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Effect of planting density and irrigation scheduling on Dry matter production , Nutrient uptake and Quality of *Rabi* maize

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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, Nutrient uptake and quality of *Rabi* maize. Higher Dry matter 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 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. The Nitrogen, phosphorus and potassium uptake by maize plant was obtained maximum at planting density of 83,333 plants ha^{-1} under 25 % of available soil moisture depletion. During second year the carbohydrate content was significantly higher (68.3%) under lowest population than rest of the treatments. The protein and carbohydrate in the grain were recorded maximum when irrigation scheduled at 25 % of Available Soil Moisture Depletion.

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. Maize 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 C4 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 al.*, 2015). 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 intensity and time span of waterlogging at various growth stages can significantly impact maize development and yield. 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 productivity. As the information available under rabi conditions is very meagre in Eastern Uttar Pradesh.

Material and method

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 (Alfisols) with 7.8 pH and 0.37 % Organic carbon, 180.42, 13.65 and 263.97 kg/ha of available N, P and K respectively. Field capacity, permanent wilting point and bulk density between 0-60 cm soil depth ranged from 22.8 to 23.33 %, 10.2- 11.08% 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 plot 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. The experiment was laid out in split plot design with 4 replication. Irrigation were applied with a depth of 6cm of water with the help of parshall flume. The crop was shown on 31 October 2022 and 01 November, 2023 and harvested on 04 April 2023 and 06 April, 2024. A 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 basal and one-fourth of nitrogen at knee high stage and rest nitrogen at silking stage. The dry matter accumulation (g/m^2) was recorded on the basis of mean dry weight par plant multiplied with 8.33,6.66,10.0 and 8.0 as par treatments. The N,P and K content in plant samples and protein and carbohydrate content in the grain were determined as par standard procedures.

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 Meena et.al. (2017) and Suryavanshi *et 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

Nutrient Uptake

The uptake of Nitrogen, Phosphorus and Potassium was significantly higher when crop was sown at planting density at 83,333 plant /ha as compared to rest of the planting density. (Table 2). Higher uptake was primarily due to higher completion for available nutrient in soil. While significantly lower nutrient uptake was recorded under planting density at 66,666plants/ha, this might may be due to lesser competition among plants for available Nutrient in soil. Similar result was also reported by Yan *et al*. 2017

Moisture regimes had significant influence on the nutrient's uptake. The higher uptake of N,P and K was recorded under irrigation scheduling at 25% Available soil Moisture deficit,this might be due better root establishment, translocation of absorbed nutrients to seed and stover yield. These results are in agreement with the results obtained by Singh *et al*. (2018).

Carbohydrate and protein content

Plant population did not influence the protein content of grain significantly (Table 3). Although, the performance was better under 66,666plant / ha due to sufficient growth resources available to them because N content an index of protein was higher under this treatment, it did not influence significantly which in turn might resulted non-significant variation in protein. Carbohydrate content in grain varied significantly more under 66,666 plants / ha than that under rest of the population due to availability of sufficient space to plants which favoured better production of assimilates and its translocation to the sink and lowest under highest population due to congestion of plants.

Moisture regimes had significant effect on both protein and carbohydrate content of grain. Highest values of both were obtained under 25% ASMD mainly due to production of assimilates and its translocation to the sink. Increase in N content under wettest regime led to the highest protein which might resulted in the utilization of carbohydrates towards protein in the grain. Similar results were also reported by Bhatt *et at* (2020).

CONCLUSION

This can be concluded from the study that planting density of 83333 plants/ha was found to be best suited for a higher dry matter accumulation and nutrient uptake with irrigation scheduling at 25% Available soil moisture depletion. While the higher protein and carbohydrate content was recorded under planting density of 66,666 plants/ha with irrigation scheduling at 25% ASMD.

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Table 1. Dry Matter Accumulation (g plant^{-1}) 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	1150.2	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	40.12	22.34
C.D. at 5%	NS	NS	7.46	5.69	13.70	13.28	39.81	37.82	NS	NS
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	50.24	52.11
C.D. at 5%	NS	NS	NS	NS	16.53	14.73	61.84	74.13	NS	NS

Table 2. Nutrient uptake by *Rabi* maize as influenced by planting density and irrigation scheduling

Treatments Dry weight of root/plant	N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		K uptake (kg ha^{-1})	
	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
Planting density						
P_1- (83,333 plants ha^{-1})	146.2	145.6	23.0	22.3	139.6	141.2
P_2-(66,666 plants ha^{-1})	131.3	130.3	18.3	18.6	122.9	123.6
P_3-(1,00,000 plants ha^{-1})	135.6	136.5	21.3	21.6	133.9	135.9
P_4-(80,000 plants ha^{-1})	144.3	138.6	21.3	21.9	132.9	131.9
SEm	0.26	0.38	0.18	0.14	0.33	0.38
C.D. at 5%	0.83	1.22	0.58	0.45	1.06	1.22
Irrigation Scheduling						
I_1-(25% ASMD)	153.6	153.4	27.9	26.5	142.9	142.8
I_2-(50% ASMD)	148.3	151.9	25.3	24.6	138.9	138.9
I_3-(75% ASMD)	136.5	133.5	21.2	20.9	130.5	131.2
I_4-(Farmer practice)	117.6	116.8	11.2	11.6	117.9	119.5
SEm	1.02	0.86	0.44	0.68	0.80	0.54
C.D. at 5%	2.91	2.45	1.25	1.94	2.28	1.54

Table.3 Protein and Carbohydrate content in grain of *Rabi* maize as influenced by planting density and irrigation scheduling

Treatments	Protein Content (%)		Carbohydrate content(%)	
	2022-23	**2023-24**	**2022-23**	**2023-24**
Planting density				
P_1- (83,333 plants ha^{-1})	9.7	9.6	67.3	67.1
P_2-(66,666 plants ha^{-1})	10.1	9.5	67.8	68.3
P_3-(1,00,000 plants ha^{-1})	9.6	9.4	66.6	67.2
P_4-(80,000 plants ha^{-1})	9.8	9.7	67.9	67.2
SEm	**0.15**	**0.14**	**0.24**	**0.26**
C.D. at 5%	**NS**	**NS**	**NS**	**0.83**
Irrigation Scheduling				
I_1-(25% ASMD)	10.5	10.2	69.8	71..2
I_2-(50% ASMD)	10.3	10.0	69.5	69.8
I_3-(75% ASMD)	9.6	9.5	67.3	68.2
I_4-(Farmer practice)	9.0	9.1	62.3	62.3
SEm	**0.20**	**0.20**	**0.55**	**0.94**
C.D. at 5%	**0.57**	**0.57**	**1.57**	**2.68**