IJPS INTERNATIONAL JOURNAL OF PLANT SCIENCES
Volume **8** | Issue 2 | July, 2013 | 208-214

RESEARCH ARTICLE

Influence of irrigation regimes and nitrogen levels on root density, nutrient uptake and grain yield of August sown hybrid maize (*Zea mays* L.)

■ GURPREET SINGH AULAKH, KRISHAN KUMAR VASHIST AND S.S. MAHAL

SUMMARY

A field experiment was conducted at Punjab Agricultural University Ludhiana, during late *Kharif* 2009-10 to study the effect of different irrigation regimes (IW/CPE ratio 0.50, 0.75, 1.00 and 1.25) and nitrogen rates (100, 125, 150 and 175 kg N ha^{-1}) on root growth, nutrient uptake and yield of August sown hybrid maize. The irrigation regimes $I_{1.25}$ (3 irrigations) and $I_{1.00}$ (3 irrigations) produced the grain yield of 83.1 and 81.2 q ha^{-1}, respectively, which was significantly higher than the grain yield observed under $I_{0.75}$ (2 irrigations) and $I_{0.50}$ (1 irrigation). Root density was higher in surface soil layers *i.e.*, 0-15 and 15-30 cm soil profile under adequate irrigation regimes ($I_{1.25}$ and $I_{1.00}$) which was statistically at par with each other but reverse trend was observed in deeper layers where root density was higher under deficit irrigation regimes. Nutrient uptake by maize *i.e.* N, P and K was also higher at higher irrigation regimes. Among nitrogen rates, N_{150} and N_{175} being statistically at par with each other gave significantly higher grain yield over N_{125} and N_{100}. Similar trend was observed for root density in different soil layers. Total N, P and K uptake was also higher at N_{175} which was significantly higher than other nitrogen levels in case of total N and P uptake whereas it was statistically at par with N_{150} in case of total K uptake.

Key Words : August sown hybrid maize, Irrigation regimes, Nitrogen levels, Root density, Nutrient uptake

How to cite this article : Aulakh, Gurpreet Singh, Vashist, Krishan Kumar and Mahal, S.S. (2013). Influence of irrigation regimes and nitrogen levels on root density, nutrient uptake and grain yield of August sown hybrid maize (*Zea mays* L.). *Internat. J. Plant Sci.*, **8** (2): 208-214.

Article chronicle : Received : 29.10.2012; **Revised :** 20.01.2013; **Accepted :** 15.02.2013

Maize (*Zea mays* L.) is one of the most versatile crops and can be grown in diverse environmental conditions and has diversified uses as human food and animal feed. Besides its use as food and fodder, maize is now gaining importance on account of its potential uses in manufacturing of starch, resins, syrups, ethanol, etc. It has got immense potential and is ,therefore, called as 'miracle crop' and as queen of cereals. Maize being a C_4 plant is an efficient convertor of absorbed nutrients into food (Srikanth *et al.*, 2009).

The uptake of nutrients and their distribution to different parts of the maize plants have been found to be vary primarily with fertility of the native soil, application of chemical fertilizers, the growth stage of the plant and the environmental conditions. There is also a close relationship between soil moisture and nutrient availability. It is generally believed that the greatest benefit from fertilizer application can be derived under irrigated conditions, where water supply is least likely to limit nutrient uptake (Hussaini *et al.*, 2008). Since nutrient uptake is closely linked to water soil status, it is expected that a decline in available soil moisture might decrease the diffusion rate of nutrients from soil matrix to roots (Ibrahim and Hala, 2007). The levels of soil moisture supply or soil moisture stress exerted considerable influence on the efficiency of water use and also upon nutrient uptake and growth of the maize plant.

MEMBERS OF THE RESEARCH FORUM

Author to be contacted :
GURPREET SINGH AULAKH, Department of Agronomy, Punjab Agricultural University, LUDHIANA (PUNJAB) INDIA
Email: aulakh.pau@gmail.com

Address of the Co-authors:
KRISHAN KUMAR VASHIST AND S.S. MAHAL, Department of Agronomy, Punjab Agricultural University, LUDHIANA (PUNJAB) INDIA
Email: kkvashist@pau.edu; ssmahal@pau.edu

Soil moisture thus, has a strong influence on the accumulation of mineral nutrients in the plant. So, the adequate supply of irrigation water and nitrogen are the two main factors affecting directly the growth and productivity of maize plants.

Nitrogen is the most limiting factor of all the essential plant nutrients in Punjab soils owing to their low organic carbon content (Benbi and Brar, 2008) and most of the work on irrigation is based on critical stages or soil moisture depletion approach without taking into consideration of climatic parameters. Concept of IW/CPE ratio incorporates the climatic factors into consideration while scheduling the irrigation and has been found to be a reliable, economical and practical basis for scheduling irrigation (Prihar *et al.*, 1976). This approach is based on the ratio between fixed depth of irrigation water (IW) and net cumulative pan evaporation (CPE) since previous irrigation (CPE minus rainfall). Hence, an attempt was made to study the effect of different irrigation regimes and nitrogen levels on the root density, nutrient uptake and grain yield of August sown hybrid maize.

MATERIAL AND METHODS

The field experiment was conducted at Department of Agronomy, Punjab Agricultural University, Ludhiana ($30^o54'$N latitude and $75^o48'$E longitude at an altitude of 247 metres above the mean sea level) during late *Kharif* 2009-10.

Soil and climate of experimental site :

The soil of experimental site was loamy sand with 0-180 cm soil profile's 0.3 and 15 bar values of 44.17 and 10.52 cm, respectively with available water of 33.65 cm. The soil pH, electrical conductivity, organic carbon, available N, P and K were 8.0, 0.21 dS m^{-1}, 0.15 per cent, 185.6 kg ha^{-1}, 13.9 kg ha^{-1} and 154.6 kg ha^{-1}, respectively. The site has been characterized by sub-tropical and semi-arid climate with average rainfall of 705 mm.

Treatments and experimental design :

The experiment was laid out in split plot design with four replications. Four irrigation regimes *viz.*, IW/CPE ratio 0.50 ($I_{0.50}$), 0.75 ($I_{0.75}$), 1.00 ($I_{1.00}$) and 1.25 ($I_{1.25}$) with 7.5 cm depth of water were assigned to the main plots and four nitrogen levels *viz.*,100, 125, 150 and 175 kg N ha^{-1}constitued the subplot treatments.Nitrogen was applied as per treatments. Phosphorus, potassium and zinc sulphate were applied @ 60, 30 and 25 kg ha^{-1}, respectively as recommended in the Punjab state (Anonymous, 2012). Urea, single super phosphate and muriate of potash formed the source for N, P and K, respectively. Entire quantity of P, K and zinc sulphate with one third of N was applied at sowing and remaining N was applied in two equal splits *i.e.* at knee high and at pre-tasselling stage. The maize hybrid PMH1 was sown on August 25, 2009. The sowing was done by dibbling two seeds per hill keeping row to row spacing of 60 cm and plant to plant spacing of 22 cm. Irrigation was scheduled when the cumulative pan evaporation (CPE) reached the level of 60, 75, 100 and 150 mm in case of IW/CPE ratio of 1.25, 1.00, 0.75 and 0.50, respectively. The irrigation water was measured with Parshall flume. The number of irrigations required during crop growing period was 3, 3, 2 and 1 at 1.2, 1.0, 0.75 and 0.50 IW/CPE ratios, respectively as given in Table A. The total rainfall and open pan evaporation during the crop season were 204.1 mm and 364.9 mm, respectively and 73 per cent of the rainfall was received during first four weeks out of total 20 weeks of the crop season. The crop was harvested manually on January 6, 2010 when more than 80 per cent of the cobs turned yellowish brown and grains became hard. The stover yield, harvest index and grain yield were monitored as per the standard methods. The grain yield was recorded for individual treatments at 14 per cent moisture and expressed as q ha^{-1}.

Root density (at Tasselling) :

Soil core samples were taken layer wise (0-15, 15-30, 30-60 and 60-90 cm) with the help of root sampling pipe having internal diameter of 7 cm. The samples were taken from the spot at tasselling stage, by keeping the plant stump in the centre of the core, in each experimental plot. The soil samples thus obtained were kept over one mm sieve under running water for washing. The washed roots were picked up and then dried at 60^0C in an oven to constant weight. The root density was expressed as weight of roots per unit volume of soil and calculated as follows:

$$\text{Root density (g m}^{-3}\text{of soil)} = \frac{\text{Total root weight in particular depth (g)}}{\text{Total soil valume from which roots were collected (m}^3\text{)}}$$

Chemical analysis :

The samples of maize leaves, stalk, grain and cob were

Table A: Details of irrigation applied during crop growing season under different irrigation scheduling treatments

Treatments	Dates of irrigation	Number of irrigations
0.50 IW/CPE ratio	01 November (69)	1
0.75 IW/CPE ratio	17 October (54), 03 December (100/46)	2
1.00 IW/CPE ratio	09 October (46), 01 November (69/23), 20 December (117/48)	3
1.25 IW/CPE ratio	27 September (34), 23 October (60/26), 20 November (87/27)	3

( ) Figures in parenthesis indicate days after sowing/days after previous irrigation collected at harvest, dried in sun and then in oven. Plant samples were grounded in Wiley Mill to 32 mesh size and grain samples in small grinding mill for chemical analysis.

Plant analysis for NPK uptake :

The leaves, stalk, grains and cob samples of maize from each plot were taken to estimate nitrogen, phosphorus and potassium content. Nitrogen content in leaves, stalk, grain and cob were determined by modified Micro-Kjeldhal's method (Subbiah and Asija, 1956). The P content was determined by method given by Jackson, (1967) and K content by using Lange's Flame Photometer (Jackson, 1967). The N, P and K uptake by leaves, stalk, grain and cob was calculated by multiplying the per cent N, P and K content with their respective biomass yields.

Statistical analysis :

Statistical analysis of different parameters and grain yield of maize was carried out by analysis of variance in split plot design (SPD) (Cochran and Cox, 1950). Mean separation for different treatments was performed using least significant difference (LSD) test at 0.05 level of probability.

RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads:

Root density (at Tasselling) :

The root density was higher in 0-15 cm soil profile and it decreased towards 60-90 cm soil profile depth (Table 1). In 0-15 cm depth, root density followed an increasing trend with increase in moisture level from $I_{0.05}$ to $I_{1.25}$. This trend continued even in 15-30 cm soil profile. However, the differences among various treatments were non significant for 0-15 cm soil profile. While in 15-30 cm soil profile depth, significantly highest root density was observed under $I_{1.25}$ followed by $I_{1.00}$ and $I_{0.75}$, respectively. The irrigation regimes $I_{0.75}$ and $I_{0.50}$ were statistically at par with respect to root density. Contrary to the higher root density under adequate irrigation regimes ($I_{1.25}$ and $I_{1.00}$) in 0-15 and 15-30 cm soil profile, in deeper soil profile layers (30-60 and 60-90 cm) root density was higher under lower irrigation regimes ($I_{0.50}$ and $I_{0.75}$). The adaptive strategy of maize under moderate stress appears to relate to an extension of rooting depth was also reported by Pandey *et al.* (2000). This might be a reason for more root density in deeper layers *i.e.* 30-60 and 60-cm soil profile under lower irrigation regimes. These trends can well be understood by the explanations put forward by Kang *et al.* (2000) who observed that moderate soil drying results in better root development, in terms of primary root number and root biomass accumulation, when compared to the adequate irrigation levels. However, severe water deficit led to significantly less primary root initiation and root biomass accumulation. Ibrahim and Hala (2007) also observed that plant roots can extract more soil moisture from greater depth under moderate stress. Sepat and Kumar (2007) also observed that relatively more but absolutely less moisture was absorbed from deeper layers under life saving irrigation than assured irrigation. Under assured irrigation more water was absorbed from the soil depth of 0-30 cm probably due to more rooting density in 0-30 cm layer and higher rate of evaporation from upper layers. However, Bharathi *et al.* (1997) observed increased root length with increasing moisture content in maize.

In general root density increased with increase in nitrogen dose in all the layers of soil profile (Table 1). In the top 0-15 cm soil profile root density under N_{175} was statistically at par with that under N_{150} but significantly higher when

Table 1: Effect of irrigation regimes and nitrogen levels on root density (g m^{-3}) of August sown hybrid maize

Treatments	Profile depth (cm)			
	0-15	15-30	30-60	60-90
Irrigation levels (IW/CPE ratio)				
	Root density (g m^{-3})			
$I_{0.50}$	720.6	173.4	63.2	20.2
$I_{0.75}$	724.4	176.5	62.0	19.1
$I_{1.00}$	729.8	186.4	56.9	17.4
$I_{1.25}$	734.0	196.8	56.0	16.4
C.D. (p=0.05)	NS	9.6	NS	NS
Nitrogen levels (kg ha^{-1})				
N_{100}	699.7	171.8	50.2	13.1
N_{125}	721.8	179.8	56.5	15.9
N_{150}	741.5	188.7	64.3	20.1
N_{175}	746.3	192.5	67.3	24.0
C.D. (p=0.05)	20.5	5.5	6.1	2.1

NS=Non-significant

compared with that recorded under N_{125} and N_{100}. Root density under N_{150} was also at par with that observed under N_{125} but significantly higher than recorded under N_{100}. Similar trend was observed in 15-30 and 30-60 cm soil profile except that root density under N_{150} was significantly higher when compared with that recorded under N_{125} and N_{100}. In 60-90 cm soil profile root density increased significantly with each increment in nitrogen dose from N_{100} to N_{175} through N_{125} and N_{150}. This increase in rooting density with increase in nitrogen levels might be due to favorable effect of nitrogen on root dry matter because higher nitrogen application encouraged above ground plant biomass which also encouraged the underground root development, leading to higher values of root density. Sepat and Kumar (2007) observed that the increasing level of nitrogen resulted into greater proliferation of roots in deeper soil layers. Increase in root length at higher nitrogen levels were also observed by Mackay and Barber (1986), Bharathi *et al.* (1997) and Eghball *et al.* (1993).

Nutrient uptake :

Nitrogen uptake :

Irrigation regimes and nitrogen levels significantly influenced the nutrient uptake. A perusal of data reveal that on quantitative basis nitrogen uptake (Table 2) followed the trend grain > stalk > leaves > cob. In leaves, stalk, grain and cob, maximum nitrogen uptake was observed under irrigation regime $I_{1.25}$ which was at par with $I_{1.00}$. Nitrogen uptake under these treatments was significantly higher than recorded under $I_{0.50}$ and $I_{0.75}$. Total nitrogen uptake also followed the same trend. Uptake of N in whole maize plant increased by irrigation due to corresponding increase in N uptake in different plant parts (Table 3). The positive influence of irrigation on nutrient

Table 2: Effect of irrigation regimes and nitrogen levels on nitrogen uptake of August sown hybrid maize

Treatments	Nitrogen uptake (kg ha^{-1}) in				Total nitrogen uptake (kg ha^{-1})
	Leaves	Stalk	Grain	Cob	
Irrigation levels (IW/CPE ratio)					
$I_{0.50}$	19.9	31.6	107.3	5.6	164.4
$I_{0.75}$	26.3	36.3	122.4	6.2	191.3
$I_{1.00}$	35.5	42.2	141.7	7.0	226.4
$I_{1.25}$	38.5	43.0	146.8	7.1	235.4
C.D. (p=0.05)	5.8	3.5	15.3	0.4	22.3
Nitrogen levels (kg ha^{-1})					
N_{100}	23.4	31.7	109.3	5.8	170.2
N_{125}	27.9	37.2	124.8	6.3	196.2
N_{150}	32.8	41.1	136.9	6.8	217.7
N_{175}	36.0	43.2	147.2	7.0	233.4
C.D. (p=0.05)	4.3	3.5	11.8	0.4	15.0

Table 3: Effect of irrigation regimes and nitrogen levels on phosphorus uptake of August sown hybrid maize

Treatments	Phosphorus uptake (kg ha^{-1}) in				Total phosphorus uptake (kg ha^{-1})
	Leaves	Stalk	Grain	Cob	
Irrigation levels (IW/CPE ratio)					
$I_{0.50}$	2.8	5.8	10.3	1.6	20.5
$I_{0.75}$	3.9	6.8	11.5	1.7	23.8
$I_{1.00}$	4.5	8.3	13.7	1.9	28.3
$I_{1.25}$	4.8	9.4	15.3	2.1	31.6
C.D. (p=0.05)	1.0	2.5	2.5	NS	3.8
Nitrogen levels (kg ha^{-1})					
N_{100}	3.1	4.9	10.5	1.4	19.9
N_{125}	3.7	5.9	12.3	1.8	23.6
N_{150}	4.5	8.5	13.4	2.0	28.4
N_{175}	4.8	10.4	14.6	2.1	32.3
C.D. (p=0.05)	0.8	2.1	1.9	0.5	2.5

NS=Non-significant

uptake was also reported by Lalitha and Rajagopal (1997) and Selvaraju and Iruthayaraj (1995) who observed increase in nitrogen uptake with increase in irrigation frequency.

Different nitrogen levels affected nitrogen uptake significantly. Maximum nitrogen uptake in leaves, stalk, grains and cob was observed under N_{175} which was statistically at par with that recorded under N_{150} but significantly higher than observed under 100 and 125 kg N ha^{-1}. N_{150} was also statistically superior with respect to nitrogen uptake, when compared with N_{100} and N_{125}. Total nitrogen uptake increased significantly with increase in nitrogen level upto 175 kg ha^{-1}. The increased uptake of nitrogen at higher doses resulted in initial build up of vigorous growth and higher photosynthetic rate, leading to better uptake of nutrients throughout the crop growth period as reported by Selvaraju and Iruthayaraj (1995). Kumar (2009) revealed that the nutrient accumulation in plants is a function of nutrient concentration and dry matter production. Increased yield levels with higher nitrogen levels and more nitrogen concentration might have resulted in increased nitrogen uptake. Brar *et al.* (2001) and Khanday and Thakur (1991) found similar trends with respect to nitrogen uptake by grains and stover.

Phosphorus uptake :

Maximum phosphorus uptake (Table 3) by all the plant parts *viz.*, leaves, stalk, grain, cob and the total phosphorus uptake was observed under $I_{1.25}$ which was comparable with that obtained under $I_{1.00}$ in stalk, grain and total phosphorus uptake while significantly better than lower irrigation regimes *i.e.* $I_{0.75}$ and $I_{0.50}$. However, in leaves phosphorus uptake was statistically at par under $I_{1.25}$, $I_{1.00}$ and $I_{0.75}$. Phosphorus uptake in cob differed non-significantly under various irrigation regimes. The higher content of phosphorus at higher irrigation level might have been due to rate of conversion of P into

Table 4: Effect of irrigation regimes and nitrogen levels on potassium uptake of August sown hybrid maize

Treatments	Potassium uptake (kg ha^{-1}) in				Total potassium uptake (kg ha^{-1})
	Leaves	Stalk	Grain	Cob	
Irrigation levels (IW/CPE ratio)					
$I_{0.50}$	28.9	55.8	19.6	8.2	112.5
$I_{0.75}$	33.0	61.4	23.0	8.7	126.2
$I_{1.00}$	38.0	69.7	26.3	9.5	143.6
$I_{1.25}$	40.4	72.5	27.1	9.8	149.7
C.D. (p=0.05)	3.6	3.9	2.8	0.6	14.7
Nitrogen levels (kg ha^{-1})					
N_{100}	27.7	55.0	20.1	8.2	111.1
N_{125}	33.7	63.5	23.1	8.8	129.0
N_{150}	38.4	69.0	25.8	9.4	143.6
N_{175}	40.6	72.0	27.0	9.7	149.2
C.D. (p=0.05)	3.5	3.6	2.1	0.6	10.2

Table 5: Effect of irrigation regimes and nitrogen levels on green cob yield, stover yield, grain yield, shelling percentage and harvest index of August sown hybrid maize

Treatments	Stover yield (q ha^{-1})	Grain yield (q ha^{-1})	Shelling percentage	Harvest index (%)
Irrigation levels (IW/CPE ratio)				
$I_{0.50}$	125.6	64.6	76.2	30.6
$I_{0.75}$	136.2	72.7	77.8	31.7
$I_{1.00}$	150.7	81.2	78.8	32.1
$I_{1.25}$	155.0	83.1	79.0	32.2
C.D. (p=0.05)	13.6	7.2	1.6	NS
Nitrogen levels (kg ha^{-1})				
N_{100}	123.8	65.6	76.4	31.3
N_{125}	139.2	73.3	77.6	31.3
N_{150}	150.0	79.8	78.6	31.9
N_{175}	154.6	82.9	79.2	32.2
C.D. (p=0.05)	7.8	6.2	1.5	NS

NS=Non-significant

soluble form (ferrous) from that of insoluble form (ferric) under lower irrigation level (Arya and Singh, 2000). This indicated that higher irrigation frequencies might have increased the solubility of phosphorus resulting in higher P uptake.

Significantly higher total phosphorus uptake was observed under 175 kg N ha^{-1} as compared to all the lower nitrogen levels. In all the plant parts phosphorus uptake recorded was maximum under N_{175} and this was statistically at par with phosphorus uptake obtained under N_{150}. A certain degree of synergy between nitrogen and phosphorus has been observed by Hussaini *et al*. (2008) who reported that the addition of nitrogen influenced the P uptake by the plant from soil and fertilizer sources. This phenomenon can be explained by the fact that the supply of nitrogen enhances the production of small roots and root hairs, which in turn facilitated the high absorbing capacity per unit of dry weight. Brar *et al.* (2001) also observed increase in total phosphorus uptake with increase in nitrogen levels.

Potassium uptake :

The potassium uptake (Table 4) followed almost similar trends in various plant parts as that of nitrogen uptake both under various irrigation regimes and nitrogen levels. Hussaini *et al.* (2008) and Selvaraju and Iruthayaraj (1995) also found similar results in potassium uptake by grain and stover. Nanjundappa *et al.* (1994) reported increase in potassium uptake with increase in N levels.

Grain yield :

The grain yield under irrigation regimes $I_{1.25}$ (3 irrigations) and $I_{1.00}$ (3 irrigations) was 83.1 and 81.2 q ha^{-1}, respectively, which was at par with each other while these yields were significantly higher than the grain yield observed under $I_{0.75}$ (2 irrigations) and $I_{0.50}$ (1 irrigation). The per cent increase in grain yield under $I_{1.25}$ was 2.3, 14.3 and 28.6 over $I_{1.00}$, $I_{0.75}$ and $I_{0.50}$, respectively. While the increase in grain yield under $I_{1.00}$ in comparison to $I_{0.75}$ and $I_{0.50}$ was to the tune of 1.7 and 25.7 per cent, respectively. Significantly higher grain yield under sufficiently irrigated regimes can be attributed to the adequate turgidity which must have prevailed inside the plant and thereby helping in significantly better root and shoot development. This process acted as a active source back up even during the photosynthates translocation to the sink which further strengthen the explanation that active translocation of photosynthates must have existed for longer period to fill the sink to achieve higher capacity as is evident from higher shelling percentage and harvest index (Table 5) under $I_{1.00}$ and $I_{1.25}$. The uptake of nutrients might be because of better root establishment (Table 1), resulting in higher absorption of nutrients to feed and sustain increased growth which led to higher grain and stover yields. In addition to it, irrigation improved air-water relationship in soil and beneficial effect of irrigation on water and nutrient availability to the crops contributed to their increased yields. Irrigation increased moisture status of soil which was conducive for greater absorption of nutrients from the soil by roots and then translocated to different plant parts. Decline in available soil moisture might decrease the diffusion rate of nutrients from soil matrix to roots. Evidence of decreased ion uptake due to water stress was attributed to the reduction in root absorption power. The decrease in maize grain yield was more related to the decrease of soil available moisture in the root zone, which reduced nutrient uptake (Ibrahim and Hala, 2007). Arya and Singh (2000) reported that with assured irrigation treatment, lesser amounts of available N, P and K were left in soil compared to life saving irrigation. The reduction in available N, P and K in soil might be attributed to the fact that the irrigation application increased the solubilization and absorption of the nutrients from soil to roots and consequently decreased their residual contents in soil.

Highest grain yield (82.9 q ha^{-1}) obtained under N_{175} was statistically at par with the yield (79.8 q ha^{-1}) recorded under N_{150}. The grain yields recorded under N_{175} and N_{150} were significantly better than those obtained under N_{125} and N_{100}. The application of nitrogen increased the grain yield, stover yield, shelling percentage, harvest index (Table 5) and uptake of N (Table 2), P (Table 3) and K (Table 4). Nutrient accumulation in the maize grain was greater than that of other components of the plant. This can be attributed to the mobilization of large proportions of nitrogen, phosphorus and potassium, from other plant parts to the grain as the grain developed. The increased nitrogen levels increased the yield of maize by better uptake of all the nutrients which results into initial build up of plants due to vigorous growth and higher photosynthetic rate and increased translocation of photosynthates from source to sink. Rana and Choudhary (2006) and Khanday and Thakur (1991) recorded similar observations.

Conclusion :

On the basis of the present study it can be concluded that in Punjab, August sown hybrid maize should be irrigated at IW/CPE ratio of 1.00 and the optimum nitrogen dose of August sown maize hybrid in low fertility soils should be 150 kg N ha^{-1}.

REFERENCES

Anonymous (2012). *Package of practices for cultivation of Kharif crops*. p 20. Punjab Agricultural University, Ludhiana (PUNJAB) INDIA.

Arya, K.C. and Singh, S.N. (2000). Effect of different levels of phosphorus and zinc on yield and nutrients uptake of maize (*Zea mays*) with and without irrigation. *Indian J. Agron.,* **45**: 717-721.

Benbi, D.K. and Brar, J.S. (2008). A 25-year record of carbon sequestration and soil properties in intensive agriculture. *Agron. Sutain. Dev.,* **29**: 257-265.

Bharathi, A., Vadivelu, K.K. and Umarani, R. (1997). Effect of irrigation management and nitrogen fertilization on shelf-life of maize. *Madras Agric. J.*, **84**: 356-360.

Brar, B.S., Dhillon, N.S. and Chhina, H.S. (2001). Integrated use of farmyard manure and inorganic fertilizers in maize (*Zea mays*). *Indian J. Agric. Sci*., **71**: 605-607.

Cochran, W.G. and Cox, G.M. (1950). *Experimental designs*. Wiley, NEW YORK, U.S.A.

Eghball, B., Settimi, J.R., Maranville, J.W. and Parkhurst, A.M. (1993). Fractal analysis for morphological description of corn roots under nitrogen stress. *Agron. J.*, **85**: 287-289.

Hussaini, M.A., Ogunlela, V.B., Ramalan, A.A. and Falaki, A.M. (2008). Mineral composition of dry season maize (*Zea mays* L.) in response to varying levels of nitrogen, phosphorus and irrigation at Kadawa, Nigeria. *World J. Agric. Sci.*, **4**: 775-780.

Ibrahim, S.A. and Hala, K. (2007). Growth yield and chemical constituents of corn (*Zea mays* L.) as affected by nitrogen and phosphorus fertilization under different irrigation intervals. *J. Appl.Sci. Res*., **3**: 1112-1120.

Jackson, M.L. (1967). *Soil chemical analysis.* Constable and Co. Ltd. 10 Orange St., London, W.C.Z.485 pages.

Kang, S., Liang, Z., Pan, Y., Shi, P. and Zhang, J. (2000). Alternate furrow irrigation for maize production in an arid area. *Agric. Water Mgmt*., **45**: 267-274.

Khanday, B.A. and Thakur, R.C. (1991). Influence of nitrogen, farm yard manure and zinc on nutrient uptake of early composite maize (*Zea mays* L.) under rainfed conditions. *Himachal J Agric. Res*., **17**: 04-07.

Kumar, A. (2009). Influence of varying plant population and nitrogen levels on growth, yield, economics and nitrogen use efficiency of pop corn (*Zea mays* everta sturt). *Crop Res*., **37**: 19-23.

Lalitha, K. and Rajagopal, A. (1997). Nutrient uptake in maize under varying irrigation regimes, soil amendments and irrigation layouts. *Madras Agric. J*., **84**: 598-600.

Mackay, A.D. and Barber, S.A. (1986). Effect of nitrogen on root growth of two corn genotypes in the field. *Agron. J*.,**78**: 699-703.

Nanjudappa, G., Manure, G.R. and Badiger, M.K. (1994). Yield and uptake of fodder maize (*Zea mays*) as influenced by nitrogen and potassium. *Indian J. Agron*., **39**: 473-475.

Pandey, R.K., Maranville, J.W. and Chetima, M.M. (2000). Deficit irrigation and nitrogen effectson maize in a Sahelian environment. II. Shoot growth, nitrogen uptake and water extraction. *Agric. Water Mgmt.*, **46**: 15-27.

Prihar,S.S.,Khera,K.L.,Sandhu, K.S. and Sandhu, B.S. (1976). Mulch, nitrogen and irrigation effects on growth, yield and nutrient uptake of forage corn. *Agron. J*., **68**: 937-941.

Rana, K.S. and Choudhary, R.S. (2006). Productivity, nitrogen uptake and water use in maize (*Zea mays* L.) + mungbean intercropping system as affected by nitrogen levels under rainfed conditions. *Crop Res*., **32**: 306-308.

Selvaraju, R. and Iruthayaraj, M.R. (1995). Effect of irrigation, methods of irrigation and nitrogen levels on nutrient uptake by maize (*Zea mays*). *Madras Agric. J*., **82**: 217-218.

Sepat, S. and Kumar, A. (2007). Nitrogen management in maize (*Zea mays*) under life saving and assured irrigations. *Indian J. Agric. Sci*., **77**: 451-454.

Srikanth, M., Amanullah, M.M. and Muthukrishnan, P. (2009). Influence of plant density and fertilizer on yield attributes, yield and grain quality of hybrid maize. *Madras Agric. J.*, **96**: 139-143.

Subbiah, B.V. and Asija, G.L. (1956). A rapid procedures for the estimation of available nitrogen in soils. *Curr. Sci*., **25**: 259-260.