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Consumptive Use, Water Use Efficiency and Economics of *Rabi* Maize as Influenced by Planting Geometry and Moisture Regimes

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A B S T R A C T

Field experiment was conducted at Agronomy Research Farm, Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.) during Rabi 2016-2017 on silty loam soils to study the “Consumptive use, Water use efficiency and Economics of Rabi Maize as Influenced by Planting geometry and Moisture regimes”. The experiment was laid out in split plot design with four planting geometriesviz., 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 which were replicated thrice. Results showed that Consumptive use (cm) was more in 60 x 10 cm spacing and 1.2 IW/CPE ratio. Maximum WUE was recorded in 60 × 25 cm spacing and 1.2 IW/CPE ratio. The highest gross return, net return and benefit-cost ratio were recorded with60 × 25 cm planting geometry and 1.2 IW/CPE ratio.

Introduction

Maize (*Zea mays* L.) belongs to family poaceae is one of the most important cereal crop in the world after wheat and rice. Maize is called ‘queen of cereal’ as it is grown throughout the year due to its photo-thermo-insensitive character and highest genetic yield among the cereals. Being a C_4 plant, it is very efficient in converting solar energy in to dry matter. Importance of maize lies in its wide industrial applications besides serving as human food and animal feed. In the world, maize occupies an area of 185.12 million hectares with a production of 872.06 million tonnes and with a productivity of 4.9 t ha^{-1}. In India, maize is cultivated in an area of 8.49 million hectares, with a production of 21.28 million tonnes and with a productivity of 2.5 tha^{-1}.*Rabi* maize is grown in an area of 1.2 million hectares with the production of 5.08 million tonnes, with an average productivity of 4.00 t/ha.

It is traditionally a rainy season crop in India and is extensively grown as an important *kharif* crop under rainfed or irrigated condition, 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 in *kharif* maize. On the contrary, the risk of damage to the crop from excessive rainfall, water stagnation, inadequate soil moisture, pest and disease infestation during winter season is less.

Maize yield is a function of climate, soil, variety and cultural practices. Inadequate irrigation and low plant population are the major factors limiting grain yield of maize in many areas. 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 India, agriculture is mainly based on monsoon that is mostly uncertain and unevenly distributed over the sub-continent So, in such situation, proper scheduling of irrigation maintains the soil moisture at levels up to the crop needs. 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).

In view of the above context, this experiment was undertaken with the objectives to study the Consumptive use, water use efficiency and economics of *Rabi* maize as influenced by planting geometry and moisture regimes in eastern part of Uttar Pradesh.

Materials and Methods

A field experiment was conducted during *rabi* 2016-2017 at Agronomy Research Farm, Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.) (26° 47' N latitude, 82° 12' E longitude and 113 m above mean sea level) to investigate “Agro-physiological attributes of *rabi* maize as Influenced by planting geometry and moisture regimes”. 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 25.64ºC and 11.59ºC respectively during crop growing season. Maize variety ‘Shakthi’ was sown during 3rd week of October with 6.25 × 3.77 m plot size. 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. 50 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.

Consumptive use of water (cm) was calculated based on formula

$$CU = \sum_{i=1}^{n} \frac{Mbi - Mei}{100} BDi \times Di + ER + \sum_{i=1}^{2} ET$$

ER = Effective rainfall received during crop period (cm)

Mbi = moisture percentage at first sampling in the 'i'th layer of the soil

Mei = Moisture percentage at second sampling in the 'i'th layer of the soil

BDi = Bulk density of the soil in the 'i' layer of soil (g/m^3)

Di = Depth of 'i'th layer of the soil with in the root zone (mm)

N = Number of soil layers in the root zone depth

ET = Evapotranspiration of 2 days after applying irrigation

Ground water fluctuation was measured from the nearby well of experimental field by inserting heavy brick tied with a rope at one end as to know the contribution of ground water. The water use efficiency (WUE) was calculated based on the cob yield (Y) of the crop per unit of Consumptive water use. From the mean data, economics was worked out on the basis of prevailing market price of the produce and inputs used in the experiment. The data were statistically analyzed by standard tools for interpretation of the results.

Results and Discussion

Consumptive use (cm)

Consumptive use of maize as influenced by planting geometry and moisture regimes (Table 1)

Consumptive use (cm) was more in 60 x 10 cm spacing followed by 60 x 15 cm, 60 x 20 cm and 60 x 25 cm. Consumptive use increased with increase in plant population.

There was a general trend that the consumptive use of water increases progressively with increasing frequency of irrigation and therefore, M_3 (1.2 IW/CPE ratio) treatment recorded the highest value of consumptive use of water (Table 1). Supply of higher levels of moisture in soil through irrigation resulted in increase in evapotranspiration losses which caused greater Consumptive use of water. Similar results were reported by Aladakatti *et al.,* (2012).

Water use efficiency (kg ha^{-1} cm^{-1})

Water use efficiency (kg ha^{-1} cm^{-1}) of maize as influenced by planting geometry and moisture regimes (Table 1)

Among different planting geometry the highest water use efficiency (129.06 kg ha^{-1} cm^{-1}) was recorded in 60 × 25 cm, lowest water use efficiency (100.73 kg ha^{-1} cm^{-1}) was recorded in 60 × 10 cm spacing. WUE was highest (3.91 kg ha^{-1} cm^{-1}) with irrigation at 0.6 IW/CPE ratio, followed by 0.9 IW/CPE ratio and the lowest value (101.89 kg ha^{-1} cm^{-1}) with irrigation at 1.2 IW/CPE ratio.

Table.1 Water use efficiency (kg ha^{-1} cm^{-1}), consumptive use (cm) of Rabi maize as affected by planting geometry and moisture regimes

Treatments	Seed yield (q ha^{-1})	Consumptive use (cm)	Water use efficiency (kg ha^{-1} cm^{-1})
Planting geometry			
P_1 60 × 10 cm	47.75	47.40	100.73
P_2 60 × 15 cm	51.74	45.07	114.79
P_3 60 × 20 cm	52.61	43.72	120.33
P_4 60 × 25 cm	54.98	42.60	129.06
Moisture regimes			
M_1 IW/CPE 0.6	49.09	35.01	140.21
M_2 IW/CPE 0.9	51.54	41.57	123.98
M_3 IW/CPE 1.2	55.38	54.35	101.89
M_4 IW/CPE 0.9/1.2	51.80	47.95	108.02

Table.2 Ground water fluctuation near experimental area

Date of Recording	Ground Water table (mt)
20.10.16	3.0
05.11.16	3.2
20.11.16	3.4
05.12.16	3.6
20.12.16	3.7
04.01.17	3.8
19.01.17	3.9
03.02.17	4.2
18.02.17	4.5
05.03.17	4.7
20.03.17	4.9
04.04.17	5.0

Table.3 Cost of cultivation, Gross return, Net return, and Benifit cost ratio in Rabi maize as affected by planting geometry and moisture regimes

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit cost
Planting geometry				
P_1 60 × 10 cm	36766	79623	42497	2.15
P_2 60 × 15 cm	35718	85228	49510	2.38
P_3 60 × 20 cm	33016	91663	58647	2.77
P_4 60 × 25 cm	32473	85206	52733	2.62
Moisture regimes				
M_1 IW/CPE 0.6	32294	79046	46752	2.44
M_2 IW/CPE 0.9	34066	84013	49947	2.46
M_3 IW/CPE 1.2	36431	90610	54178	2.48
M_4 IW/CPE 0.9/1.2	35248	87691	52443	2.48

Water use efficiency (kg ha^{-1} cm^{-1}) showed declined trend with increasing levels of irrigation. This was due to the fact that with increased water supply, the rate of evapotranspiration was proportionally higher than the increase in yield up to certain limit. Similar result was reported by Mahajan *et al.,* (2007) and sani *et al.,* (2008).

Ground water fluctuation

Data pertaining to ground water fluctuation (Table 2) reveal that Ground water table was quite below the soil surface (5mt) hence not contributed to growing maize crop might due to occurrence of low rainfall in the area. Similar findings were reported by Singh *et al.,* (1997).

Economics

The maximum cost of cultivation was recorded with 60 x 10 cm spacing (36766Rs ha^{-1}) and 1.2 IW/CPE ratio (36431 Rs ha^{-1}), minimum cost of cultivation was recorded with 60 x 25 cm (32473Rs ha^{-1}) and 0.6 IW/CPE ratio (32294 Rs ha^{-1}). The cost of cultivation increased with increase in frequency of irrigation and seed rate. The maximum gross return, net return and benefit-cost ratio was recorded with 60 x 25 cm spacing and 1.2 IW/CPE ratio, minimum gross returns and net returns was recorded with 60 x 10 cm spacing and 0.6 IW/CPE ratio. Optimum spacing and high irrigation frequencies lead to higher yields and higher gross returns. Similar findings were reported by Panchanan Sahu *et al.,* (2005), Bharathi *et al.,* (2007), Sahoo and Mahapatra (2007), singh and Singhi (2006), Sanjeev Kumar *et al.,* (2006), and Arvadiya *et al.,* (2012).

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