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Effect of twin row system and levels of nitrogen on yield and economics of *rabi* maize (Z*ea mays* L.)

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Abstract
A field experiment was conducted during *rabi* season of the year 2017-18 at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand to study yield and economics of *rabi* maize (Z*ea mays* L.) as influenced by twin row system and levels of nitrogen. The experiment consisted of twelve treatment combinations comprised of three row systems *viz.,* 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) relegated to main plot and four levels of nitrogen *viz.,* 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 allotted to sub plot tested under Split Plot Design (SPT) with four replications. The results revealed that cob length and number of grains/cob was recorded higher under conventional row system of 60 cm x 20 cm while higher cob girth under twin row system of 30-60 cm x 20 cm. Twin row system of 30-60 cm x 20 cm recorded significantly higher grain yield. Among the levels of nitrogen, application of 140 kg N/ha resulted in increased length and girth of cob, number of grains/cob and protein content and thereby yields. Twin row system of 30-60 cm x 20 cm and fertilized with 140 kg N/ha fetched the highest net realization of ₹ 73233 /ha with maximum benefit cost ratio of 3.31 followed by twin row system of 30-60 cm x 20 cm and fertilized with 120 kg N/ha. While conventional row system of 60 cm x 20 cm and fertilized with 80 kg N/ha recorded minimum net realization of ₹ 37039/ha with benefit cost ratio of 2.21.

Keywords: Twin row, nitrogen, economics, maize

Introduction
Maize (*Zea mays* L.) popularly known as 'corn' is one of the most important cereal crops in the world's agriculture economy both as food for human and feed for animals. Globally, maize is known as "Queen of cereals" because it has the highest genetic yield potential to give high biological yield as well as grain yield in a short period due to its unique photosynthesis mechanism owing to C_4 mechanism among the cereals. Maize crop bears high yield potential and responds well to various agro management practices. Low yield of maize is due to many constraints but among them, imbalanced use of fertilizers and lack of optimal crop stand are the factors of prime importance which intensely and repeatedly impact resource availability. Decreasing row spacing at equal plant density promotes more equidistant plant spacing, theoretically allowing for better land use, reducing plant-to-plant competition for water, light and nutrients both in the rows and between them, while improving plant resource capture and utilization (Andrade *et al*., 2002 and Barbieri *et al*., 2008) [2, 4]. Maize grown in narrow rows use water and nutrients more efficiently than grown in wider rows i.e. 76 cm. Balkcom *et al*. (2011) [3] reported that twin row spacing yielded 16 per cent more than single spacing while Jones (2010) [8] observed 12.5 per cent higher yield under twin row system than conventional row system in corn. Nitrogen is typically the most limiting nutrient for high yields. As plant density increases, there is a greater need for total nutrient availability to promote optimal growth for all plants. It is well known that nitrogen is one of the most essential elements to corn growth and development and is often the key to production of profitable yields. Nitrogenous fertilizer application has also been used to increase crop yields globally. In India and Gujarat, many field experiments were conducted on various aspect of increasing yield potentiality of maize by different researchers in the last decades; however, studies on twin row system configurations are still new and needs evaluation. With this background, a field trial was undertaken to study the yield and economics of *rabi* maize (Z*ea mays* l.) as influenced by twin row system and levels of nitrogen.

Materials and Methods

Field study was carried out at College Agronomy Farm, Anand Agricultural University, Anand during *rabi* season of the year 2017-18 on yield and economics of *rabi* maize (*Zea mays* l.) as influenced by twin row system and levels of nitrogen. The soil of the experiment field was loamy sand, popularly known as "*Goradu*" soil. It 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. There were 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 relegated 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 allotted to sub plot in Split Plot Design with four replications. Seeds (Var. 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 experiment period was statistically analyzed as per the standard procedure developed by Cocharan and Cox (1967). The gross realization in terms of rupees per hectare was worked out separately for each treatment by taking the average maize grain yield into consideration of the respective treatments on the basis of their prevailing market prices. The cost of cultivation for each treatment was worked out considering the cost of all the operations and the inputs used.

Results and Discussion

Effect of row system

The results presented in Table 1 indicated that significantly higher cob length and girth was measured under conventional row system of 60 cm x 20 cm which was at par with twin row system of 30-60 cm x 20 cm. The higher cob length under said treatment could be attributed to maximum exploitation of ground area and optimum availability of space and resources led to better translocation of photosynthates towards the sink which resulted in higher cob length. Further, it was observed that significantly the lowest cob length was recorded under twin row system of 30-45 cm x 20 cm. Gozubenli (2010) [7] also observed non-significant difference in ear length under twin row system and narrow row system in corn. Whereas, Akbar *et al*. (2016) [1] reported that ear length differed with planting arrangements wherein, twin rows tended to produced longer ears. Further, higher cob girth under twin row system might be due minimum intra plant completion, adequate supply of photosynthates for development of sink would become possible due to enough space available in two pair. Similar findings were also reported by Raja (2001) [15]. Number of grains/cob was observed significantly higher under conventional row system of 60 cm x 20 cm which was remained at par with twin row system of 30-60 cm x 20 cm. Increase in number grains/cob could be attributed to increased cob length and cob girth. Higher number of grains/cob might be due to better source size filled with adequate quantity of food reserves helped the plant to develop better sink size as supported by significantly higher cob length and girth which contributed to produced more number of grains/cob. The highest harvest index was recorded under conventional row system of 60 cm x 20 cm which was followed by twin row system of 30-60 cm x 20 cm. The results are in accordance with results of Nandeha *et al.* (2016) [6] they also observed variation in harvest index due to different spacing. Different row systems did not differ significantly among themselves with respect to protein content of grain.

Significantly higher grain and stover yield was produced under twin row system of 30-60 cm x 20 cm 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. Generally yields increases with increasing planting density as higher plant densities enhance light interception and dry matter accumulation hence, higher yields of maize obtainable with higher population encouraged under twin row system. Significantly the lowest grain yield was registered under conventional row system of 60 cm x 20 cm. The enhanced grain yield under twin row system was also reported by Bruns (2012) [5], Modolo *et al.* (2014) and Roth *et al*. (2017) [16].

Effect of nitrogen levels

Length and girth of cob generally declined with decreasing levels of nitrogen from 140 to 80 kg N/ha wherein, 140 kg N/ha was recorded the highest cob length and girth while significantly the lowest cob length and girth was observed with 80 kg N/ha. The increased supply of nitrogen and their higher uptake by plants might have stimulated the rate of various physiological processes in plant and leads to increased growth parameters and yield attributes. These results are akin to those reported by Matusso *et al.* (2016) [10] and Pal *et al.* (2017) [13]. Number of grains/cob was significantly affected by different levels of nitrogen. Application of 140 kg N/ha recorded significantly higher number of grains/cob (382) but remained at par with 120 kg N/ha. Increase in the number of grains/cob at higher nitrogen rates might be due to the lower competition for the nutrient allowing the plants to accumulate more plant biomass with higher capacity to convert more photosynthesis into sinks resulting in more number of grains/cob (Zeidan *et al.*, 2006) [19]. Further, application of 80 kg N/ha recorded significantly the lowest number of grains/cob (332). Lower number of grain under lower nitrogen application (80 kg N/ha) might be attributed to poor development of sinks and reduced translocation of photosynthates. Harvest index was unaffected due to levels of nitrogen but higher and lower value of harvest index was recorded with 140 kg N/ha and 80 kg N/ha, respectively. These findings are in the line of the results reported by Singh *et al*. (2012) [17] they indicated that harvest index did not influenced by different levels of nitrogen. Significantly the highest protein content of grains recorded with 140 kg N/ha while lower with 80 kg N/ha. Higher protein content of grains under the highest levels of nitrogen seems that the availability of nitrogen in the grain filling stage of maize increased grain protein content. While inadequate nitrogen decreases both the size of the grains and protein content of grains. Increase in protein content of grains with increase in levels of nitrogen was also reported by Kar *et al*. (2006) [9].

Significantly higher grain and stover yield of maize was recorded with 140 kg N/ha. increased availability of nitrogen might have increased cell number and cell size leading to better growth in terms of plant growth, yield attributes *viz.*, cob length, girth of cob, number of grains/cob and there by yield. Further, increase in grain yield in response to increasing rate of nitrogen could be attributed to enhanced availability of the nutrient for uptake by the plants and increased photo assimilate production that would eventually lead to improved partitioning of carbohydrate to the grains. While the lowest grain and stover yield was observed with 80 kg N/ha. The results are in conformity with the findings of Patel *et al.* (2006) [14] and Gozubenli (2010) [7].

Economics

From the data presented in Table 2 treatment combination R_2N_4 (30-60 cm x 20 cm + 140 kg N/ha) was found superior by recording maximum net realization of ₹ 73233/ha with benefit cost ratio of 3.31 and it was followed by treatment combinations R_2N_3 (30-60 cm x 20 cm + 120 kg N/ha) and R_1N_4 (45-60 cm x 20 cm + 140 kg N/ha) which recorded ₹ 70466 and 66322/ha net realization with benefit cost ratio of 3.25 and 3.07, respectively. Treatment combination R_3N_1 (60 cm x 20 cm + 80 kg N/ha) recorded minimum net realization of ₹ 37039/ha with benefit cost ratio of 2.21. This result supported the studies conducted by Cox *et al.* (2006) [6] and Zakkam, (2011).

Table 1: Yield attributes and yields of maize as influenced by different row system and levels of nitrogen

Treatment	Cob length (cm)	Cob girth (cm)	No. of grains/cob	Seed index (g)	Protein content of grains (%)	Grain yield (kg/ha)	Stover yield (kg/ha)
Row system (R)							
R_1: 30-45 cm x 20cm	14.81	14.25	349	22.35	10.71	4352	11771
R_2: 30-60 cm x 20 cm	16.04	15.32	368	22.80	10.92	4767	10845
R_3: 60 cm x 20 cm	16.11	15.11	374	22.54	10.46	3825	8034
S. Em. +	0.29	0.19	5.50	0.30	0.18	125	331
C. D. at 5%	1.00	0.66	19	NS	NS	433	1145
C. V. (%)	7.36	5.13	6.04	5.26	6.73	11.61	12.96
Level of nitrogen (N)							
N_1: 80 kg/ha	14.59	14.27	332	20.87	10.27	3772	9288
N_2: 100 kg/ha	15.21	14.72	363	22.01	10.59	4173	9866
N_3: 120 kg/ha	16.18	15.21	377	23.29	10.62	4492	10482
N_4: 140 kg/ha	16.65	15.38	382	24.07	11.31	4820	11229
S. Em. +	0.14	0.13	3.71	0.26	0.17	93	202
C. D. at 5%	0.41	0.38	11	0.76	0.51	270	587
R x N interaction	Sig.	Sig.	Sig.	NS	NS	Sig.	Sig.
C. V. (%)	3.14	3.04	3.54	4.02	5.78	7.48	6.86

Table 2: Combined effect of different row systems and nitrogen levels on gross realization, total cost of production, net realization and benefit cost ratio (BCR)

Treatments (kg/ha)	Grain yield (kg/ha)	Stover yield (kg/ha)	Gross realization (₹/ha)	Cost of cultivation (₹/ha)	Net realization (₹/ha)	BCR
R_1N_1	4006	10317	80727	31148	49579	2.59
R_1N_2	4180	11883	86467	31424	55043	2.75
R_1N_3	4378	12058	89790	31700	58090	2.83
R_1N_4	4843	12825	98299	31977	66322	3.07
R_2N_1	3837	9825	77205	30826	46379	2.50
R_2N_2	4604	9888	88834	31102	57732	2.86
R_2N_3	5249	11554	101844	31378	70466	3.25
R_2N_4	5378	12111	104888	31655	73233	3.31
R_3N_1	3473	7722	67543	30504	37039	2.21
R_3N_2	3735	7828	71681	30780	40901	2.33
R_3N_3	3850	7834	73418	31056	42362	2.36
R_3N_4	4240	8752	81104	31333	49771	2.59

Selling price of produce: Seed ₹ 15/kg and Stover ₹ 2/kg

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