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Influence of twin row production system and levels of nitrogen on growth and yield of *rabi* maize (*Zea mays* L.)

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Abstract
A field experiment was conducted at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand with a view to study influence of twin row production system and levels of nitrogen on growth and yield of *rabi* maize (*Zea mays* L.) during *rabi* season of the year 2017-18. The experiment consisted of twelve treatment combinations comprised of three row systems and four levels of nitrogen tested under Split Plot Design (SPT) with four replication. The results revealed that twin row system of 30-60 cm x 20 cm recorded maximum plant height at 60 DAS and at harvest, higher plant dry biomass and crop growth rate at 60 DAS. Relative growth rate (g/g/day) remained unaffected due to different row systems. Application of 140 kg N/ha recorded significantly higher plant height at 60 DAS and at harvest, plant dry biomass at 60 DAS, crop growth rate at 30-60 DAS and relative growth rate (g/g/day) at 0-30 DAS. Among all the treatment combinations, treatment combination R_2N_4 (30-60 cm x 20 cm + 140 kg/ha) recorded significantly higher plant dry biomass (56.88 g/plant) and grain yield (5378 kg/ha) while treatment combination R_1N_4 (30-45 cm x 20 cm + 140 kg/ha) recorded significantly higher Stover yield (12825 kg/ha).

Keywords: Twin row, nitrogen, growth, maize

Introduction
Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions and in production next to wheat and rice in the world. Maize is also important not only because of its great adaptability to widely divergent conditions, but also because of its high responsiveness to better management practices. Recent development in maize genetics has enhanced plant density in maize production system by narrowing and intensifying the rows. An increase in the yield of crop can be brought forward either by increasing the area under cultivation or by increasing the productivity per unit area. Row spacing is one of the important management factors affecting agronomic and physiological parameter of maize. Decreasing the distance between rows at any particular plant population may reduce competition among plants within rows for light, water and nutrients and produce higher biological, grain and stover yield (Shah *et al*., 2001) [15]. Ali *et al*. (2017) [2] reported that increasing plant density, yield per plant decreases but grain yield per unit area increases. Gozubenli *et al*. (2004) [7] obtained the highest grain yield from 90,000 plant/ha density with twin-row (60:20cm) system, which yielded 4 per cent more grain yield than the single row (80cm) system. Also twin-row system of sowing in maize have been proposed as an alternative spatial arrangement that should theoretically decrease plant-to-plant competition, alleviate crop crowding stress and improve yields (Robles *et al*., 2012) [14]. Since projected increases in yield will undoubtedly involve an increase in plant density, strategies to reduce plant-to-plant competition involve improved plant management through better fertility practices. Nitrogenous fertilizer application has also been used to increase crop yields globally (Miao *et al.*, 2011) [11]. Studies on twin row system configurations are still new and needs evaluation. In view of the above all consideration, present experiment was planned to study the influence of twin row production system and levels of nitrogen on growth and yield of *rabi* maize (*Zea mays* L.).

Materials and Methods
A field experiment was conducted during *rabi* season of the year 2017-18 at College Agronomy Farm, Anand Agricultural University, Anand on loamy sand soil to study the

influence of twin row production system and levels of nitrogen on growth and yield of *rabi* maize (*Zea mays* L.). The soil is alluvial in origin, having pH of 8.03, 0.37 organic carbon, 232.50 kg/ha available N, 43.83 kg/ha available P_2O_5 and 308.20 kg/ha available K_2O. Twelve treatment combination comprising three row systems and four levels of nitrogen were included in the experiment. Three row system (R_1: 30-45 cm x 20 cm (twin row system), R_2: 30-60 cm x 20 cm (twin row system) and R_3: 60 cm x 20 cm (conventional row system)) were allotted to main plot while four levels of nitrogen (N_1: 80 kg N/ha, N_2: 100 kg N/ha, N_3: 120 kg N/ha and N_4: 140 kg N/ha) were relegated to sub plot in Split Plot Design with four replications. Mize seeds (Variety: GM 3) were dibbled at a depth of 5 cm in conventionally tilled soil on 20th November, 2017 keeping the distance as per the treatment to get desired plant population. The crop was fertilized with 50 per cent nitrogen and entire quantity of phosphorus through urea and single super phosphate, respectively as a basal application at the time of sowing and the remaining quantity of nitrogen was applied in two equal splits, applied at knee high stage and at tasseling stage. Data on various observations during the course of experimental period was statistically analyzed as per the standard procedure developed by Cochran and Cox (1957) [4].

Results and Discussion

Effect of row system

Data given in Table 1 revealed that significantly higher plant population/net plot (198.06) was observed in case of twin row system of 30-45 cm x 20 cm as compared to twin row system of 30-60 cm x 20 cm and 60 cm x 20 cm at 20 DAS. Akbar *et al*. (2016) [1] also observed higher plant population under twin rows 30 cm apart and interspersed with 70 cm between two pairs as against conventional row system in maize. Similar trend was also observed under different row systems at harvest. Significantly higher plant height was recorded under twin row system of 30-60 cm x 20 cm which at par with twin row system of 30-45 cm x 20 cm. Further, conventional row system of 60 cm x 20 cm recorded significantly the lowest plant height at 60 DAS. The taller plant under twin row system might be due to increase in number of plants per unit area certainly reduced the amount of light availability to the individual plant, especially to lower leaves due to greater shading hence, mutual shading increases at high population densities which leads plant tends to grow taller. Such increase in height of the plant under twin row system was also reported by Akbar *et al*. (2016) [1] in maize. Novacek *et al.* (2013) [12] also observed that plant height increased linearly with increasing plant population.

Significantly the highest plant dry biomass of 48.99 g/plant was recorded under twin row system of 30-60cm x 20cm. Similar results, *i.e.* higher dry biomass of maize plant with twin rows system of 75/45 cm was also noticed by Ion *et al*. (2014) [8]. There was no significant differences observed among the twin row system of 30-45 cm x 20 cm and conventional row system of 60 cm x 20 cm however, both were recorded significantly the lowest plant dry biomass. Significantly the highest crop growth rate of 1.417 g/day was recorded under twin row system of 30-60 cm x 20 cm between 30-60 DAS. The twin row system of 30-45 cm x 20 cm registered significantly lower crop growth rate which remained at par with conventional row system of 60 cm x 20 cm between 30-60 DAS. Similarly in peanut, Jaaffar and Gardner (1988) [9] observed that twin row patterns had greater ground cover, leaf area indices, canopy light interception and crop growth rates as compared to conventional row pattern. Relative growth rate (g/g/day) recorded between 0-30 and 30-60 DAS showed non-significant differences due to row system.

With respect to grain and stover yield, twin row system of 30-60 cm x 20 cm and 30-45 cm x 20 cm remained at par with each other and recorded significantly higher grain and stover yield as compared to conventional row system of 60 cm x 20 cm. Under high plant density, more numbers of plants per unit area was responsible for higher yield because higher plant population utilized the production resources more efficiently towards plant development. Significantly the lowest grain yield was registered under conventional row system of 60cm x 20cm. The lower grain yield under conventional row system might be due to grain yield of individual plant of sparsely planted maize crop is usually high but because of low population the total grain yield per unit area remains low. Our findings are in good agreement with the report of Gozubenli *et al*. (2004) [7], Balkcom *et al*. (2011) [3] and Williams *et al*. (2014) [19] they suggested that sowing of corn in twin rows may be an effective alternative to single row planting patterns because of increased grain yield under high corn populations.

Effect of nitrogen levels

The results pertaining to the effect of different levels of nitrogen did not showed significant influence on the plant population recorded at 20 DAS and at harvest (Table 1). Application of 140 kg N/ha recorded significantly the highest plant height while significantly the lowest plant height was recorded under 80 kg N/ha. The increase in plant height in response to higher levels of nitrogen was in conformity with the previous findings of Patel *et al*. (2006) [13] and Matusso *et al.* (2016) [10]. Significantly higher plant dry biomass was recorded with 140 kg N/ha as compared to rest of the nitrogen treatments except 120 kg N/ha which was at par with respect to plant dry biomass recorded at 30 and 60 DAS. Singh *et al.* (2006) [17] and Sharma *et al.* (2017) [16] also reported that dry biomass of plant was increase with increase in levels of nitrogen in maize. Significantly lower plant dry biomass was recorded with 80 kg N/ha but was statistically similar with 100 kg N/ha.

Significantly higher crop growth rate (0.229 g/day) was noticed with 140 kg N/ha which remained analogous with 120 kg N/ha. Patel *et al*. (2006) [13] reported that crop growth rate between 30-60 and 60-90 days were significant due to nitrogen levels and these parameters tended to increase with the increase in levels of nitrogen from 75 to 175 kg N/ha. Irrespective of nitrogen levels relative growth rate was more at early stage (0-30 DAS) and showed a decreasing trend with the advancement of plant growth stage, significantly higher relative crop growth rate of 0.064 g/g/day was recorded with 140 kg N/ha as compared to others except 120 kg N/ha. Sharma *et al*. (2017) [16] also observed that increase in nitrogen fertilization upto 100 kg/ha significantly increased relative growth rate between 25 and 50 days growth stage of crop.

Application of 140 kg N/ha recorded significantly the highest grain and stover yield of maize. The improvement in grain yield under higher level of nitrogen might be due to an early and plentiful availability of nitrogen leading to better nutritional environment in the root zone for growth and development. Our findings are in agreement with observations made by Patel *et al*. (2006) [13] who reported that grain yield increased with increasing nitrogen rates. Gozubenli (2010) [6] also suggested that higher grains yield at higher nitrogen levels might be due to the lower competition for nutrient and positive effect of nitrogen on plant growth, leaf area expansion and thus, increase solar radiation use efficiency that ultimately increases in grain yield. Significantly the lowest grain and stover yield was recorded with 80 kg N/ha. The enhanced yield with nitrogen was also reported by Patel *et al*. (2006) [13] and Sharma *et al.* (2017) [16].

Interaction effect

Results given in Table 2 and 3 revealed that treatment combination R_2N_4 (30-60cm x 20cm + 140 kg N/ha) recorded significantly the highest plant dry biomass at 60 DAS and grain yield of maize while R_1N_4 (30-45 cm x 20 cm + 140 kg N/ha) produced significantly higher stover yield. Increased nitrogen rates and seeding rates through twin row system significantly increased the grain yield of corn (Ebelhar, 2008) [5]. The results are in accordance with the findings of Tajul *et al.* (2013) [18] they observed that dry matter production increased progressively with the progressive increase in planting densities and nitrogen levels. Treatment combination R_1N_1 (30-45 cm x 20 cm + 80 kg N/ha) recorded lower plant dry biomass and stover yield while R_3N_1 (60 cm x 20 cm + 80 kg N/ha) grain yield of maize.

Table 1: Growth and yield of maize as influenced by different row systems and levels of nitrogen

Treatment	Plant population/net plot		Plant height (cm)			Plant dry biomass (g/plant)		Crop growth rate (g/day)		Relative growth rate (g /g/ day)		Grain yield (kg/ha)	Stover yield (kg/ha)
	At Harvest	At 20 DAS	At 30 DAS	At 60 DAS	At Harvest	At 30 DAS	At 60 DAS	0-30 DAS	30-60 DAS	0-30 DAS	30-60 DAS		
Row system (R)													
R_1: 30-45cm x 20cm	198.06	197.50	65.68	181.39	208.55	6.28	43.13	0.210	1.228	0.061	0.065	4352	11771
R_2: 30-60cm x 20cm	149.81	149.19	66.16	182.14	216.05	6.50	48.99	0.216	1.417	0.062	0.067	4767	10845
R_3: 60cm x 20cm	148.56	147.06	64.97	170.92	206.59	6.30	44.26	0.212	1.264	0.062	0.065	3825	8034
S. Em. ±	2.16	2.32	0.93	2.76	2.17	0.16	1.17	0.005	0.040	0.001	0.001	125	331
C. D. at 5%	7.48	8.04	NS	9.56	7.52	NS	4.05	NS	0.139	NS	NS	433	1145
C. V. (%)	5.23	5.65	5.69	6.20	4.13	9.96	10.29	10.73	12.32	5.84	8.13	11.61	12.96
Level of nitrogen (N)													
N_1: 80 kg/ha	165.42	164.33	61.79	171.92	197.67	5.82	39.41	0.196	1.118	0.059	0.064	3772	9288
N_2: 100 kg/ha	165.33	164.50	64.33	175.08	208.90	6.16	43.66	0.206	1.250	0.061	0.065	4173	9866
N_3: 120 kg/ha	165.67	164.67	66.31	180.02	215.05	6.59	48.32	0.220	1.399	0.063	0.067	4492	10482
N_4: 140 kg/ha	165.50	164.83	69.97	185.57	219.97	6.87	50.45	0.229	1.444	0.064	0.066	4820	11229
S. Em. ±	2.22	2.01	0.52	1.41	1.63	0.11	0.62	0.004	0.022	0.001	0.001	93	202
C.D. at 5%	NS	NS	1.52	4.10	4.73	0.32	1.80	0.012	0.063	0.002	NS	270	587
R x N interaction	NS	NS	NS	Sig.	Sig.	NS	Sig.	NS	Sig.	NS	NS	Sig.	Sig.
C. V. (%)	4.65	4.25	2.77	2.75	2.68	6.01	4.71	6.49	5.80	3.55	4.62	7.48	6.86

Table 2: Plant dry biomass as influenced by interaction effect of different row systems and levels of nitrogen

Plant dry biomass (g/plant) at 60 DAS				
Treatments	**N_1**	**N_2**	**N_3**	**N_4**
R_1	38.57	40.12	46.72	47.10
R_2	39.77	47.32	51.97	56.88
R_3	39.87	43.53	46.27	47.38
S. Em. ±	1.07			
C.D. at 5%	3.11			
C.V. (%)	4.71			

Table 3: Grain yield and stover yield as influenced by interaction effect of different row systems and levels of nitrogen

Yields (kg/ha)								
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Treatments	**N_1**		**N_2**		**N_3**		**N_4**	
R_1	4006	10317	4180	11883	4378	12058	4843	12825
R_2	3837	9825	4604	9888	5249	11554	5378	12111
R_3	3473	7722	3735	7828	3850	7834	4240	8752
	Grain				**Straw**			
S. Em. ±	161				351			
C. D. at 5 %	468				1017			
C. V. %	7.48				6.86			

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