of green cobs without husk (kg/ha) and U= Total depth of irrigation applied in each treatment (mm)

Water productivity :

Water productivity was calculated by dividing the yield of green cobs without husk with total water received (total irrigation depth + total rainfall) by the crop and expressed as kg/ha-mm.

Soil moisture measurement :

The soil moisture in the drip plots was recorded upto a depth of 15cm by the TDR (model TRIME -3). It was recorded at 10cm away from the emitter. In flood irrigated plots, the moisture was recorded by TDR / gravimetrically depending upon the dryness of the soil. The moisture was recorded at an average interval of 7$\pm$1day. The gravimetric moisture was multiplied by BD value to get volumetric moisture content.

Economic studies :

Cost of cultivation :

The cultivation cost of maize was calculated on the basis of prevailing local market prices for different inputs and farm operations.

Gross return :

The gross return for each treatment was calculated by converting the green cob and stover yields into monetary value *i.e.* yields multiplied by the prevailing market price.

Net return :

Net return was calculated by deducting cost of cultivation from gross return.

Benefit: cost ratio :

Benefit: cost ratio was calculated by dividing the net return by the cost of cultivation for a particular treatment.

■ RESULTS AND DISCUSSION

The experimental findings based on the data recorded during the course of investigation are elucidated in this chapter. The results obtained in experiment are discussed here in the light of scientific facts.

Growth and development :

Plant height :

The data pertaining to plant height at different growth stages are given in Table 1. At this stage, the plant height was significantly higher at 100% CPE than 60% CPE but remained at par with 80% CPE. At all the stages of growth, the plant height increased with increase in depth of irrigation through drip, being the highest at 100% CPE level. At knee high stage, flood irrigation IW: CPE 1.0 treatment had lower plant height compared to drip irrigation treatments while at other two stages it was superior. Flood irrigation IW: CPE 0.80 with mulch was found superior to all the irrigation treatments at all the growth stages of crop development. Non significant differences were noted between 75 and 100% RDF for plant height with later treatment had an edge over the former at all stages of crop growth.

Number of leaves:

The data pertaining to number of leaves are given in Table 2. At tasseling stage, 100% CPE irrigation regime produced significantly more number of leaves than 60 and 80% CPE irrigation regimes. Flood irrigation IW: CPE 1.0 had higher value than 60 and 80% CPE but remained lower than 100% CPE drip irrigation treatments. However, flood irrigation IW: CPE 0.80 with mulch had more number of leaves/plant than all the drip Irrigation levels at both the stages of crop growth.

Leaf area index (LAI) :

Drip irrigation levels did not affect the LAI of maize crop significantly at knee high stage but did affect at tasseling stage. At knee high stage, the LAI increased as the amount of water increased per irrigation being the highest at 100% CPE. At tasseling stage, 100% CPE recorded significantly higher LAI than 60% CPE but was at par with 80% CPE. At knee high stage, both the

Table 1 : Effect of drip irrigation levels, NPK dose and PK splitting on plant height of maize at different growth stages

Treatments	Plant height (cm)		
	Knee high	Tasseling	Harvest
Drip irrigation level			
60% CPE	97.9	144.7	149.5
80% CPE	98.1	147.2	153.7
100% CPE	98.7	149.7	157.0
S.E. ±	1.5	1.4	1.7
C.D. (P=0.05)	NS	NS	5.5
NPK dose			
75% RDF	97.5	146.5	152.2
100% RDF	98.8	148.1	154.6
S.E. ±	1.2	1.2	1.4
C.D. (P=0.05)	NS	NS	NS
PK splitting			
Equal	97.8	146.9	153.1
70/30	98.5	147.5	153.7
S.E. ±	1.1	1.2	0.8
C.D. (P=0.05)	NS	NS	NS
Control (flood irrigation)			
Flood IW:CPE 1.0	95.8	159.4	164.0
Flood IW:CPE 0.80 with mulch	103.1	161.3	167.0

NS=Non-significant

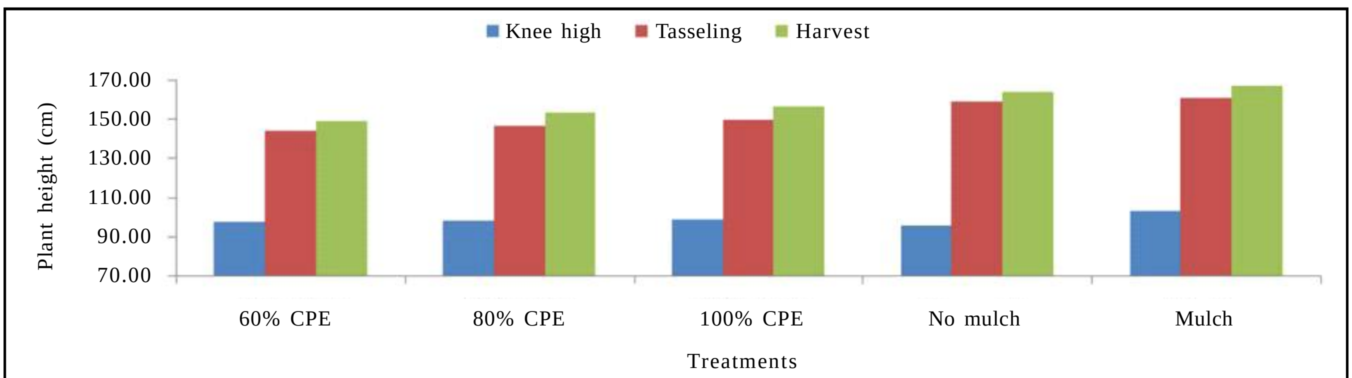

Fig. 1 : Effect of drip irrigation levels, NPK dose and PK splitting on plant height of maize at different growth stages

Table 2 : Effect of drip irrigation levels, NPK dose and PK splitting on number of leaves of maize at different growth stages

Treatments	No. of leaves/plant	
	Knee high	Tasseling
Drip irrigation level		
60% CPE	4.7	11.2
80% CPE	5.2	12.1
100% CPE	5.5	13.0
S.E. ±	0.3	0.3
C.D. (P=0.05)	NS	0.8
NPK dose		
75% RDF	4.8	11.8
100% RDF	5.4	12.4
S.E. ±	0.2	0.2
C.D. (P=0.05)	NS	NS
PK splitting		
Equal	5.1	11.9
70/30	5.2	12.3
S.E. ±	0.2	0.2
C.D. (P=0.05)	NS	NS
Control (flood irrigation)		
Flood IW:CPE 1.0	5.3	12.3
Flood IW:CPE 0.80 with mulch	5.7	13.3

NS=Non-significant

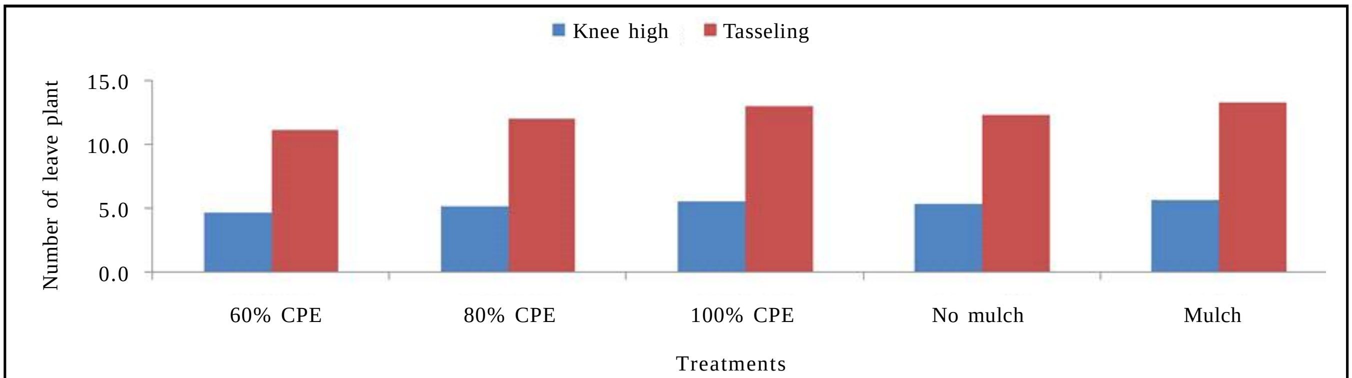

Fig. 2 : Effect of drip irrigation levels, NPK dose and PK splitting on number of leaves of maize at different growth stages

control treatments recorded higher LAI than all the drip irrigation treatments. At tasseling stage, flood irrigation at IW: CPE 0.80 with much was superior to 60 and 80% CPE and comparable to 100% CPE. Under control treatments, flood irrigation at IW: CPE 0.80 with much had more LAI than none mulched one. The higher LAI value under higher moisture regimes was largely associated with the increased number of leaves and size. At both the stages of LAI determination, 100% RDF produced significantly higher LAI than 75% RDF.

Dry matter accumulation :

The data on dry matter accumulation are given in Table 4. At knee high stage, 100% CPE produced significantly higher dry matter than 60% CPE but it was at par with 80% CPE. At tasseling stage also, similar trend was noted to that of knee high stage. At harvesting stage, 100% CPE was found significantly superior over both the moisture regimes *i.e.* 60 and 80% CPE. Taller plants with more number of leaves were noted as the moisture regime was improved under drip irrigation

Table 3 : Effect of drip irrigation levels, NPK dose and PK splitting on LAI at different growth stages

Treatments	Leaf area index (LAI)	
	Knee high	Tasseling
Drip irrigation level		
60% CPE	1.90	3.18
80% CPE	1.95	3.44
100% CPE	2.04	3.49
S.E. ±	0.05	0.07
C.D. (P=0.05)	NS	0.21
NPK dose		
75% RDF	1.89	3.28
100% RDF	2.03	3.46
S.E. ±	0.04	0.05
C.D. (P=0.05)	0.13	0.17
PK splitting		
Equal	1.92	3.34
70/30	2.01	3.40
S.E. ±	0.04	0.04
C.D. (P=0.05)	NS	NS
Control (flood irrigation)		
Flood IW:CPE 1.0	2.05	3.26
Flood IW:CPE 0.80 with mulch	2.13	3.49

NS=Non-significant

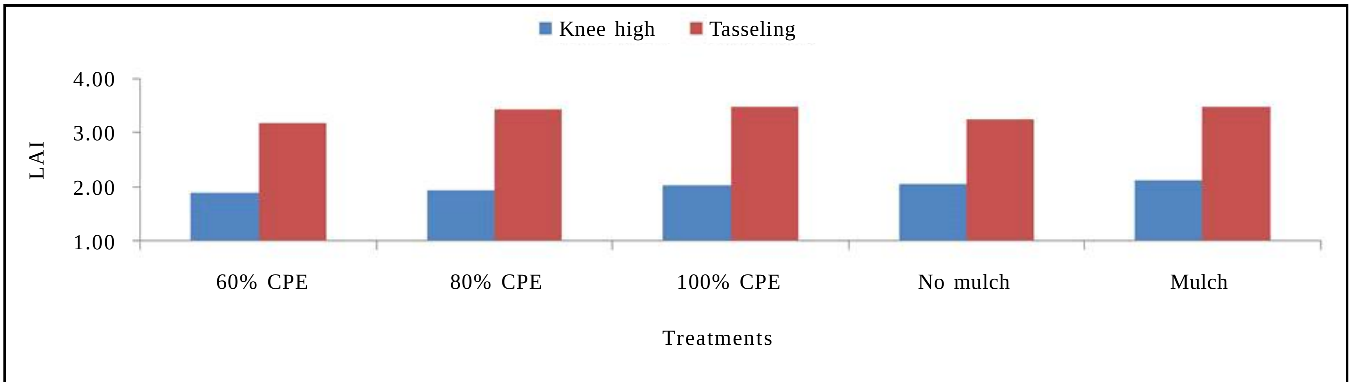

Fig. 3 : Effect of drip irrigation levels, NPK dose and PK splitting on LAI at different growth stages

system. At all the stages of dry matter recording, flood irrigation IW: CPE 0.80 with mulch was found superior to flood irrigation without mulch might be due to favorable effect of rice straw mulch in maintaining the better moisture regime and also ensured better nutrient availability. Flood irrigation without mulch remained superior to drip irrigation treatment 60% CPE and almost comparable to 80 and 100% CPE moisture regimes. Difference in dry matter yield between surface floods IW: CPE 1.0 and flood irrigation IW: CPE 0.80 with mulch was 32.3% at knee high stage, which decreased to 7.2% at tasseling and 5.8% at harvest stage.

Plant moisture content:

The data pertaining to moisture in plant are given in Table 5. At all the stages of crop growth, increasing CPE value recorded higher plant moisture content. At tasseling stage, 100% CPE recorded significantly higher plant water content than remaining irrigation regimes. NPK dose did not affect moisture of maize plants significantly

Table 4 : Effect of drip irrigation levels, NPK dose and PK splitting on dry matter accumulation at different growth stages

Treatments	Dry matter (t/ha)		
	Knee high	Tasseling	Harvest
Drip irrigation level			
60% CPE	1.54	5.94	16.06
80% CPE	1.60	6.51	16.62
100% CPE	1.65	6.66	17.76
S.E. ±	0.02	0.11	0.27
C.D. (P=0.05)	0.07	0.33	0.84
NPK dose			
75% RDF	1.57	6.25	16.42
100% RDF	1.63	6.49	17.22
S.E. ±	0.02	0.09	0.22
C.D. (P=0.05)	0.06	NS	0.69
PK splitting			
Equal	1.59	6.29	16.59
70/30	1.60	6.45	17.04
S.E. ±	0.03	0.09	0.18
C.D. (P=0.05)	NS	NS	NS
Control (flood irrigation)			
Flood IW:CPE 1.0	1.55	5.98	17.48
Flood IW:CPE 0.80 with mulch	2.05	6.41	18.50

NS=Non-significant

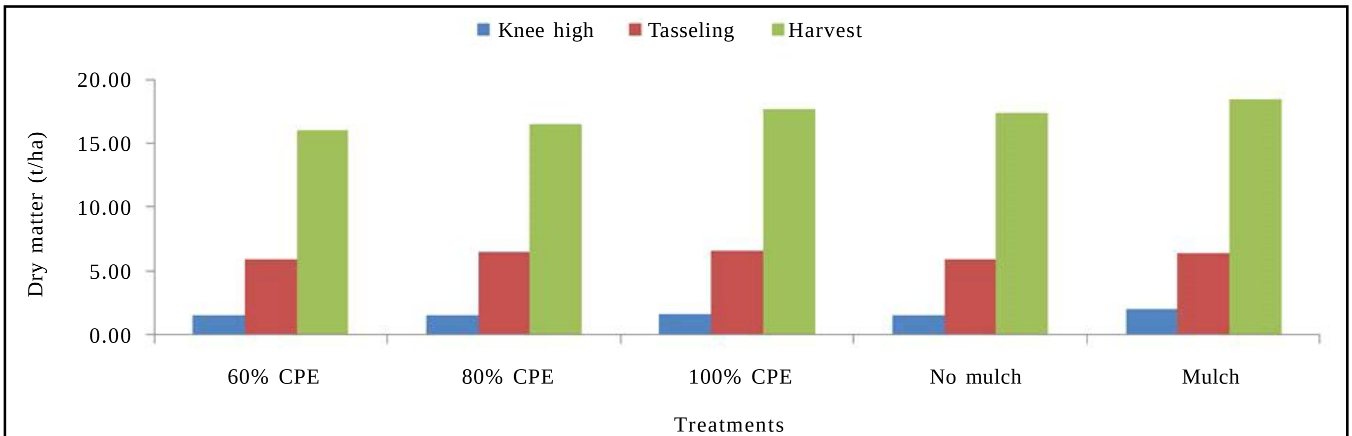

Fig. 4 : Effect of drip irrigation levels, NPK dose and PK splitting on dry matter accumulation at different growth stages

at any stage of crop growth stage. With 100% RDF the plant moisture content was slightly higher than with 75% RDF, which may be attributed to better root growth under higher fertility level.

Root dry weight density and root volume density:

The data pertaining to root dry weight are given in Table 6. The root growth was determined in the top 0-15cm layer of the soil 2cm away from the stem. The dry weight density and volume density of roots increased as the irrigation depth was increased from 60% CPE level to 100% CPE level. The mean increase was more from 60% CPE to 80% CPE than 80% CPE to 100% CPE. Drip irrigation depth equal to 100% CPE brought significant increase in the root dry weight and volume density over 60% CPE, but remained at par with 80% CPE. Further 60% CPE did not differ significantly with 80% CPE for both the root growth parameters. Flood

Table 5 : Effect of drip irrigation levels, NPK dose and PK splitting on plant moisture content at different growth stages

Treatments	Plant moisture content (%)		
	Knee high	Tasseling	Harvest
Drip irrigation level			
60% CPE	85.9	73.32	57.0
80% CPE	86.3	74.45	58.4
100% CPE	86.6	75.42	59.9
S.E. ±	0.70	0.29	0.88
C.D. (P=0.05)	NS	0.93	NS
NPK dose			
75% RDF	86.2	74.33	58.1
100% RDF	86.3	74.46	58.8
S.E. ±	0.57	0.24	0.72
C.D. (P=0.05)	NS	NS	NS
PK splitting			
Equal	86.2	74.17	58.2
70/30	86.4	74.62	58.7
S.E. ±	0.44	0.51	0.70
C.D. (P=0.05)	NS	NS	NS
Control (flood irrigation)			
Flood IW:CPE 1.0	85.9	68.6	58.5
Flood IW:CPE 0.80 with mulch	86.9	73.5	61.2

NS=Non-significant

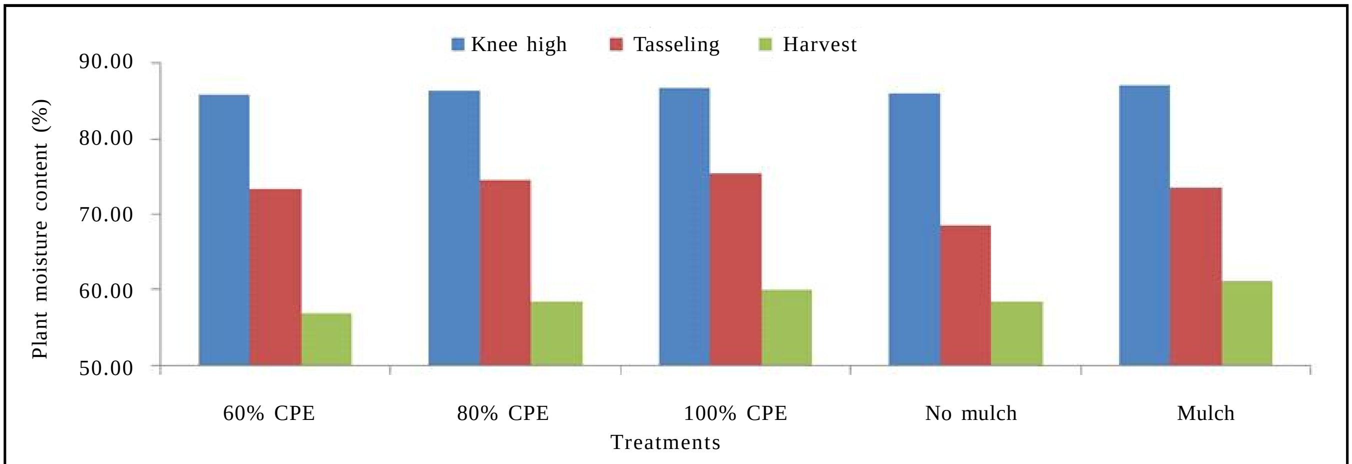

Fig. 5 : Effect of drip irrigation levels, NPK dose and PK splitting on plant moisture content at different growth stages

irrigation IW: CPE 1.0 recorded higher root dry weight density than both 60 and 80% CPE level, but lower than 100% CPE level. Flood irrigation IW: CPE 0.80 with mulch produced higher dry weight than all the drip irrigation as well as flood irrigation without mulch treatments. Between the NPK doses, significantly higher root dry weight density was observed in 100% RDF over 75% RDF.

Yield attributes and yield:

The data pertaining to yield attributing characters and yields of maize harvested for green cobs are given in Tables from 7 to 9.

Cob length :

Higher cob length was obtained under Flood IW: CPE 0.80 with mulch treatment than Flood IW: CPE

Table 6 : Effect of drip irrigation levels, NPK dose and PK splitting on root dry weight density and root volume density

Treatments	Root dry weight density (mg/cc)	Root volume density (mm^3/cc)
Drip irrigation level		
60% CPE	2.5	34.9
80% CPE	3.2	38.6
100% CPE	3.9	42.0
S.E. ±	0.2	1.2
C.D. (P=0.05)	0.5	3.7
NPK dose		
75% RDF	2.9	36.7
100% RDF	3.5	40.3
S.E. ±	0.1	0.9
C.D. (P=0.05)	0.4	3.0
PK splitting		
Equal	3.1	37.9
70/30	3.3	39.1
S.E. ±	0.2	0.8
C.D. (P=0.05)	NS	NS
Control (Flood irrigation)		
Flood IW:CPE 1.0	3.5	47.8
Flood IW:CPE 0.80 with mulch	4.0	52.9

NS=Non-significant

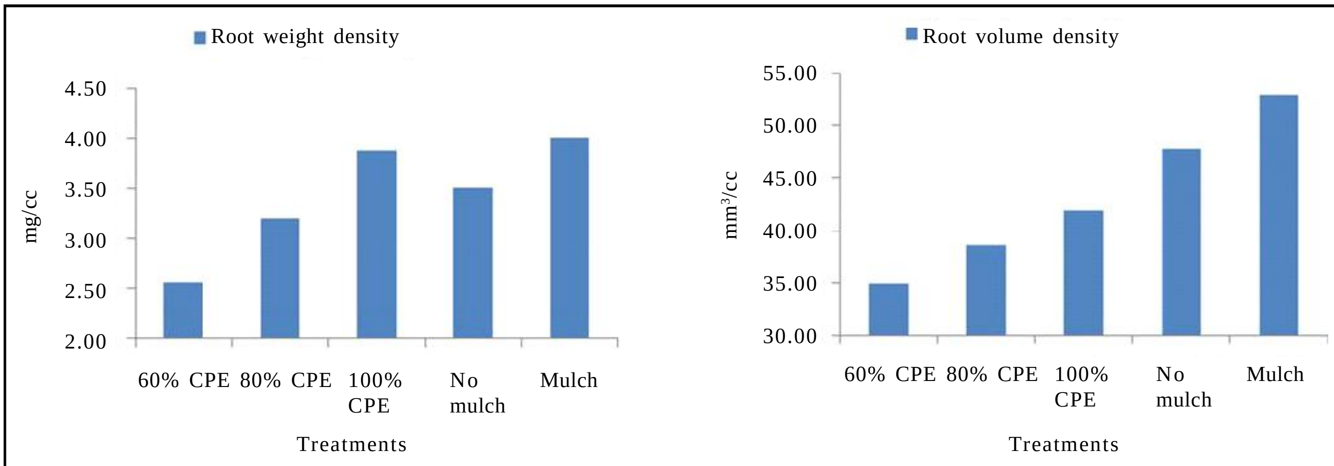

Fig. 6 : Effect of drip irrigation levels, NPK dose and PK splitting on root dry weight density and root volume density

1.0. All the drip irrigation treatments recorded higher cob length than Flood IW: CPE 1.0 treatment. Lower cob yield in CPE 60% might be due to moisture stress which hampered cell division and cell elongation of emerging ears. Cob length also remained statistically same between two doses of fertilizers however; there was more cob length under 100% RDF than 75% RDF. PK splitting did not bring significant difference in the cob length.

Cob girth :

Significantly higher cob girth was attained in 100% CPE over 60% CPE but was at par with 80% CPE. Flood irrigation IW: CPE 0.80 with mulch produced higher cob girth than flood IW: CPE 1.0. Cob girth under flood IW: CPE 1.0 was relatively less than all other irrigation treatments. The reasons cited for variation in cob length also hold true for lower cob girth in water stressed treatment *i.e.* 60% CPE moisture regime.

Number of grain rows per cob:

Among the drip irrigation levels, 100% CPE recorded significantly higher value than 60% CPE but remained at par with 80% CPE. In flood irrigation IW: CPE 1.0 treatment, there was less number of grain rows per cob than the flood IW: CPE 0.80 with mulch treatment. Further, flood irrigation IW: CPE 1.0 treatment contained less number of grain rows per cob compared to all the drip irrigated treatments. Number of grain rows per cob was observed to be decline at lower dose of NPK but differences were not significant between 75 and 100% recommended doses of fertilizer.

Number of grains per row :

Among the drip irrigation levels, the highest numbers of grains per row was recorded at 100% CPE *i.e.* 31.1 which was significantly higher than 60 and 80% CPE. Flood irrigation IW: CPE 0.80 with mulch contained more number of grains per row compared to flood irrigation IW: CPE 1.0. Further flood irrigation IW: CPE 1.0 treatment contained more grains per row compared to 60% CPE but less than 100% CPE. Flood irrigation IW: CPE 1.0 contained equal grains per row to that of 80% CPE drip irrigation level. Less number of grains per row in 60% CPE moisture regime against 80 and 100% CPE moisture regimes could be due to relatively more water deficit which delayed the silking.

Hundred grain weight :

Among the drip irrigation levels, the difference for 100 grain weight was significant. Significantly higher 100 grain weight was obtained with 100% CPE drip irrigation level than 60% CPE and at par with 80% CPE. The 100 grain weight was found higher under flood irrigation IW: CPE 0.80 with mulch than flood IW: CPE 1.0 treatment. Flood irrigation IW: CPE 1.0 obtained lower value of 100 grain weight than all the drip irrigation treatment except 60% CPE irrigation level. Differences in 100 grain weight were non-significant due to NPK doses and PK splitting. Both the levels of fertilizers possessed similar values for 100 grain weight.

Weight per cob with husk :

Crop irrigated at 100% CPE with drip resulted in significantly higher individual cob weight than 60% CPE but was at par with 80% CPE. Flood irrigation IW: CPE 0.80 with mulch obtained more individual cob weight than flood irrigation IW: CPE 1.0 treatment. Among all the irrigation treatments, the highest individual cob weight was obtained under 100% CPE drip irrigation. Except

Table 7 : Effect of drip irrigation levels, NPK dose and PK splitting on yield attributing characters of maize

Treatments	Cob length (cm)	Cob girth (cm)	No. of grain rows /cob	No. of grains / row
Drip irrigation level				
60% CPE	16.1	14.0	14.9	28.3
80% CPE	17.0	14.3	15.1	30.1
100% CPE	16.9	14.5	15.4	31.1
S.E. ±	0.3	0.1	0.2	0.3
C.D. (P=0.05)	NS	0.40	0.5	0.9
NPK dose				
75% RDF	16.5	14.2	15.1	29.9
100% RDF	16.9	14.3	15.2	29.7
S.E. ±	0.2	0.1	0.1	0.2
C.D. (P=0.05)	NS	NS	0.4	NS
PK splitting				
Equal	16.5	14.3	14.8	30.0
70/30	16.9	14.2	15.4	29.7
S.E. ±	0.3	0.2	0.2	0.5
C.D. (P=0.05)	NS	NS	NS	NS
Control (flood irrigation)				
Flood IW:CPE 1.0	15.6	13.7	14.7	30.1
Flood IW:CPE 0.80 with mulch	17.0	14.9	15.4	31.2

NS=Non-significant

60% CPE drip irrigation treatment, remaining both the levels produced heavier cobs than flood irrigation treatment without mulch. Higher individual cob weight in 100% CPE moisture regime was due to higher cob girth and relatively good cob length as compared to other treatments. Application of 100% RDF through drip resulted in statically higher individual cob weight than that of 75% RDF.

Weight per cob without husk :

Both drip irrigation and nutrient levels influence the individual cob weight without husk significantly. Drip irrigation at 100% CPE recorded the highest individual dehusked cob weight, which was at par with 80% CPE but significantly superior to 60% CPE. The increase in dehusked cob weight at 100% CPE was 0.90% over 80% CPE and 6.7% over 60% CPE. Between flood irrigated treatments, flood irrigation IW: CPE 0.80 with mulch produced heavier cob than flood IW: CPE 1.0 treatment. The difference in weight was 6.9%. Different doses of fertilizer also affected the individual dehusked cob yield significantly and 100% RDF recorded significantly heavier cobs than 75% RDF. The extent of increase in cob weight at 100% RDF over 75% RDF was 3.9%.

Husk weight per cob :

All the 3 factors tested through drip system failed to cause significant difference in the husk weight per cob. Husk weight increased numerically with increase in CPE level, being the maximum at 100% CPE. The magnitude of increase at 100% CPE was 1 and 4.4 per cent, respectively over 80 and 60% CPE levels. Flood irrigation IW: CPE 0.80 with mulch possessed more husk weight compared to flood IW: CPE 1.0 treatment. Flood irrigation with mulch had almost comparable husk weight per cob to that of 100% CPE through drip system. Application of 75 or 100% NPK through drip had similar values for husk weight per cob. Equal splitting of PK contained more cob weight than 70/30 splitting of PK and the increase in husk weight per cob was 5.7%.

Cob yield with husk :

The drip irrigation regimes differed statistically with each other for cob yield with husk. 100% CPE drip irrigation level produced significantly more cob yield compared to 60% CPE but remained at par with 80% CPE. As compared to 100% CPE level, the cob yield

Table 8 : Effect of drip irrigation levels, NPK dose and PK splitting on yield attributing characters of maize

Treatments	100-grain weight (g)	Per cob weight with husk (g)	Per cob weight without husk (g)	Husk weight per cob (g)
Drip irrigation level				
60% CPE	16.2	177.2	138.7	38.6
80% CPE	17.8	186.6	146.7	39.9
100% CPE	18.2	188.3	148.0	40.3
S.E. ±	0.4	3.1	2.7	2.5
C.D. (P=0.05)	1.3	9.9	8.6	NS
NPK dose				
75% RDF	17.4	181.2	140.7	39.6
100% RDF	17.4	186.9	147.8	39.6
S.E. ±	0.3	2.6	2.2	2.1
C.D. (P=0.05)	NS	8.1	7.0	NS
PK splitting				
Equal	17.6	182.3	141.6	40.7
70/30	17.4	185.8	147.3	38.5
S.E. ±	0.3	4.8	4.0	2.2
C.D. (P=0.05)	NS	NS	NS	NS
Control (flood irrigation)				
Flood IW:CPE 1.0	16.8	182.0	145.0	37.0
Flood IW:CPE 0.80 with mulch	17.4	190.0	155.0	40.0

NS=Non-significant

with husk decreased by 5.9 and 9.3% at 80 and 60% CPE levels. Flood irrigation IW: CPE 0.80 with mulch obtained higher cob yield with husk than flood IW: CPE 1.0 treatment. Cob yield with husk under flood irrigation IW: CPE 1.0 was numerically almost equal to 60% CPE drip irrigation treatment but remained lower than 80% and 100% CPE treatments. Flood irrigation with mulch had almost comparable cob yield with husk to that of 100% CPE drip irrigation treatment. Under PK splitting treatment 70/30 splitting obtained slightly higher cob yield than equal splitting.

Dehusked cob yield :

The data pertaining to dehusked cob yield are given in Table 9. The maximum dehusked cob yield was obtained under 100% CPE that was statistically superior to 60% CPE but was statistically at par with 80% CPE irrigation level. Further, drip irrigation 80% CPE recorded significantly higher green cob yield than 60% CPE. In flood irrigation IW: CPE 0.80 with mulch higher dehusked cob yield was found than flood IW: CPE 1.0 treatment. In comparison to drip irrigation treatments, flood irrigation IW: CPE 1.0 recorded lower dehusked cob yield than 80% CPE and 100% CPE irrigation regimes, but was slightly superior to 60% CPE level. Raising the nutrient level from 75 to 100% RDF caused significant increase in dehusked cob yield. Crop fertilized with 100% RDF produced 0.9t/ha higher dehusked cob yield than 75% RDF. PK splitting failed to cause significant variation in the dehusked cob yield. But application of PK as 70/30 recorded 6.0% higher dehusked cob yield than equal splitting of PK during the crop period.

Stover yield :

Application of drip irrigation at 100% CPE possessed significantly more stover yield than 60% CPE but remained at par with 80% CPE. The increase in stover yield from 60% CPE to 80% CPE and from 80% CPE to 100% CPE was 3.8% and 2.1%, respectively. Due to more accumulation of dry matter under flood IW: CPE 0.80 with mulch condition more stover yield was found, which was numerically higher than flood IW: CPE 1.0 treatment. Nutrients play important role in photosynthesis and thus influence dry matter accumulation in plants. Therefore, more green fodder yield at higher dose of nutrients may be reasoned to more dry matter accumulation. The stover yield was numerically similar between PK equal and 70/30 splitting.

Table 9 : Effect of drip irrigation levels, NPK dose and PK splitting on yields of spring maize

Treatments	Yield (t/ha)			
	Cob yield with husk	Cob yield without husk	Stover yield	Biological yield
Drip irrigation level				
60% CPE	14.6	10.8	18.4	32.9
80% CPE	15.2	12.1	19.1	34.4
100% CPE	16.1	12.6	19.5	35.6
S.E. ±	0.3	0.2	0.2	0.4
C.D. (P=0.05)	0.9	0.6	0.6	1.3
NPK dose				
75% RDF	14.9	11.4	18.8	33.8
100% RDF	15.6	12.3	19.2	34.8
S.E. ±	0.2	0.1	0.2	0.3
C.D. (P=0.05)	NS	0.5	NS	NS
PK splitting				
Equal	15.1	11.5	19.0	34.1
70/30	15.5	12.2	19.0	34.5
S.E. ±	0.4	0.3	0.11	0.5
C.D. (P=0.05)	NS	NS	NS	NS
Control (flood irrigation)				
Flood IW:CPE 1.0	14.7	11.8	18.2	32.9
Flood IW:CPE 0.80 with mulch	15.9	12.9	19.6	35.5

NS=Non-significant

Biological yield:

The biological yield increased by 8.2% over 60% CPE and by 3.5% over 80% CPE. Further, 80% CPE recorded 4.6% higher biological yield than 60% CPE. The biological yield under flood irrigation IW: CPE 0.80 with mulch treatment was higher than flood IW: CPE 1.0, the difference being 7.9%. The green cob yield and stover yields were also benefitted by mulching, which consequently produced more biological yield under mulched flood irrigation treatment. Non-significant relationship was found between different fertilizer doses. But relatively higher value of biological yield was obtained under 100% RDF compared to 75% RDF.

Nutrient studies in plant :

Nutrient content and uptake (N, P and K) in plant :

The data pertaining to nutrient content and uptake in plant at different growth stages are given in Tables 10 to 12.

Nitrogen content in plant :

The data presented in Table 10. Significantly higher N content was recorded at 100% CPE and the respective values at knee high, tasseling and harvesting stage were 1.45, 0.91 and 0.83%. Flood irrigation IW: CPE 0.80 with mulch showed numerically higher N content as compared to flood irrigation IW: CPE 1.0 at knee high and tasseling stage but it was not so at harvest stage. Flood irrigation IW: CPE 1.0 showed relatively higher N content than all drip treatments at tasseling stage but at knee high and harvesting stage it was relatively equal to 80% and 60% CPE, respectively. Plots fertilized with 75 and 100% recommended dose of fertilizer showed significant differences for content of N in plant at all the growth stages except at knee high.

Nitrogen uptake by maize :

The interaction effect between drip irrigation levels and fertilizer doses on N uptake by maize was found significant at tasseling stage showed in Table 11. At 60% CPE level, 100% RDF recorded significantly higher N uptake than 75% RDF. At higher CPE values the increase was not significant. At 75% RDF, N uptake increased significantly at 80% CPE over 60% CPE but did not differ significantly between 80% and 100% CPE. At 100% RDF, 80 and 100% RDF differed significantly for N uptake, but 60 and 80% CPE remain at par.

Table 10 : **Effect of drip irrigation levels, NPK dose and PK splitting on N content and uptake in plant at different growth stages**

Treatments	N content (%)			N uptake (kg/ha)		
	Knee high	Tasseling	Harvest	Knee high	Tasseling	Harvest
Drip irrigation level						
60% CPE	1.36	0.83	0.75	20.8	49.3	120.5
80% CPE	1.39	0.86	0.82	22.3	55.6	136.5
100% CPE	1.45	0.91	0.83	23.9	60.9	147.9
S.E. ±	0.01	0.01	0.01	0.3	1.0	3.0
C.D. (P=0.05)	0.06	0.03	0.02	1.1	3.2	9.3
NPK dose						
75% RDF	1.38	0.85	0.78	21.6	53.4	128.8
100% RDF	1.42	0.88	0.82	23.2	57.1	141.2
S.E. ±	0.05	0.01	0.01	0.3	0.8	2.4
C.D. (P=0.05)	NS	0.02	0.02	0.90	2.6	7.6
PK splitting						
Equal	1.40	0.86	0.81	21.9	55.7	134.3
70/30	1.41	0.86	0.79	22.7	54.9	135.7
S.E. ±	0.01	0.01	0.01	0.3	0.8	1.7
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Control (flood irrigation)						
Flood IW:CPE 1.0	1.39	0.93	0.77	21.5	55.6	134.6
Flood IW:CPE 0.80 with mulch	1.41	0.95	0.73	28.9	60.9	135.1

NS=Non-significant

Phosphorus content in plant:

The data presented in Table 12. At this stage 100% CPE drip irrigation regime had significantly higher P content than 60% CPE and 80% CPE. Flood irrigation IW: CPE 0.80 with mulch contained higher P than flood IW: CPE 1.0 treatment only at tasseling stage. Across the crop growth stages, 100% RDF showed relatively higher value of P than 75% RDF.

Phosphorus uptake by maize crop :

At both the stages *i.e.* knee high and tasseling, 100% CPE drip irrigation recorded significantly higher P uptake than 60% CPE, but was at par with 80% CPE at tasseling stage. While at tasseling stage 100% CPE recorded significantly higher P uptake than both the irrigation regimes. Flood irrigation IW: CPE 0.80 with mulch possessed the highest P uptake both at knee high and tasseling stages of crop growth. Whereas at harvesting stage, it remained equal to flood IW: CPE 1.0 treatment. Flood treatment recorded higher P uptake than only 60% CPE irrigation regime at all the stages. Between fertilizer doses, 100% RDF recorded higher P uptake than 75% RDF at knee high and tasseling stage.

Potassium content in plant:

K content in plant varied significantly at knee high and tasseling stages but at harvesting it was non-significant for the drip irrigation regimes. At knee high stage, 100% CPE possessed significantly higher K content than both the irrigation levels. Whereas, at tasseling stage, 100% CPE had significantly higher K content than 60% CPE but remained at par with 80% CPE irrigation level. Flood irrigation IW: CPE 0.80 with mulch treatment had numerically higher values compared

Table 11 : Interaction effect of drip irrigation levels and fertilizer dose on N-uptake by maize at tasseling stage

Irrigation regime	Fertilizer dose	
	75% RDF	100% RDF
60% CPE	44.48	54.14
80% CPE	55.93	55.31
100% CPE	59.91	61.97
C.D. (P=0.05) : 4.58		

Table 12 : Effect of drip irrigation levels, NPK dose and PK splitting on P content and uptake in plant at different growth stages

Treatments	P content (%)			P uptake (kg/ha)		
	Knee high	Tasseling	Harvest	Knee high	Tasseling	Harvest
Drip irrigation level						
60% CPE	0.81	0.27	0.19	12.4	15.8	30.5
80% CPE	0.84	0.27	0.19	13.4	17.8	31.9
100% CPE	0.86	0.29	0.20	14.1	19.2	35.7
S.E. ±	0.01	0.01	0.01	0.2	0.8	1.7
C.D. (P=0.05)	0.02	NS	NS	0.6	2.4	NS
NPK dose						
75% RDF	0.83	0.26	0.19	12.9	16.6	30.8
100% RDF	0.84	0.28	0.20	13.7	18.5	34.7
S.E. ±	0.01	0.01	0.01	0.2	0.6	1.4
C.D. (P=0.05)	NS	NS	NS	0.5	NS	NS
PK splitting						
Equal	0.82	0.26	0.20	13.1	16.7	33.2
70/30	0.84	0.29	0.19	13.5	18.5	32.3
S.E. ±	0.01	0.01	0.01	0.1	0.4	1.5
C.D. (P=0.05)	0.02	0.02	NS	0.4	1.1	NS
Control (flood irrigation)						
Flood IW:CPE 1.0	0.82	0.25	0.18	12.7	14.9	31.5
Flood IW:CPE 0.80 with mulch	0.83	0.27	0.17	17.1	17.3	31.5

NS=Non-significant

to flood IW: CPE 1.0 treatment at all growth stages except tasseling stage.

Potassium uptake by maize crop:

Drip irrigation levels significantly influenced the K uptake by maize crop at all the stages of crop growth. Irrigation at 100% CPE was found significantly superior to 60% CPE at all the stages and at par with 80% CPE at tasseling and harvesting stages. Flood irrigation IW: CPE 0.80 with mulch obtained numerically higher K uptake than flood IW: CPE 1.0 treatment at all growth stages. Flood irrigation IW: CPE 1.0 treatment had lower K uptake than all drip irrigated treatments except 60% CPE irrigation regime. Between the fertilizer doses, 100% RDF was significantly superior to 75% RDF at knee high and tasseling stages only.

Water/moisture studies:

Soil moisture content:

Data pertaining to soil moisture content are depicted in Fig. 7. During the crop growth period soil moisture content varied from 18.1 to 26.2% under 60% CPE irrigation regime, 19.2 to 27.5% under 80% CPE and 20.1 to 29.1% under 100% CPE irrigation regime. Whereas under control treatments, flood irrigation IW: CPE 0.80 with mulch had the soil moisture content in the range of 21.0 to 29.1% and flood irrigation IW: CPE 1. 0; 18.5 to 29.1%. The deviation from mean for soil moisture was the maximum in flood irrigation IW: CPE 1.0. In drip irrigated treatments and mulched plots the deviation was quite low. In drip irrigated plots particularly at 100% CPE, the soil moisture remained very close to FC and difference increased with reduction in the CPE values.

Irrigation water use efficiency (IWUE) :

Data pertaining to IWUE are summarized in Table 14. Drip irrigation levels had substantial effect on IWUE. The highest IWUE was obtained at 60% CPE drip irrigation level. It decreased by 22 and 34% at 80 and 100% CPE levels. In the present study, drip irrigation method had marked influence on the IWUE. The IWUE was higher at 100% RDF over 75% RDF. The increase was to the tune of 2.6cm/ha-cm. Since in both the fertility levels, similar quantity of water was applied, but higher dose produced more economic yield and in turn the IWUE. It further indicates that full utilization of the applied water was realized when crop was fertilized with

Table 13 : Effect of drip irrigation levels, NPK dose and PK splitting on K content and uptake in plant at different growth stages

Treatments	K content (%)			K uptake (kg/ha)		
	Knee high	Tasseling	Harvest	Knee high	Tasseling	Harvest
Drip irrigation level						
60% CPE	1.48	1.45	1.23	22.8	86.5	198.2
80% CPE	1.50	1.53	1.24	24.1	99.6	206.3
100% CPE	1.58	1.56	1.24	26.1	104.1	220.3
S.E. ±	0.01	0.02	0.02	0.3	2.3	5.1
C.D. (P=0.05)	0.05	0.06	NS	0.8	7.3	16.1
NPK dose						
75% RDF	1.51	1.49	1.23	23.7	93.4	202.2
100% RDF	1.53	1.54	1.24	24.9	100.1	214.4
S.E. ±	0.01	0.02	0.02	0.2	1.9	4.2
C.D. (P=0.05)	NS	0.05	NS	0.7	5.9	NS
PK splitting						
Equal	1.50	1.49	1.25	23.8	93.8	207.3
70/30	1.55	1.54	1.23	24.9	99.6	209.3
S.E. ±	0.01	0.02	0.03	0.3	1.3	5.2
C.D. (P=0.05)	0.03	NS	NS	1.0	3.9	NS
Control (flood irrigation)						
Flood IW:CPE 1.0	1.49	1.46	1.18	23.1	87.3	206.9
Flood IW:CPE 0.80 with mulch	1.53	1.45	1.19	31.4	92.9	220.1

NS=Non-significant

recommended dose of fertilizer.

Water productivity:

Data pertaining to water productivity are summarized in Table 14. The highest water productivity was obtained at 60% CPE treatment which decreased to 36.55kg/ha-mm at 80 and 31.77kg/ha-mm at 100% CPE levels. The water productivity was 26.26kg/ha-mm and 27.29kg/ha-mm, respectively with flood irrigation IW: CPE 1.0 and flood irrigation IW: CPE 0.80 with mulch.

Irrigation water saving :

During the entire crop season 75.5mm rainfall was received. The depth of irrigation water applied under drip irrigation levels was in the order of 357mm at 100% CPE, 288mm at 80% CPE and 218mm at 60% CPE. In flood irrigation IW:CPE 1.0, a total 6 irrigation amounting to 360mm irrigation depth and in IW:CPE 0.80 with mulch, a total 5 irrigations amounting to 300 mm irrigation depth was applied. Water saving in terms of irrigation depth as compared to flood irrigation IW: CPE 1.0 was the highest 142mm at 60% CPE level and reduced to

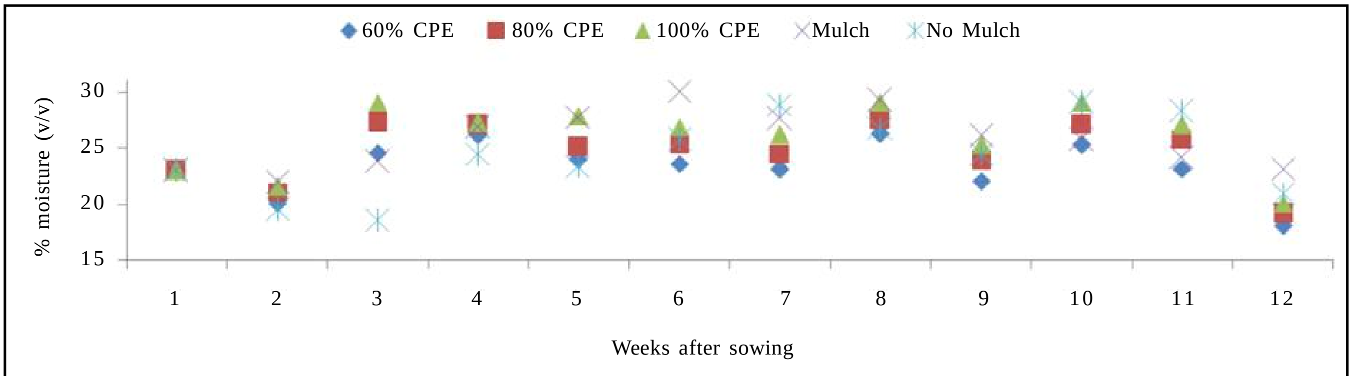

Fig. 7 : Soil moisture content (0-15 cm) under different moisture regimes at weekly interval during the crop growth period

Table 14 : Effect of drip irrigation levels, NPK dose and PK splitting on water use efficiency and water productivity

Treatments	IWUE (Kg/ha-mm)	Water productivity (Kg/ha-mm)
Drip irrigation level		
60% CPE	56.32	40.43
80% CPE	47.32	36.55
100% CPE	39.26	31.77
NPK dose		
75% RDF	45.99	34.98
100% RDF	49.28	37.51
PK splitting		
Equal	46.57	35.38
70/30	48.70	37.11
Control (flood irrigation)		
Flood IW:CPE 1.0	31.55	26.26
Flood IW:CPE 0.80 with mulch	33.00	27.29

Table 15 : Irrigation depth and water savings under different moisture regimes compared to control

Treatments	Irrigation depth	Water saving over flood (mm)	% water saving
Drip irrigation 60% CPE	218	142	39.4
Drip irrigation 80% CPE	288	72	20.0
Drip irrigation 100% CPE	357	3	0.8
Flood IW:CPE 1.0	300	60	16.7
Flood IW:CPE 0.80 with mulch	360	-	-

20.0% at 80% CPE and 0.30% at 100% CPE. Use of mulch could save irrigation equal to 60mm.

Economics:

Cost of cultivation :

The data pertaining to added cost due to different treatments to the cost of cultivation are presented in Table 15. Data indicated that the cost of maize cultivation in conventional practice flood irrigation IW: CPE 0.80 with mulch was the lowest which increased by Rs. 1300/ha in the treatment flood irrigation IW: CPE 1.0. Among drip irrigation treatments, the cost of cultivation decreased with decrease in CPE level mainly due to reduction in cost of irrigation. Between the fertilizer doses, more cost was incurred in 100% RDF over 75% because of additional cost of 25% water soluble fertilizers.

Gross return :

Under different irrigation levels, 100% CPE obtained significantly higher gross return compared to the 60% CPE but was at par with 80% CPE. Flood irrigation IW: CPE 0.80 with mulch had higher gross return than the flood irrigation at IW: CPE 1.0 treatment and was comparable to 60% CPE drip irrigation treatment. Flood irrigation IW: CPE 0.8 with mulch had higher gross return compared to flood IW: CPE 1.0. NPK dose affected the gross return significantly. Application of 100% RDF gave significantly higher gross return of Rs. 4534/ha over 75% RDF. PK splitting treatment failed to show significant effect of the gross return. But, PK splitting 70/30 gave higher gross return than equal splitting of PK.

Net return :

Irrigation of maize at 100% CPE gave significantly higher net return compared to 60% CPE but remained at par with 80% CPE irrigation regime. The per cent increase in net returns at 100% CPE over 80 and 60% CPE was 8.7 and 15.4%, respectively. The highest net returns of Rs. 77794/ha was obtained from flood irrigation IW: CPE 0.80 with much treatment. It was higher by Rs. 9548, 13356, 18506, and 21974/ha, respectively over flood irrigation at IW: CPE 1.0, drip irrigation at 100, 80 and 60% CPE treatments. Contrary to gross returns, lower dose of fertilizer fetched higher net returns than 100% RDF by a margin of Rs. 1200/ha, but the difference was non-significant. Similarly, differential splitting of PK in maize also failed to bring significant differences in net return. An advantage of Rs.1195/ha with PK splitting as 70/30 was noted over

Table 16 : Effect of drip irrigation levels, NPK dose and PK splitting on economics of maize cultivation

Treatments	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio
Drip irrigation level				
60% CPE	42893	98713	55820	1.31
80% CPE	43533	102821	59288	1.37
100% CPE	44174	108612	64438	1.47
S.E. ±	-	1853	1853	0.04
C.D. (P=0.05)	-	5837	5837	NS
NPK dose				
75% RDF	40665	101115	60449	1.49
100% RDF	46400	105649	59249	1.28
S.E. ±	-	1513	1513	0.04
C.D. (P=0.05)	-	NS	NS	0.11
PK splitting				
Equal	43533	102784	59252	1.37
70/30	43533	103980	60447	1.39
S.E. ±	-	2107	2107	0.05
C.D. (P=0.05)	-	NS	NS	NS
Control (flood irrigation)				
Flood IW:CPE 1.0	30666	98912	68246	2.23
Flood IW:CPE 0.80 with mulch	29366	107160	77794	2.64

NS=Non-significant

equal splitting.

B: C ratio :

Different drip irrigation treatments did not differ significantly for B: C ratio. However, there was an increase in B: C ratio with increase in depth of irrigation water from 60 to 100% CPE. The respective B: C ratio at 60, 80 and 100% CPE was 1.31, 1.37 and 1.47. The B: C ratio for conventional control was 2.23 and 2.64. The B: C ratio was higher at 75% RDF compared to 100% RDF. Although the economic products of the maize were favored by higher dose of fertilizers, but the income received from the increased values of these products was quite lower than the additional cost incurred on 25% RDF. Therefore, the B: C ratio was adversely affected at higher fertilizer dose.

Conclusion :

The experiment consisting of 3 irrigation regimes (100% CPE, 80% CPE and 60% CPE), 2 fertilizer dose (75% RDF and 100% RDF), 2 PK splitting (equal and 70/30) along with 2 control treatments (flood IW: CPE 0.8 with mulch and flood IW:CPE 1.0) was laid out in Split Plot Design with three replications. From findings of present investigation based on cob weight without husk it can be inferred that spring maize in sandy loam soil should be irrigated at 80% CPE. It should be fertilized at 90:45:30 N, P_2O_5, K_2O kg/ha with PK application as 70% upto tasseling and 30% thereafter. In flood irrigation use of mulch is quite beneficial.

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