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Growth and Yield Response in Maize (*Zea mays* L.) to Organic and Inorganic Nutrient Sources under Haryana Conditions

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ABSTRACT

Field experiments were conducted on the response of organic and inorganic nutrient sources in spring maize (HQPM-1) at RRS, Karnal, Haryana during spring 2016 and 2017. The experiment consisted of combination of four organic manures (pressmud @ 7.5 t ha^{-1}, vermicompost @ 7.5 t ha^{-1}, FYM @ 15 t ha^{-1} and no organic manure) in main plot and six fertilizer levels (135 kg N ha^{-1}, 180 kg N ha^{-1}, 135 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}, 180 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}, 75% RDF and 100% RDF) in sub plots, laid out in a split plot design with three replications. The results revealed that the application of pressmud @ 7.5 t ha^{-1} being at par with vermicompost @ 7.5 t ha^{-1} recorded highest value of growth and yield attributing characters viz. plant height, leaf area index cob length, test weight and grain yield over no organic manure. Among the inorganic fertilizer levels, application of 100% RDF being at par with 75% RDF and 180 N + 30 P recorded highest value of above growth and yield attributing characters over 135 N.

Key words: *Organic manures, Fertilizer, Growth and Yield*

INTRODUCTION

Maize (*Zea mays* L.) is referred as "queen of cereal" because of its higher potential yield among cereals and year-round cultivation. Maize is one of the most versatile and promising crop in world's agricultural economy grown over 187.9 mha with an average productivity of 5.64 tons ha^{-1} [8]. Globally, India ranks fourth in area (9.63 m ha) with productivity of 2.69 tons ha^{-1}. In Haryana, maize is cultivated over an area of 9,000 ha, with production of 23,000 tonnes and productivity of 3.4 tons ha^{-1} [1]. Across India, maize has been sown in 79.23 lakh hectares as on 20th September 2018 which is slightly lower than 79.28 lakh hectares covered during corresponding period of last year[2]. In India, the utilization of quality protein maize (QPM) is emerging out rapidly in diversified ways and common maize can be replaced by QPM to meet the quality protein needs of ever increasing human population. During past four decades intensive agriculture involving exhaustive high yielding varieties of cereals and decreasing inputs of organic sources have led to severe degradation of the soil resulting in a reduction on soil organic matter, soil fertility and productivity[12,10].

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The gap between nutrient removal and supply through fertilizers is likely to widen further as the food grains and other agricultural commodities needed for projected population of 1.5 billion by the turn of century. The erratic fertilizers use patterns, if continued for years, would cause much greater drain or native soil fertility and the soil may not be able to support high production levels in future. Therefore, in the event of nutrient turn over in soil-plant-system being considerably high under intensive cultivation, neither chemical fertilizers nor organic sources alone can achieve production sustainability. Application of different organic-inorganic sources has been found very effective in realizing improved growth and yield attributes in number studies conducted around the globe[22,6,14]. Among the organics, farmyard manure, vermicompost and pressmud are the major sources of organic manures which have proved their worth in terms improving soil health, nutrient status and better crop yields, alone or in combination with different inorganic fertilizers[3,16,26]. Haryana state has an ample scope to increase its acreage and productivity during spring season. Thus for the enhancement of system productivity through the efficient and judicious use of organic and inorganic sources of plant nutrients in an integrated manner was planned for spring maize under Haryana conditions.

MATERIAL AND METHODS

Field experiments were conducted at Regional Research Station, Karnal, CCS HAU during two consecutive spring seasons *i.e*., 2016 and 2017 to study the effect of different organic manures and inorganic fertilizers on growth, development and yield of spring maize (HQPM-1). The experimental site, Karnal is situated in semi-arid, sub-tropics (29°43'N latitude and 76°58'E longitude, 245 metres above mean sea level) having sandy loam textured soil and characterized by hot and dry summer and severe cold during winter season. The experiment consisted of combination of four organic manures *viz*. pressmud @ 7.5 t ha^{-1}, vermicompost @ 7.5 t ha^{-1}, farmyard manure (FYM) @ 15 t ha^{-1} and no organic manure in main plot and six fertilizer levels *viz*., 135 kg N ha^{-1}, 180 kg N ha^{-1}, 135 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}, 180 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}, 75% RDF and 100% RDF (N_{180} P_{60} K_{60} Zn_{25} kg ha^{-1}) in sub plots, laid out in a split plot design with three replications. All the cultural practices were followed from sowing till harvesting as per the recommended package and practices of CCS HAU, Hisar. Observations were recorded on various growth and yield attributing character *viz*. plant stand, plant height, leaf area index, cob length, number of cobs per plant, test weight and grain yield. All the experimental data were statistically analyzed using analysis of variance (ANOVA)[19]. The significance of treatment effects was tested with the help of 'F' (variance ratio) test. Appropriate standard errors along with critical differences (CD at 5%) were recorded for differentiating the treatment effects.

RESULT AND DISCUSSION

Plant stand at 15 DAS and at harvest

The data presented in Table 1 indicates that there were non-significant differences in plant stand at 15 DAS (days after sowing) and at harvest among various levels of organic manures and inorganic fertilizers during both the years of experimentation. This might be due to assured irrigation facilities throughout the crop growth period, manual sowing of seed by dibbling method, creation of congenial environment and no adverse effect of different organic sources leading to assured germination and plant stand. Non significant effects of organics and inorganics on plant stand have been recorded in maize crop by Nasim *et al.*[18].

Plant height (cm) at 60 DAS

The data on plant height recorded at 60 DAS as influenced by various levels of organic and inorganic nutrient sources are presented in Table 1. In general, higher plant height at 60 DAS was observed during 2017 than 2016, might be attributed to the additive effect of organics applied during previous year, which led to better plant growth. The application of pressmud @ 7.5 t ha^{-1} being at par with vermicompost @ 7.5 t ha^{-1}, gave significantly taller plants than FYM @ 15 t ha^{-1} and no organic manure during both the years. Maximum plant height (154.8 and 158.7 cm) was recorded under pressmud @ 7.5 t ha^{-1} whereas minimum (143.7 and 142.4 cm) was observed in no organic manure during 2016 and 2017, respectively. Increase in plant height might be attributed to rapid meristematic cell-division and cell elongation, adequate moisture in organic manures treated plots. Higher plant height has been recorded in organic treatments as compared to no organic manure reported by Jayaprakash *et al*.[11], Balyan *et al*.[4], Bunker *et al.*[6], Shinde *et al.*[28], and Gunjal and Chidodhar[9]. Tallest plants were observed in 100% RDF being at par with 75% RDF, 180 N + 30 P and 135 N + 30 P and significantly higher over rest of the treatments whereas shortest were recorded in 135 N during both the years. The increase in plant height might be due to nitrogen being an essential constituent of plant tissue favours rapid cell division and its enlargement, which together with the adequate quantity of phosphorus and potassium helps in the rapid cell division and better development of the cell size. In line with findings, Meena *et al*.[15], reported significantly higher plant height (157.8 cm) with the application of RDF (N_{120} P_{25} k_{35} kg ha^{-1}) over control. These findings are in conformity with Kalsoom *et al.*, Kumar *et al.*[14], and Singh *et al.*[29].

Leaf Area Index (LAI) at 60 DAS

Various organic and inorganic treatments resulted in significant variations in leaf area index at 60 DAS (Table 1). Among the organic manures, the maximum LAI was recorded under pressmud @ 7.5 t ha^{-1} (4.07 and 4.36 during 2016 and 2017, respectively) remaining at par with vermicompost @ 7.5 t ha^{-1} but higher as compared to FYM @ 15 t ha^{-1} and no organic manure during both the years. Likewise, maximum leaf area index was recorded by Rameshwar and Singh[24] and Jayaprakash *et al*.[11], also reported increased leaf area index in organic treatments as compared to no organic. As regards the effect of inorganic fertilizers, maximum LAI was recorded with 100% RDF (4.08 and 4.32 during 2016 and 2017, respectively) being statistically at par with 75% RDF, 180 N + 30 P and 135 N+ 30 P during both the years. Lowest LAI was attained with 135 N (3.88 and 4.10 during 2016 and 2017, respectively). In line, The increase in LAI, due to increased leaf area with increasing fertilizer levels was because of increased amount of cellular constituents, mainly protoplasm[27] and also due to promotion of cell division, cell enlargement, cell differentiation and cell multiplication[25]. Singh *et al.*[29], noticed significantly higher leaf area index (4.27) with the application of 100% RDF over rest of the treatments including control. In agreement, Kumar and Kumar *et al.*[14], also reported higher LAI with 100 % RDF.

Table 1. Effect of organic and inorganic nutrient sources on plant stand, plant height and leaf area index in spring maize during 2016 and 2017

Treatments	Plant stand at 15 DAS		Plant stand at harvest		Plant height (cm) at 60 DAS		Leaf area index at 60 DAS	
	2016	2017	2016	2017	2016	2017	2016	2017
Organic Sources								
No organic manure	83.0	83.1	82.3	82.4	143.7	142.4	3.91	4.01
Farmyard manure (15 t ha^{-1})	83.0	83.1	82.5	82.7	147.8	148.8	3.94	4.19
Vermicompost (7.5 t ha^{-1})	83.1	83.2	82.5	82.7	152.8	155.0	3.98	4.27
Pressmud (7.5 t ha^{-1})	83.2	83.3	82.6	82.8	154.8	158.7	4.07	4.36
SEm±	0.08	0.07	0.19	0.15	1.9	2.0	0.03	0.04
CD at 5%	NS	NS	NS	NS	6.7	6.9	0.11	0.14
Fertilizer levels (kg ha^{-1})								
135 N	82.9	83.1	82.3	82.6	142.9	144.9	3.88	4.10
180 N	83.0	83.1	82.4	82.6	146.2	147.7	3.92	4.14
135 N + 30 P	83.0	83.2	82.5	82.6	150.3	151.6	3.97	4.21
180 N + 30 P	83.1	83.2	82.5	82.7	152.0	152.7	3.99	4.22
75% RDF	83.1	83.3	82.6	82.7	153.0	153.9	4.00	4.25
100% RDF	83.2	83.3	82.6	82.7	154.2	156.6	4.08	4.32
SEm±	0.09	0.09	0.14	0.12	2.1	2.1	0.04	0.04
CD at 5%	NS	NS	NS	NS	5.9	6.1	0.11	0.11

No. of cobs/plant and Cob length (cm)

The data presented in Table 2 indicate that number of cobs per plant was not comparable among treatments of organic and inorganic nutrient sources during both the years. However, cob length differed significantly due to organic and inorganic nutrient sources. Maximum cob length (14.7 cm) was recorded under pressmud @ 7.5 t ha^{-1} being at par with vermicompost @ 7.5 t ha^{-1} and significantly superior over rest of the treatments during spring 2016. Whereas, all the organic manure treatments were at par and significantly superior over no organic during 2017. The lowest cob length (12.5 and 12.4 cm) was recorded under no organic manure during 2016 and 2017, respectively. Among different inorganic fertilizer levels, maximum cob length was recorded under 100% RDF treatment (16.1 and 16.0 cm) remaining at par with 75% RDF and 180 N + 30 P and significantly higher over rest of the treatments. Minimum cob length (11.1 and 11.0 cm) was recorded under 135 N + 30 P during both the ye2016 and 2017, respectively. Hashim *et al.*, working at New Delhi reported that the highest cob length, was recorded owing to combined application of 50% RDF + 50% RDN.

Table 2. Effect of organic and inorganic nutrient sources on number of cobs per plant, cob length, test weight and grain yield of spring maize during 2016 and 2017

Treatments	No. of cobs plant^{-1}		Cob length (cm)		Test weight (g)		Grain yield (q ha^{-1})	
	2016	2017	2016	2017	2016	2017	2016	2017
Organic Sources								
No organic manure	1	1	12.5	12.4	20.0	19.8	60.7	58.6
Farmyard manure (15 t ha^{-1})	1	1	13.7	13.5	20.9	21.5	69.8	71.6
Vermicompost (7.5 t ha^{-1})	1	1	14.3	14.1	22.0	22.3	73.4	75.5
Pressmud (7.5 t ha^{-1})	1	1	14.7	14.6	22.5	23.2	75.7	78.9
SEm±	-	-	0.3	0.3	0.3	0.3	1.5	1.1
CD at 5%	-	-	0.9	1.2	0.9	1.1	5.5	4.0
Fertilizer levels (kg ha^{-1})								
135 N	1	1	11.1	11.0	20.5	21.0	64.6	65.6
180 N	1	1	12.0	11.9	20.8	21.1	67.7	68.8
135 N + 30 P	1	1	13.0	12.9	21.2	21.6	69.8	71.3
180 N + 30 P	1	1	15.3	15.1	21.7	22.0	71.4	72.7
75% RDF	1	1	15.3	15.1	21.8	22.1	72.2	73.5
100% RDF	1	1	16.1	16.0	22.1	22.4	73.7	75.2
SEm±	-	-	0.3	0.3	0.3	0.4	1.1	1.3
CD at 5%	-	-	0.9	0.9	1.0	1.0	3.1	3.7

Test weight (g)

The data pertaining to 100-grain weight presented in Table 2 revealed that 100-grain weight differed significantly due to different organic manures and inorganic fertilizers. The application of pressmud @ 7.5 t ha^{-1} resulted in maximum grain weight (22.5 and 23.2 g) reaminig at par with vermicompost @ 7.5 t ha^{-1} (22.0 and 22.3 g) and significantly higher than FYM @ 15 t ha^{-1} and no organic manure during 2016 and 2017, respectively. Minimum test weight was recorded under no organic (20 and 19.8 g) during both the years of experimentation. The 100% RDF produced maximum 100-grain weight (22.1 and 22.4 g) which was statistically at par with 75% RDF, 180 N + 30 P and 135 N + 30 P treatments and significantly higher compared to 180 N and 135 N treatments during both the years.

Grain yield (q ha $^{-1}$)

The data on grain yield are presented in (Table 2) revealed that grain yield was significantly different under various organic and inorganic fertilizer treatments. Significantly higher grain yield was observed under different organic manures compared to no manure during both the years. Application of pressmud @ 7.5 t ha^{-1} produced significantly higher grain yield (75.7 and 78.9 q ha^{-1}) over FYM @ 15 t ha^{-1} and no organic manure while at par with vermicompost @ 7.5 t/ha during both the years. Likewise, vermicompost 7.5 t ha^{-1} proved superior over no organic manure with respect to grain yield of spring maize while at par with FYM at 15 t ha^{-1} during both the years of experimentation. The lowest grain yield (60.7 and 58.6 q ha^{-1}) was recorded under no organic manure during both the years. The increase in potential yields of maize might be due to the fact that the organic manures which improved physical, chemical and biological properties of soil resulting increased uptake of nutrients that leads to better growth of plant and as a result higher grain and stover yields. These results are in close agreement with those of Channavasavanna *et al.*[7], Pattanshetti *et al.*[21], Rajkhowa *et al.*[23], Jayaprakash *et al.*[11], Pathan[20] and Meena *et al.*[17]. The cursory look at the data showed that different inorganic fertilizer treatments significantly influenced the grain yield during both the years. Application of 100% RDF gave highest grain yield (73.7 and 75.2 q ha^{-1}) at par with 75% RDF and 180 N + 30 P while significantly higher over rest of the treatments. Application of 135 N + 30 P gave grain yield at par with 180 N while significantly higher over 135 N. Lowest grain yield (64.6 and 65.6 q ha^{-1}) was recorded under 135 N treatment during 2016 and 2017, respectively. It might be due to adequate and readily available of nutrients, which resulted in greater assimilation, production and partitioning of dry matter yield. Gupta *et al.*, found that the significantly highest yield and yield components of maize crop were recorded with 100% RDF + Zn 20 kg ha^{-1} and grain yield (24.1 q ha^{-1}) was about 101% higher over control. Likewise, application of NPK fertilizers at the different levels also had significant effect on the growth and yield of maize[5,13].

CONCLUSION

The results of two years study reveals that the application of pressmud or vermicompost @ 7.5 t ha^{-1} recorded significant effect on plant height, LAI, cob length, test weight and yield of spring maize over no organic manure. Similar trend was observed with the application of 100% RDF or 75% RDF or 180 N + 30 P as compared to other fertilizer levels. Based on these studies, it may be concluded that for getting maximum yield the combination of pressmud @ 7.5 t ha^{-1} or vermicompost @ 7.5 t ha^{-1} with 180 N + 30 P should be applied in spring maize and there may be a saving of 30 kg P_2O_5 + 60 kg K_2O + 25 kg Zn SO_4 ha^{-1}.

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