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Effect of land configuration and nutrient management on growth and yield of hybrid maize

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Abstract
A field experiment was conducted during two consecutive *Kharif* (2016 and 2017) at Students' Instructional Farm, Department of Agronomy, C. S. Azad University of Agriculture and Technology, Kanpur. The main objective of the experiment was to assess the effect of land configuration and nutrient management on the yield attributes and yield of the maize grown during *Kharif*. The experiment consisted of five land configurations *viz.*, broadcasting, flat sowing, flat followed by earthing, narrow bed and furrow & broad bed & furrow in main plot and four nutrient management practices *viz.*, basal + top dressing of N in two splits, basal + foliar spray of N in two splits, basal + N through LCC and basal dose of P & K + N through LCC only in sub plot and was laid out in split plot design with three replications. The soil of experimental site was sandy loam in texture, low in organic carbon and available Nitrogen, medium in available Phosphorous and Potassium with almost normal in reaction.
The hybrid variety (DKC9144) was sown as per treatment in plant geometry (50×25cm) maintained by thinning. The observations were recorded on growth, yield attributes and yield. The results revealed that broad bed and furrow method produced significantly maximum biological (197.3 q ha^{-1}), grain (69.0 q ha^{-1}) and stover (128.2 q ha^{-1}) yields, as compared to the seeds sown through broad casting and flat sowings during both the years and in pooled analysis. The application of nutrients through basal + N through LCC also recorded significantly the highest biological (193.5 q ha^{-1}), grain (67.4 q ha^{-1}) and stover (126.1 q ha^{-1}) yields, as compared to the application of basal P & K + N through LCC only.

Keywords: Maize (*Zea mays* L.), land configuration, nitrogen application, fertilizer application

Introduction
Maize (*Zea mays* L.), a cereal grain, called "queen of cereals" is the third most important crop in India after rice and wheat. Globally, India stands at 5th rank in acreage while in production it is at 8th rank. It is cultivated on 9.26 million hectares with a production of 21.81 million tonnes having productivity of 25.10 quintals ha^{-1} and contributes about 3% towards total world production (Anonymous $_{a,}$ 2016-17) [3]. Maize is an important and versatile cereal grown over diverse environment and geographical range for human food, poultry feed and fodder for livestock as well as raw material for industries. Maize has a nutritional value for both animals and humans. Maize has gradually become an industrial crop rather than cereal food by which, India earns ₹100 billion and provides employment of nearly 100 million man days with maize cultivation.
In Uttar Pradesh, maize is cultivated on about 0.68 million hectares area with a production of about 1.26 million tonnes and productivity of about 18.48 quintals ha^{-1}, which is more than the national average (Anonymous $_{b,}$ 2016) [4]. Although, it is a *Kharif* crop but can be grown throughout the year in *Kharif*, *Rabi* and *Zaid* seasons. Under rainfed condition during *Kharif* season, it suffers from natural calamities such as erratic and heavy rainfall or drought with heavy infestation of insect-pests.
Land configuration plays a major role in minimizing soil erosion and improving water and nutrient use efficiency of field crops. Easy and uniform germination as well as growth and development of plant are provided by manipulation of sowing methods (Chiroma *et al.* 2008) [6] and also increases availability of nutrients to crops. The superiority of ridges and furrow system could be ascribed to proper drainage of excess water coupled with adequate airation at the time of irrigation or heavy rainfall. Parihar *et al.* (2009) [17] reported that ridges and furrow method of sowing improved grain as well as stover yield of maize over the flat bed method of sowing.
Among the plant nutrients, nitrogen (N) management is one of the most important factor required for improving crop productivity and profitability under semi-arid climates (Amanullah, 2016) [2].

According to Guo *et al.* (2016) [9], N is the most yield-restraining nutrient in maize crop production, globally.

Leaf Colour Chart is basically a guide to supply the necessary nitrogen fertilizer for the optimal nitrogen content which is very necessary in achieving maximum yield. It is found that Leaf Colour Chart based nitrogen management in different maize genotypes, saved, 25-50% fertilizer nitrogen Clements, (1964). Keeping above points in view this experiment was formulated with the objectives to study the impact of land configurations and nutrient (Nitrogen) management on growth, yield attributes and yield of *Kharif* maize.

Materials and methods

Field experiment was conducted during two consecutive *kharif* seasons of 2016 and 2017 at the Students' Instructional Farm (SIF), C.S. Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India, situated at 125.9 meter altitude, 26.41'48^0 North latitude and 80.23'21^0 East longitude. Factors included in the study were land configurations viz. Broadcasting, Flat sowing, Flat followed by earthing, Narrow bed & furrow and Broad bed & furrow in main plot and nutrient management *viz*. Basal + top dressing of N in two splits, Basal + Foliar spray of N in two splits, Basal + N through LCC and basal P & K + N through LCC only in sub plot. N, P, K were used through Urea, DAP, MOP respectively. Entire dose of phosphorus, potassium, and half dose of nitrogen were applied as basal and remaining half of the nitrogen was applied either top dressing in two equal split or as foliar spraying. At 30 DAS and at tasseling stage. The nitrogen was also applied with the help of Leaf colour chart (LCC) readings fell below the 5-4.5 critical value of leaf colour, the urea solution (2%) was sprayed at weekly interval after 20 to 22 DAS. Thus, there were 5×4 = 20 treatments laidout in Split Plot Design and replicated three times. The soil of experimental field was sandy loam in texture with a pH of 7.80 in 2016 and 7.85 in 2017. It was moderately fertile being low in carbon (0.34 & 0.37%) and available N (170.40 & 175.50kg ha^{-1}), medium in available P_2O_5 (14.10 & 14.20 kg ha^{-1}) and K_2O (154.0 & 156.25kg ha^{-1}) during 2016 and 2017, respectively.

The meteorological observation recorded during the two seasons of study revealed that the maximum temperature averaged at 32.8 ^{0}C and 34.1 ^{0}C, minimum at 25.6 ^{0}C and 25.9 ^{0}C, relative humidity at 80.2% and 77.1% and cumulative rainfall at 34.3 and 41.5 mm, respectively, during the year 2016 and 2017. A high rainfall was recorded in the 27 SMW (Standard Meteorological Weeks) during-I year (101.8mm) and during year-II (141.8mm). The crop experienced an average evaporation 28.8 and 29.5mm day^{-1}, respectively, during the corresponding two years. During both the year experimental crop received rainfall at all the critical stages that favors the crop growth and development which ultimately gave good yield.

Crop responses to the treatments were measured in terms of predetermined quantitative characters. The year wise observations recorded were subjected to statistical analysis (Fisher and Yates, 1975). Valid comparisons between various treatments were drawn using the respective CD (Critical difference) values.

Results and Discussion

The observations recorded during 2016 and 2017 were analyzed statistically on individual year basis and on pooled basis too. It is, therefore, the results and discussion presented below are on the basis of pooled analysis.

Growth characters

Observations on plant height, leaf area index, fresh weight and dry weight were recorded to see the effect of different treatments on growth characters of *kharif* maize. The results and logics behind the results are presented below.

The significantly maximum plant height (227.0 cm) was recorded when sowing was done through broadcasting. Application of nutrients through basal + N through LCC recorded significantly the highest plant height (218.3 cm) over all the remaining methods of nutrient application under test. The results are in line with findings of Premalatha (2001) [18].

The sowing of seed in broad bed & furrow recorded maximum leaf area index (5.8) showed in pooled analysis. These results were in conformity with the findings of Thakur *et al*. (2011) [21]. Nutrients management through basal + N through LCC recorded significantly maximum leaf area index (5.6) as compared to the other nutrients management practices. The present findings are corroborated with the findings of Maiti Debtanu (2003) [14].

Fresh weight was recorded significantly higher with broad bed and furrow sowing 578.4g plant^{-1} but narrow bed and furrow sowing was statistically at par to it with 560.3 g plant^{-1} fresh weight. However, lowest fresh weight of 461.3 g plant^{-1} was recorded when sowing was done through broadcasting. There results are in conformity with Thakur *et al*. (2011) [21].

Among different methods of nutrient management application of fertilizer as basal + N through LCC superseded to all except for basal + top dressing of N in two splits (554.2 g plant^{-1}).

Dry weight per plant was also find in the same trend of fresh weight plant^{-1}. Broadbed and furrow sowing among different methods of sowing and application of fertilizer @ basal + N through LCC among all the methods fertilizer application were superior then others.

Yield attributes

Observations on number of number of cobs plant^{-1}, cob length, cob width, grain rows cob^{-1}, number of grains row^{-1}, 100 seed weight was recorded to find out the effect of different treatment on yield attributing characters of maize. The results and reasons behind the results are given below.

The yield attributes *viz.*, number of cobs plant^{-1}, cob length, cob width, grain rows cob^{-1}, number of grains row^{-1}, 100 seed weight were significantly influenced due to land configuration and nitrogen management manifested in pooled analysis.

The results clearly indicated that significantly maximum number of cobs (1.40), cob length (21.9 cm), cob width (13.3 cm), grain rows cob^{-1} (15.0), number of grains row^{-1} (40.4) and 100 seed weight (27.0 g) were recorded under broad bed and furrow sowing method as compared to broad casting and flat method of sowing as showed in pooled analysis. This may be due to the plants got maximum exposure to sunlight which enhanced the photosynthetic activity. It also improved the plant vigour, resulted in producing the wider and bigger cob. The length and width of cob was positively correlated with the number rows cob^{-1} and number of grains row^{-1}. The earlier reserecher Manwar, and Mankar (2015) [15] reported similar findings.

The present investigation revealed that the nitrogen management through basal dose + N through LCC recorded significantly higher number of cobs plant^{-1} (1.36), cob length (21.5 cm), cob width (12.9 cm), grain rows cob^{-1} (14.67), number of grains row^{-1} (39.4), 100 seed weight (26.7 g) over nitrogen management through basal + two split (foliar spray

of N) and N through LCC only. This might be due to the higher synthesis of chlorophyll because of higher photosynthesis due to vigorous plant growth. The present findings were corroborated with the findings of Alam *et al.*, (2006) [1], Balaji and Jawahar (2007) [5] and Jayanthi *et al.*, (2007) [11].

Yield

Biological yield, grain yield and stover yield is the resultant of cumulative effect of the better growth and yield attributes. The seeds sown on the broad bed and furrow produced significantly the highest biological (197.3 q ha^{-1}), grain (69.0 q ha^{-1}) and stover yield (128.2 q ha^{-1}) compared to other treatments, while the seeds sown in broadcasting produced the lowest biological (158.2 q ha^{-1}), grain (55.0 q ha^{-1}) and stover yield (103.2 q ha^{-1}). This might be due to seeds sown in broad bed and furrow have highest number of cobs $plant^{-1}$, cob length, cob width, grain rows cob^{-1}, number of grains row^{-1} and 100 seed weight. Shaikh *et al.*, (2006), Jadhav and Shelke (2007) [10], Singh and Sudhishri (2009) [20], Kumar and Gill (2009) [13] and Parihar *et al.*, (2010) [16] reported higher yield with broad/narrow bed and furrow sowing thus supported above findings.

The different methods of nutrient application influenced significantly the biological, grain and stover yield during both the years. The significantly maximum biological (193.5 q ha^{-1}), grain (67.4 q ha^{-1}) and stover yield (126.1 q ha^{-1}) was recorded with nutrient application through basal+ N through LCC as compared to other treatments. This might be due to nutrient application through basal + N through LCC produced maximum number of cobs $plant^{-1}$, cob length, cob width, grain rows cob^{-1}, number of grains row^{-1} and 100 seed weight. These results are in agreement with the findings of Jayanthi *et al.*, (2007) [12]. They proved that the application of LCC based nitrogen either at the rate of 20 or 30 kg N ha^{-1}, accounted for significantly higher grain yield.

Table 1: Effect of treatments on plant height (cm), Leaf area index fresh weight and dry weight at 90 DAS of Hybrid Maize.

Treatments		Plant height (cm)			Leaf area index			Fresh weight(g $plant^{-1}$)			Dry weight(g $plant^{-1}$)		
A.	Land configuration	**2016**	**2017**	**pooled**	**2016**	**2017**	**pooled**	**2016**	**2017**	**pooled**	**2016**	**2017**	**pooled**
1.	Broad casting	216.9	219.4	218.2	4.6	4.6	4.6	459.5	463.2	461.3	252.0	254.9	253.5
2.	Flat sowing	198.3	200.6	199.5	5.0	5.1	5.1	504.0	508.6	506.3	276.7	279.7	278.2
3.	Flat followed by earthing	192.3	194.4	193.3	5.3	5.4	5.3	530.6	535.9	533.2	291.3	294.7	293.0
4.	Narrow bed & furrow	185.9	188.1	187.0	5.6	5.6	5.6	557.6	563.1	560.3	306.1	309.7	307.9
5.	Broad bed & furrow	181.8	183.9	182.8	5.7	5.8	5.8	575.6	581.3	578.4	315.9	319.7	317.8
6.	S Em±	4.1	4.6	3.1	0.1	0.1	0.1	12.2	14.1	8.8	6.7	7.8	5.1
7.	CD (P=0.05)	13.4	15.1	9.3	0.4	0.5	0.3	39.6	45.9	26.4	21.9	25.3	15.4
B.	**Nutrient management**												
1.	Basal dose of NPK+ top dressing of N in two splits	204.7	207.2	206.0	5.5	5.6	5.5	551.5	556.9	554.2	302.7	306.3	304.5
2.	Basal dose of NPK+ Foliar spray of N in two split	189.3	191.4	190.3	5.1	5.2	5.1	509.8	514.5	512.1	279.8	282.9	281.4
3.	Basal dose of NPK + N through LCC	208.6	211.1	209.9	5.6	5.7	5.6	562.6	567.5	565.1	308.7	312.2	310.5
4.	Basal dose of P & K + N through LCC only	177.4	179.5	178.5	4.8	4.8	4.8	477.9	482.7	480.3	262.3	265.4	263.9
5.	S Em±	3.7	3.5	2.6	0.1	0.1	0.1	10.3	9.8	7.1	5.7	5.4	3.9
6.	CD (P=0.05	10.8	10.1	7.3	0.3	0.4	0.2	29.8	28.3	20.1	16.4	15.6	11.1

Table 2: Effect of treatments on yield attributes of Hybrid Maize at different growth stages.

Treatments		Yield attributes																	
A.	**Land configuration**	**No. of cobs $plant^{-1}$**			**Cob length (cm)**			**Cob width (cm)**			**Grain rows cob^{-1}**			**No. of grains row^{-1}**			**100-seed weight (g)**	
		2016	**2017**	**pooled**	**2016**	**2017**	**Pooled**	**2016**	**2017**	**Pooled**	**2016**	**2017**	**pooled**	**2016**	**2017**	**pooled**	**2016**	**2017**	**pooled**
1.	Broad casting	1.09	1.14	1.11	18.2	18.5	18.4	10.5	10.7	10.6	11.80	12.67	12.23	31.0	32.5	31.8	24.5	25.0	24.7
2.	Flat sowing	1.20	1.25	1.22	19.5	19.8	19.7	11.5	11.7	11.6	12.67	13.80	13.23	35.0	35.7	35.3	25.3	25.8	25.6
3.	Flat followed by earthing	1.26	1.31	1.29	20.4	20.7	20.5	12.1	12.4	12.2	13.78	14.23	14.00	36.9	37.6	37.2	25.9	26.3	26.1
4.	Narrow bed & furrow	1.33	1.38	1.35	21.2	21.5	21.4	12.7	13.0	12.9	14.23	15.12	14.67	38.2	39.5	38.9	26.3	26.7	26.5
5.	Broad bed & furrow	1.37	1.42	1.40	21.7	22.1	21.9	13.2	13.4	13.3	14.67	15.34	15.00	40.0	40.8	40.4	26.7	27.2	27.0
6.	S Em±	0.03	0.03	0.02	0.5	0.6	0.3	0.3	0.3	0.2	0.3	0.4	0.2	1.0	1.0	0.7	0.6	0.7	0.4
7.	CD (P=0.05)	0.09	0.11	0.06	1.6	1.8	1.0	0.9	1.0	0.6	1.1	1.2	0.7	3.4	3.2	2.1	NS	NS	NS
B.	**Nutrient Management**																		
1.	Basal dose of NPK + top dressing of N in two splits	1.31	1.37	1.34	21.0	21.3	21.2	12.7	12.9	12.8	14.23	14.50	14.35	37.6	39.1	38.4	26.3	26.7	26.5
2.	Basal dose of NPK + Foliar spray of N in two split	1.21	1.26	1.24	19.7	20.0	19.9	11.6	11.9	11.8	13.12	14.00	13.56	35.0	36.1	35.6	25.4	25.8	25.6
3.	Basal dose of NPK + N through LCC	1.34	1.39	1.36	21.4	21.7	21.5	12.8	13.1	12.9	14.23	15.12	14.67	39.0	39.8	39.4	26.4	26.8	26.7
4.	Basal dose of P & K + N through LCC only	1.14	1.18	1.16	18.7	19.0	18.9	10.9	11.2	11.1	12.23	12.90	12.56	33.2	33.8	33.5	25.0	25.5	25.2
5.	S Em±	0.02	0.02	0.02	0.4	0.4	0.3	0.2	0.2	0.1	0.3	0.2	0.2	0.8	0.7	0.5	0.5	0.5	0.3
6.	CD (P=0.05)	0.07	0.07	0.05	1.2	1.1	0.8	0.6	0.6	0.4	0.8	0.7	0.5	2.2	2.0	1.4	NS	NS	NS

Table 3: Effect of treatments on yield of Hybrid Maize at different growth stages.

Treatments		Yield											
A.	Land configuration	Biological yield (q ha^{-1})			Grain yield (q ha^{-1})			Stover yield (q ha^{-1})			Harvest index (%)		
		2016	2017	pooled	2016	2017	pooled	2016	2017	pooled	2016	2017	Pooled
1.	Broad casting	156.5	159.8	158.2	54.6	55.4	55.0	101.9	104.2	103.2	34.9	34.6	34.7
2.	Flat sowing	170.6	174.1	172.4	59.9	60.8	60.4	110.7	113.1	112.0	35.1	34.9	35.0
3.	Flat followed by earthing	180.1	183.9	182.0	63.1	63.9	63.5	117.0	119.6	118.4	35.1	34.8	34.9
4.	Narrow bed & furrow	188.5	192.4	190.4	66.3	67.3	66.8	122.1	124.9	123.6	35.2	35.0	35.1
5.	Broad bed & furrow	195.3	199.2	197.3	68.5	69.5	69.0	126.7	129.5	128.2	35.1	34.9	34.9
6.	S Em±	3.8	4.3	3.9	1.4	1.5	1.0	2.6	3.1	2.0	0.8	0.9	0.6
7.	CD (P=0.05)	12.5	14.2	12.9	4.5	5.0	3.1	8.6	10.2	6.1	NS	NS	NS
B.	**Nutrient management**												
1.	Basal dose of NPK + top dressing of N in two splits	184.5	188.3	186.4	65.6	66.4	66.0	118.9	121.7	120.3	35.6	35.3	35.5
2.	Basal dose of NPK + Foliar spray of N in two split	172.7	176.1	174.4	60.7	61.5	61.1	112.0	114.6	113.3	35.0	34.9	35.0
3.	Basal dose of NPK + N through LCC	191.5	195.5	193.5	66.9	67.8	67.4	124.6	127.7	126.1	34.9	34.7	34.8
4.	Basal dose of P & K + N through LCC only	164.2	167.6	165.9	56.9	57.7	57.3	107.3	108.9	108.6	34.6	34.4	34.5
5.	S Em±	3.5	3.2	3.3	1.2	1.1	0.8	2.2	2.2	1.6	0.7	0.6	0.5
6.	CD (P=0.05)	10.1	9.3	9.6	3.4	3.2	2.3	6.5	6.3	4.4	NS	NS	NS

Conclusion

On the basis of results, it may be concluded that seed sown in broad bed and furrow recorded maximum growth characters, yield attributes as well as grain yield during both the years of investigation and on pooled basis. Among the nutrient management, the Nitrogen applied through basal + LCC produced significantly highest growth, yield attributes and grain yield during both the years. Thus it would be better to row the hybrid maize with broad bed and furrow method while fertilizer should be applied @ basal + N through LCC for obtaining higher grain yield from this crop during *kharif* season.

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