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Effect of planting density and irrigation scheduling on Dry matter production,yield attributes and yield of Rabi maize (*Zea mays* L.)

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ABSTRACT

A field experiment was conducted during rabi season of 2022-23 and 2023-24 to study the effect of planting density and irrigation scheduling on dry matter accumulation, yield attributes and yield of *Rabi* maize. Higher drymatter accumulation was recorded under highest plant population of 1,00,000 plants/ha , which was significant when compared to rest of the population at 60,90 and 120 DAS and at harvest during both the seasons and higher dry matter accumulation was recorded under irrigation scheduling of 25% Available soil moisture depletion and it decreased with decreasing moisture availability under different treatment while the lowest under 75% ASMD at all the stages of crop during both the seasons. Yield-contributing characteristics such as the no. of cobs per plant, cob length (cm), no. of grain rows, per cob, no. of grains, per cob, cob weight (g), and shelling percentage were significantly higher with planting density of (66,666 plants ha^{-1}) and irrigation scheduling at 25 % Available soil moisture deficit And grain and straw yield was recorded significantly higher under cropping density of 83,333 plants/ha with irrigation scheduling at 25% Available soil moisture deficit.

INTRODUCTION

Maize (Zea mays L.) is called 'queen of cereal' as it is grown throughout the year due to its photo-thermo insensitive character and highest genetic yield potential among the cereals. It is one of the major cereal crops that occupy third position among the cereals after rice and wheat, since it is representing 24 % of total cereal production in the world. Being a C_4 plant, maize is capable of utilizing solar radiation more efficiently compared to other cereals. It contains about 70 to 75 % starch, 8 to 12 % protein, 3 to 8 % oil. It is cultivated as a food and feed crop under varying soil topography, seasons and management practices throughout the country (Singh *et al.*, 2007).

Maize is more impacted by differences in spacing compared to other members of the Gramineae family (Vega et al., 2001). Yield differences under varying spacing levels are due to genetic potential differences (Liu *et al.*, 2004). Plant populations significantly influence most growth parameters of maize, even under optimal conditions, making it a major factor in determining plant competition (Sangakkara *et al.*, 2004). Ideal plant density depends on several factors namely water availability, soil fertility, maturity, row spacing, and spatial arrangement (Imran *et a*l., 2015). Under sufficient water and nutrient supply, higher plant density can increase the total number of cobs per unit area, thereby boosting grain yield (Novacek, 2013). To achieve profitable maize production, producers must implement advanced management strategies as balanced soil fertility, effective weed control, timely sowing, optimal spacing, and selecting suitable maize varieties (Norwood, 2001). Favourable plant geometry enhances maize growth, sunlight interception, and radiation use efficiency, increasing dry matter and yield (Westgate *et al.*, 1997).

The monoecious nature of maize make's it particularly susceptible to reproduction issues under mild to severe water stress. Water stress can reduce silk growth or delay its emergence from the husk, leading to potential pollination failure if there is insufficient pollen remaining when the silk finally appears (Steduto *et al.*, 2012). Similarly, the 3 Introduction intensity and time span of waterlogging at various growth stages can significantly impact maize development and yield. Waterlogging negatively affects cob characteristics such as the number of grains per cob and the weight of 1000 grains, as well as plant morphology, including plant height, cob length, and leaf area index. Additionally, it increases the length of the bald tip. Under waterlogged conditions, the maximum grain filling rate declines, dry matter production is reduced, and the proportions of dry material distributed to the stem and leaf increase (Ren *et al.*, 2014). The water requirements of crops are primarily Influenced by evapotranspiration, which is mainly determined by climate. Hence, there is need to study the integrated effect of different irrigation schedules and optimum plant population of maize under rabi conditions to improve the water use efficiency. As the information available under rabi conditions is very meagre in Eastern Uttar Pradesh. Hence present investigation was undertaken.

Materials and methods

A field experiment was conducted during the *Rabi* season of 2022-23 and 2023-24 at Agronomy Research Farm of A.N.D.U.A& T Ayodhya, Uttar Pradesh. The soil was silty loam with 7.8 pH and 0.37 % Organic carbon, 180.4, 13.6 and 263.9 kg/ha of available N, P_2O_5 and K_2O respectively. Field capacity, permanent wilting point and bulk density between 0-60 cm soil depth ranged from 22.8 to 23.3 %, 10.2- 11.0% and 1.32- 1.40 g/cc respectively. The treatments comprised four plant density 83,333; 66,666; 1, 00,000 and 80,000 plants/ha (maintained through 60 cm x 20 cm, 60 cm x 25 cm , 50 cm x 20 cm and 50 cm x 25 cm) representing P_1, P_2, P_3 and P_4 respectively as main treatments and four irrigation scheduling based on available soil moisture deficit (I_1-25% of Available soil moisture deficit, I_2-50% of Available soil moisture deficit, I_1-75% of Available soil moisture deficit and I_4-Farmers practices were taken as sub-treatment. The experiment was laid out in split plot design and replicated four times.The crop was sown on 31 October 2022 and 01 November, 2023 and harvested on 04 April 2023 and 06 April, 2024. An uniform dose of 150 kg Nitrogen, 60 kg Phosphorus and 40 kg Potassium were applied by side placement method. Half Nitrogen and full dose of phosphorus and potassium applied as basal and one-fourth of nitrogen at knee high stage and rest nitrogen at silking stage. Total rainfall during crop season was 3.31 and 3.57 cm in the respective years

RESULT AND DISCUSSION

Dry matter Accumulation

Dry matter accumulation increased successively with increase in crop growth stages during both the years of experimentation. It increased slowly during initial stages and thereafter increased rapidly till the harvest. Planting density had significant effect on dry matter accumulation (g/m2) at all the growth stages of the crop except at 30 DAS during both the years. At all the successive stages of growth, highest drymatter accumulation was recorded under highest plant population of 1,00,000 plants/ha , which was significantly higher when compared to rest of the population at 60,90 and 120 DAS and at harvest during both the season. The lowest was recorded under lowest population at all the stages during both the seasons. At 60 DAS, dry matter accumulation obtained under plant population of 1, 00,000 plants/ha was significantly higher as compare to rest of the planting density under the experiment. plant population of 83,333 plants/ha and 80,000 plants/ha were at par during both the seasons. At 90 and 120 DAS, drymatter accumulation decreased significantly with decreasing plant population levels. The decrease in dry matter accumulation at 120 DAS were in tune of 20.67 and 25.63 percent between 1, 00,000 to 66,666 plants /ha during 2022-23 and 2023-24 respectively. The trend was similar to other stages. The maximum accumulation of drymatter at higher planting densities (1, 00,000 plants/ha) might be due to more plants per square meter. Similar findings of increased drymatter at higher planting densities relative to lower planting densities were obtained by **Singh and Singh (2006) and Suryavanshiet al. (2009).**

Irrigation scheduling practices had significant influence on dry matter accumulation (g/m2) at all the growth stages of crop except 30 and 60 DAS during both the seasons of investigation. The higher dry matter accumulation was recorded under irrigation scheduling of 25% ASMD and it decreased with decreasing moisture availability under different treatment while the lowest under 75% ASMD at all the stages of crop during both the seasons. At 90 DAS , it was significantly higher under the irrigation scheduling at 25% ASMD level as compared to rest of the Irrigation scheduling practices. The differences in drymatter accumulation was non-significant under the irrigation scheduling of 50% ASMD and 75 % ASMD during both the seasons.At 120 DAS , significantly higher drymatter accumulation was recorded under irrigation scheduling of 25% ASMD as compared to irrigation scheduling at 75% ASMD and farmer practices while on par with irrigation scheduling at 50% ASMD. At harvest stage, same trends observed due to different irrigation scheduling. Similar finding were reported by **Katiyar et.al 2018**

Yield attributes

Planting density has significant influence on all the yield attributes (Table 2 and Table 3). Higher value of these parameters was under 66,666 plants / ha, followed by 80,000 plants / ha because of better performance of the individual plants due to reduced competition among the plants for the available growth resources. Irrigation Scheduling had significant effect on all the attributes. These increased successively with increase in moisture availability. Significantly higher value were observed under 25 % ASMD and followed by 50 % ASMD. This might be due to increased photosynthetic activity of the plant which favour plant height, girth of stem, leaf area index dry matter and translocation of photosynthates from source to sink which resulted into higher yield attributes. Similar findings were also reported by **Bhatt et.al (2020).**

Grain yield

There was significant yield variation due to planting density (Table 4). Significantly higher grain yield of 57.65 and 57.62 q / ha was recorded under 83.333 plants / ha than rest of the populationexcept 80.000 plants / ha, during both years. Increasing plant population above 83,333 plants/ha reduced the grain yield. This might be due to increased mutual shading and interplant competition, which significantly decreased individual plant growth in larger populations. Internal competition within the individual plant between vegetative and reproductive parts becomes more severe as plant population density increases. As plant density increased, the allocation of assimilates to different plant parts may change, resulting in a greater proportion of plants becoming barren, along with a critical period for light in order to grain formation at higher populations. Comparable results were attained by Muniswamy et al., (2007), Singh et al., (2023), Narayanaswamy and Siddaraju (2011).

Grain yields (56.63, 56.32 q/ha) were recorded significantly higher under irrigation scheduling at 25% ASMD as compared to those obtained under 75% ASMD and farmer practices while on par with 50% ASMD during both the years. The lowest grain yields of 48.36 and 48.96 q/ha was obtained under farmer practices.

CONCLUSION

Conclusively the planting density of 83333 plants per hectare was found to be best suited for a higher, growth and yield, of rabi maize. And irrigation scheduling at 25% Available soil moisture depletion was found best suited for higher yield of rabi maize. It can be recommended that planting density of 83,333 plants /ha with irrigation scheduled at 25% ASMD recorded higher grain yield of *rabi*maize.

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Table 1. Dry Matter Accumulation (g/m²) of *Rabi* maize as influenced by planting density and irrigation scheduling.

Treatments	30 DAS		60 DAS		90 DAS		120 DAS		At harvest	
	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
Planting density										
P_1- (83,333 plants ha^{-1})	39.26	40.15	87.6	89.3	321.7	358.6	115.2	1160.0	1491.5	1490.4
P_2-(66,666 plants ha^{-1})	38.05	39.26	77.5	83.2	281.0	296.5	1046.3	1020.2	1390.2	1404.3
P_3-(1,00,000 plants ha^{-1})	42.02	43.15	99.3	95.3	401.3	417.3	1318.8	1371.6	1497.3	1497.5
P_4-(80,000 plants ha^{-1})	39.14	40.45	88.8	90.3	326.4	364.9	1193.5	1189.1	1498.2	1494.1
SEm±	0.18	0.53	2.33	1.78	4.28	4.15	12.44	11.82	10.12	12.34
C.D. at 5%	NS	NS	7.46	5.69	13.70	13.28	39.81	37.82	32.38	39.48
Irrigation Scheduling										
I_1-(25% ASMD)	39.59	40.15	89.3	92.3	357.7	392.0	1272.1	1291.4	1514.1	1534.6
I_2-(50% ASMD)	39.24	40.58	86.1	89.5	340.5	370.5	1237.1	1275.5	1500.0	1528.2
I_3-(75% ASMD)	38.86	39.18	87.0	87.2	337.1	364.4	1109.0	1116.4	1434.8	1434.5
I_4-(Farmer practice)	38.45	39.25	83.5	85.1	292.2	304.0	1028.3	1029.0	1372.6	1364.0
SEm±	0.61	0.68	2.52	2.04	5.80	5.17	21.70	26.01	10.34	12.11
C.D. at 5%	NS	NS	NS	NS	16.53	14.73	61.84	74.13	29.18	34.51

Table 2. Yield Attributes of *Rabi* maize as influenced by planting density and irrigation scheduling

Treatments	No. of cobs plant^{-1}		No.of grains row^{-1}		No. of grains cob^{-1}		No. of rows cob^{-1}		Test weight(g)	
	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
Planting density										
P_1- (83,333 plants ha^{-1})	1.63	1.69	24.3	26.6	382.5	402.4	14.0	13.5	225.4	221.6
P_2-(66,666 plants ha^{-1})	1.72	1.74	27.5	28.6	434.1	448.6	14.2	14.9	232.1	232.1
P_3-(1,00,000 plants ha^{-1})	1.09	1.15	22.8	23.4	349.1	349.1	13.4	13.5	212.9	214.8
P_4-(80,000 plants ha^{-1})	1.66	1.72	24.6	27.9	390.4	411.5	14.2	13.8	230.5	224.9
SEm±	0..4	0..5	0.44	0.61	6.70	12.36	0.37	0.20	1.60	2.42
C.D. at 5%	0.13	0.16	1.41	1.95	21.4	39.55	NS	NS	5.12	7.74
Irrigation Scheduling										
I_1-(25% ASMD)	1.82	1.86	26.4	28.8	426.8	446.8	14.5	14.9	222.1	230.9
I_2-(50% ASMD)	1.76	1.78	25.6	27.6	422.3	446.8	14.0	14.4	231.3	230.1
I_3-(75% ASMD)	1.54	1.67	24.6	26.4	383.4	413.5	13.8	13.7	224.6	224.6
I_4-(Farmer practice)	1.08	1.09	22.3	22.1	327.1	317.9	13.2	12.5	213.9	209.2
SEm±	0.04	0.06	0.75	0.64	11.72	9.42	0.32	0.34	2.02	2.28
C.D. at 5%	0.11	0.17	2.14	1.82	33.40	26.85	0.91	0.97	5.76	6.50

Table3. Yield attributes of *Rabi* maize as influenced by planting density and irrigation scheduling

Treatments	Wt. of grain cob^{-1} (g)		Length of cob (cm)		Weight of cob (g)		Girth of cob (cm)		Shelling percentage	
	2022-23	**2023-24**	**2022-23**	**2023-24**	**2022-23**	**2023-24**	**2022-23**	**2023-24**	**2022-23**	**2023-24**
Planting density										
P_1- (83,333 plants ha^{-1})	78.3	77.6	15.6	15.3	112.6	113.6	13.8	14.8	69.9	69.4
P_2-(66,666 plants ha^{-1})	85.4	87.6	16.8	16.9	114.2	116.8	13.8	14.6	73.5	74.9
P_3-(1,00,000 plants ha^{-1})	62.8	67.9	13.4	13.5	90.1	97.5	11.6	12.9	67.6	68.8
P_4-(80,000 plants ha^{-1})	80.1	80.8	15.9	15.8	114.3	115.8	13.5	14.9	71.6	71.9
SEm±	1.11	1.31	0.26	0.37	1.38	2.05	0.14	0.12	0.70	0.68
C.D. at 5%	3.55	4.19	0.83	1.18	4.42	6.56	0.45	0.38	2.24	2.18
Irrigation Scheduling										
I_1-(25% ASMD)	81.8	25.6	16.4	16.7	116.9	120.8	14.1	14.8	72.6	13.5
I_2-(50% ASMD)	80.1	85.2	16.9	16.5	114.3	119.4	14.6	14.5	72.6	73.5
I_3-(75% ASMD)	77.6	79.4	14.6	15.4	109.4	111.7	13.6	13.8	71.2	71.5
I_4-(Farmer practice)	59.2	59.9	13.4	13.4	90.4	93.4	11.5	11.8	65.9	66.9
SEm±	1.24	1.42	0.45	0.49	1.67	2.00	0.27	0.28	1.01	0.81
C.D. at 5%	3.53	4.05	1.28	1.39	4.76	5.70	0.77	0.80	2.88	2.31

Table 4. Grain yield and Stover yield of *Rabi* maize as influenced by planting density and irrigation scheduling

Treatments	Grain yield (qha^{-1})	
	2022-23	**2023-24**
P_1- (83,333 plants ha^{-1})	57.65	57.62
P_2-(66,666 plants ha^{-1})	51.21	52.36
P_3-(1,00,000 plants ha^{-1})	49.32	50.98
P_4-(80,000 plants ha^{-1})	57.48	57.46
SEm±	0.64	0.64
C.D. at 5%	2.05	1.98
I_1-(25% ASMD)	56.63	56.32
I_2-(50% ASMD)	55.32	56.98
I_3-(75% ASMD)	53.65	53.25
I_4-(Farmer practice)	48.36	48.96
SEm±	0.52	0.46
C.D. at 5%	1.48	1.31