International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(6): 1151-1153

Received: 07-09-2019
Accepted: 09-10-2019

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Soil moisture depletion as influenced by planting geometry and moisture regimes in *rabi* maize (*Zea mays* L.)

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Abstract
A field experiment was conducted during *rabi* season 2016-2017 at Agronomy Research Farm, Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad (U.P.) to study soil moisture depletion as influenced by planting geometry and moisture regimes in *rabi* maize. The experiment was laid out in split plot design with three replications keeping combinations of planting geometry *viz.*, 60 × 10 cm, 60 × 15 cm, 60 × 20 cm, 60 × 25 cm and four moisture regimes *viz.*, 0.6 IW/CPE ratio, 0.9 IW/CPE ratio, 1.2 IW/CPE ratio, 0.9 IW/CPE ratio up to silking and 1.2 IW/CPE ratio for rest of the crop season. Among four planting geometries, highest soil moisture depletion (40.16 cm) was recorded in 60 × 10 cm. Among four moisture regimes, highest soil moisture depletion (45.91 cm) was recorded in 1.2 IW/CPE ratio. With respect to treatment combinations, higher soil moisture depletion (47.8 cm) was recorded in 60 × 10 cm and 1.2 IW/CPE ratio.

Keywords: Soil moisture depletion, *Rabi* maize, planting geometry, IW/CPE ratio, moisture regimes

Introduction
Maize (*Zea mays* L.) is the third most important grain crop in India after rice and wheat with respect to area and productivity. Globally maize is cultivated in an area of 177 million hectares with a production and productivity of 989 and 5.5 metric t ha^{-1}, respectively (Commodity profile-maize, 2015). In India it is grown in an area of 9.43 million hectares with production of 24.35 Mt and 2562 kg ha^{-1} productivity (CMIE, 2016). It has wide ecological adaptability and is grown in extreme semi-arid to sub-humid and humid regions as a staple crop for human beings, feed for animals and as a basic raw material for production of starch, oil, protein, alcoholic beverages, food sweeteners and more recently bio-fuel (Dass *et al*., 2008) [3]. The average grain yield of maize is not only substantially lower compared with other important maize growing countries but also less than the production potential of existing genotypes. Traditionally maize is a rainy/*kharif* season crop in India and is extensively grown under rainfed conditions, but *kharif* crop suffers due to vagaries of monsoon, excessive rainfall leading to water stagnation, poor drainage, erratic and insufficient rainfall leading to moisture stress condition, severe infestation of pests and diseases, fertilizer losses, greater weed menace and high temperature throughout the growth period which tend to reduce grain yield. On the contrary, the risk of damage to the crop from excessive rainfall, water stagnation, inadequate soil moisture, pest and disease infestation during winter/*rabi* season is less. The average grain yield of maize is not only substantially lower compared with other important maize growing countries but also less than the production potential of existing genotypes. Low yield of maize is due to many constraints but among them, cultivation of local genotypes, imbalanced use of fertilizers, traditional sowing methods, improper water management, lack of optimal crop stand and optimum planting geometry are the factors of prime importance. Planting geometry and water management play an important role in enhancing the crop productivity. Planting geometry *i.e.* plant population per unit area have immense role since it is a non tillering crop. Sub optimal plant stand *i.e.* wider spacing leads to poor yield per unit area. While higher plant populations have greater competition for growth resources and leads to poor yield. In order to produce higher yields of maize, optimum soil moisture should be maintained as it is susceptible to both water logging and water deficit. Among the different approaches for scheduling, the climatological approach based on IW/CPE ratio (IW - irrigation water, CPE - cumulative pan evaporation) has been found most appropriate as it integrates all weather

Parameters that determine water use by the crop and is likely to increase production by at least 15-20% (Dastane, 1972) [4]. With this background information the present study was conducted to determine the effect four planting geometry *viz.*, 60 × 10 cm, 60 × 15 cm, 60 × 20 cm, 60 × 25 cm and four moisture regimes *viz.*, 0.6 IW/CPE ratio, 0.9 IW/CPE ratio, 1.2 IW/CPE ratio, 0.9 IW/CPE ratio up to silking and 1.2 IW/CPE ratio for rest of the crop season on soil moisture depletion in *rabi* maize.

Materials and Methods

A field experiment was conducted during *rabi* 2016-2017 at Agronomy Research Farm, Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad (U.P.) (26° 47' N latitude, 82° 12' E longitude and 113 m above mean sea level) to investigate “Soil moisture depletion as influenced by planting geometry and moisture regimes in *rabi* maize (*Zea mays* L.)”. The soil of the experimental field was silty loam with bulk density (1.35 g cm^{-3}), pH (8.10), organic carbon (0.32%) and available N, P and K contents were 185.0, 15.2 and 265 kg ha^{-1} respectively. The moisture content at field capacity and permanent wilting point was 23.69% and 11.28% respectively. The experiment was laid out in split-plot design and replicated thrice. Main plots treatments consisted of 4 planting geometry, *viz.*, 60 × 10 cm, 60 × 15 cm, 60 × 20 cm, 60 × 25 cm and the sub-plots with 4 levels of moisture regimes *viz.*, 0.6 IW/CPE ratio, 0.9 IW/CPE ratio, 1.2 IW/CPE ratio, 0.9 IW/CPE ratio up to silking and 1.2 IW/CPE ratio for rest of the crop season. Recommended doses of N: P_2O_5: K_2O ha^{-1} @ 150:60:40 kg ha^{-1} were applied in the form of urea, single super phosphate and muriate of potash, respectively. Full dose of P_2O_5, K_2O and one fourth dose of nitrogen was applied as basal and half N was applied as topdressing after 35 DAS while the remaining one fourth N was applied at tasseling stage. The maximum and minimum temperatures were 25.64 ºC and 11.59 ºC respectively during crop growing season. Maize variety ‘Shakthi’ was sown during 3rd week of October. Plant protection measures were taken as and when required. Other cultural operations were carried out as per recommendations. Harvesting of Maize was done during 1st week of March. A common irrigation was given at 30 DAS. Remaining irrigations were scheduled as per treatments when CPE reached at respective levels. 60 mm depth of irrigation water was maintained with the help of parshall flume. Number of irrigations at 0.6 IW/CPE ratio, 0.9 IW/CPE ratio, 1.2 IW/CPE ratio, 0.9 IW/CPE ratio up to silking and 1.2 IW/CPE ratio for rest of the crop season were 6, 9, 11 and 10 respectively. Total rainfall during the crop growth period was 17.5 mm. Soil samples were taken from 0-15, 15-30, 30-45 and 45-60 cm depth to monitor the profile moisture status of the active root zone gravimetrically at sowing, before and after each irrigation and at harvest. The moisture in entire root zone (60 cm) was computed by changes in the soil moisture content in the root zone during the crop period.

Table 1: Details of the treatments

S. No.	Treatment	Symbol used
Planting geometry (main plots)		
1	60 × 10 cm	P_1
2	60 × 15 cm	P_2
3	60 × 20 cm	P_3
4	60 × 25 cm	P_4
Moisture regimes (sub plots)		
1	0.6 IW/CPE ratio	M_1
2	0.9 IW/CPE ratio	M_2
3	1.2 IW/CPE ratio	M_3
4	0.9 IW/CPE ratio up to silking and 1.2 IW/CPE ratio for rest of the crop season	M_4

Table 2: Details of Irrigation

Moisture regimes	No of irrigations	Depth of irrigation (mm)	Total water applied (mm)	Rainfall (mm)	Total water received (mm)
I_1	6	60	360	17.5	377.50
I_2	9	60	540	17.5	557.50
I_3	11	60	660	17.5	677.50
I_4	10	60	600	17.5	617.50

Table 3: Soil moisture depletion (cm) at varying depth as influenced by planting geometry and moisture regimes

Treatments	Soil depth (cm)				
	0-15	15-30	30-45	45-60	Total depletion (cm)
Planting geometry					
P_1	11.22	10.25	9.72	8.97	40.16
P_2	10.52	10.00	9.52	8.80	38.84
P_3	10.25	9.92	9.37	8.67	38.21
P_4	9.90	9.87	9.30	8.62	37.69
Moisture regimes					
M_1	8.27	7.70	7.02	6.45	29.44
M_2	9.82	8.87	8.22	7.62	34.53
M_3	12.82	11.82	11.25	10.02	45.91
M_4	10.97	10.07	9.67	9.30	40.01
Mean	10.47	9.81	9.26	8.55	38.09

Table 4: Soil moisture depletion (cm) at varying depth as influenced by planting geometry and moisture regimes

Treatment combinations	Soil depth (cm)				
	0-15	15-30	30-45	45-60	Total depletion (cm)
P_1I_1	9.2	8.6	7.8	7.2	32.9
P_1I_2	10.5	9.3	8.9	8.2	37.0
P_1I_3	13.3	12.3	11.8	10.4	47.8
P_1I_4	11.9	10.8	10.4	10.1	43.4
P_2I_1	8.1	7.6	7.0	6.5	29.3
P_2I_2	10.0	9.0	8.3	7.7	35.1
P_2I_3	13.0	12.1	11.5	10.2	46.9
P_2I_4	11.0	10.3	9.7	9.4	40.5
P_3I_1	8.0	7.4	6.8	6.1	28.5
P_3I_2	9.6	8.7	8.0	7.4	33.8
P_3I_3	12.6	11.7	11.0	9.8	45.2
P_3I_4	10.8	9.9	9.4	9.0	39.2
P_4I_1	7.8	7.2	6.5	6.0	27.6
P_4I_2	9.2	8.5	7.7	7.2	32.7
P_4I_3	12.4	11.2	10.7	9.7	44.1
P_4I_4	10.2	9.3	9.2	8.7	37.5

Results and Discussion

Among four planting geometries, 60 × 10 cm recorded highest soil moisture depletion (40.16 cm) followed by 60 × 15 cm (38.84 cm), 60 × 20 cm (38.21 cm). Higher soil moisture depletion in these treatments is due to higher plant population which leads to higher crop water requirement owing to increased LAI and hence increased ET demand. Low soil moisture depletion was recorded in 60 × 25 cm due to lower plant population. Among four moisture regimes, 1.2 IW/CPE ratio recorded highest soil moisture depletion (45.91 cm) followed by 0.9 IW/CPE ratio up to silking and 1.2 IW/CPE ratio for rest of the crop season, 0.9 IW/CPE ratio. Low soil moisture depletion was recorded in 0.6 IW/CPE ratio due reduced frequency in irrigation. Soil moisture depletion increased progressively with increase in frequency of irrigation, similar reports were reported by Aladakatti *et al*. (2012) [1]. With respect to treatment combinations, higher soil moisture depletion (47.8 cm) was recorded in 60 × 10 cm and 1.2 IW/CPE ratio. From the depth-wise soil moisture extraction pattern was higher from the uppermost soil layers (0-15) irrespective of treatments due to maximum root mass and root growth activity in this layer. Moisture extraction was lower from deeper soil layers. Moreover, the surface soil, being exposed to direct radiation, was subjected to higher loss of water through evaporation. Similar findings were reported in wheat by Maurya and Singh (2008) [6] at Faizabad (UP) under irrigated conditions in silt loam soil.

Conclusion

Planting of *rabi* maize at 60 × 10 cm planting geometry depleted higher soil moisture when irrigated at 1.2 IW/CPE ratio.

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