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Impact of Manures and Nitrogen Levels on Growth and Productivity of Spring Maize (*Zea mays* L.)

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Abstract: Field experiment was conducted at the Regional Research Station of Chaudhary Charan Singh Haryana Agricultural University, Karnal during 2016 and 2017 to evaluate the effect of manures and nitrogen levels on growth phenology, growth, and yield of maize (*Zea mays* L.) The experiment was laid out in a split plot design, keeping four organic manures applications as main and six fertilizers levels as sub treatment. Based on two years pooled data, different levels of manures and fertilizers levels had significant effect on various phenophases. Higher values of plant height, leaf area, leaf area index, and cob yield (with and without husk) were with the application of PM @ 7.5 t ha^{-1} and VM (@ 7.5 t ha^{-1} over FYM @ 15 t ha^{-1} and No-OM treated plots. The increase in cob yield (with and without husk) of maize with application of PM @ 7.5 t ha^{-1} over FYM @ 15 t ha^{-1} was 8.7 and 7.9%, respectively. Among the fertility levels, application of 100% RDF was at par with 75% RDF and 180 kg Nha^{-1} + 30 kg P_2O_5 ha^{-1} with significantly higher plant height, leaf area, leaf area index and higher cob yield with and without husk over rest of the treatments.

Keyords: Maize, Pressmud, Vermicompost, Phenology and yield

The profit-motivated intensified cropping system, which has high turnover of nutrients, poor recycling of organic sources and application of imbalanced fertilizers, which are more pronounced in arid and semi-arid areas leads to environmental pollution (Liu et al 2009). Increasing public awareness of the negative environmental impacts, growing consumer demand for healthier products and criticism of high input cost of production systems lead to more emphasis on organic crop production under integrated management systems. Such organic sources, viz. FYM, VM and PM improves soil structure, soil microbial activity, soil moisture conservation, source of macro and micronutrients, vitamins, enzymes, antibiotics, growth hormones and immobilized micro flora and stabilize crops productivity. Among the organic manures, FYM improves the nutrient and water holding capacity of soils, increases nutrients availability, enhance the beneficial soil microorganism activity, and improves the soil structure (Wendimu 2017). Vermicompost is a rich source of major and micronutrients and it improves the physical, chemical and biological properties of the soil (Meena and Yadav 2015). Morever, pressmud, a by-product of sugar industry serves as a nutrient rich source providing high quality organic matter when applied to the soil and results in better sustainable yield. No doubt, the cost of chemical fertilizers is increasing day by day which is not affordable by farmers and it is also undesirable due to its hazardous environmental effects (Olowoake 2014). In this respect, pressmud is a promising economic source of plant nutrients for sustainable crop production. The value of pressmud as an organic manure has been well recognized for agricultural production, as it contains substantial quantities of nutrients for improving soil fertility, physical, chemical and biological properties (Singh et al 2015). Maize (*Zea mays* L.) occupies third rank after rice and wheat and is grown all over the world in a wide range of climatic condition in sequence or as companion crop with a range of crops under different production systems due to its photo-thermo-insensitive character. In India, 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 of soil organic matter, soil fertility and productivity (Gopakkali et al 2012, Rajanna et al 2012, Choudhary and Suri 2018a, 2018b). In India, Haryana state has ample scope to increase its acreage and productivity during spring season with the introduction of high yielding single cross hybrids and suitability of maize after potato and sugarcane harvest. Keeping the above aspects in view, this study evaluated the effect of organic and inorganic nutrient sources on plant growth, phenological stages and yield on spring maize in Haryana condition.

MATERIAL AND METHODS

Experimental site: Field experiment was conducted at the

Regional Research Station of Chaudhary Charan Singh Haryana Agricultural University, Karnal (29°43"N latitude and 76°58"E longitude at an altitude of 245 meters above mean sea level) during 2016 and 2017, has semi-arid climate characterized by hot and dry summer and severe cold during winter. The mean maximum temperature is as high as 45°C during summer and minimum temperature near 0°C accompanied by frost in peak winter months of December and January. The average rainfall is about 600 mm per annum. The soil of this region is derived from Indo-Gangetic alluvium and is clay loam in texture, slightly alkaline in reaction, medium in organic carbon (0.44%) and low in available nitrogen (148.5kg ha^{-1}), phosphorus (9.3 kg ha^{-1}) and medium in available potassium(172.5 kg ha^{-1}).

Experimental procedures: The field experiment was conducted in split plot design comprising of four organic manures assisted in main plot, viz. No-OM , FYM @15 t ha^{-1},VM @ 7.5 t ha^{-1} and PM @7.5 t $ha^{-1}$and six fertilizers levels, viz.135 kg N ha^{-1} , 180 kg N ha^{-1}, 135 kg N ha^{-1} + 30 kg P2O5 ha^{-1}, 180 kg N ha^{-1} + 30 kg P2O5 ha^{-1}, 75% RDF and 100% RDF (N180 P60 K60 Zn25 kg ha^{-1}in sub plot with three replications. Maize hybrid HQPM-1 as seed material; FYM, VM and PM as organic nutrient sources and urea (46% N), diammonium phosphate (18% N and 46% P_2O_5), murate of potash (60% K_2O) and zinc sulphate (22% Zn) as inorganic nutrient sources were used to supply nitrogen, phosphorus, potassium and zinc as per treatments.. Manures were applied 15 days before sowing as per treatment.

On well-prepared field, the sowing of single cross maize hybrid HQPM-1 was done by manual dibbling using seed @ 20 kg ha^{-1} at depth of 5-6 cm in the first week of February in both the years. The crop was sown at row-to-row distance of 60 cm and plant-to-plant distance of 20 cm. After completing manual dibbling on dry ridges, light irrigation up to half of ridges was applied in furrows on same day to ensure proper germination of seed. Full dose of phosphorus, potash, zinc and 1/4th dose of nitrogen as per treatment were applied as basal dose at the time of sowing and remaining 3/4th dose of N was supplied by line placement in three equal splits at different growth stages of maize *i.e.* knee high stage, tasseling and dough stage. The five irrigations at different growth stages *i.e.* four leaf stage, knee high stage, 50% tasseling, grain filling and dough stage were applied through furrow method. For growth and yield attributes were recorded from ten plants selected randomly in second row of either side in the field. The crop was harvested after full maturity *i.e.* when husk became dry which is considered the ideal stage for harvesting. Harvesting of maize from each plot was done manually. After complete drying mature cobs of each plot was weighed to record grain and stover yield.

Statistical analysis: All the recorded data were statistically analyzed using SAS 9.2 (SAS 9.2, 2009) and http://sscnars.icar.gov.in/spltfactm2s2.aspx software (SAS Institute 2001)

RESULTS AND DISCUSSION

Phenological phages: The different manures and fertility levels showed significant effect on various phenophases. Among the manures, early initiation of tasseling and silking and the lesser number of days to attain 50% tasseling and silking were with application of PM @ 7.5 t $ha^{-1}$and VM @ 7.5 t ha^{-1} and FYM @ 15 t ha^{-1} as compared to No-OM (Table 1). However, higher number of days taken to maturity recorded under PM application over No-OM. The lesser days to 50% tasseling and silking initiation in organic manures integration with inorganic fertilization may be attributed to enhanced and quick availability of plant nutrients particularly phosphorus that plays an important role in initiating primordia for the reproductive parts of the plants. Similarly, among the fertilizer levels, the application of 100% RDF, 75% RDF and 180 N + 30 P recorded lesser number of days to attain 50% tasseling. The higher number of days to attain maturity was with application of 100 per cent RDF, 135 N +30P, 180N +30 P and 75% RDF. The length of maize crop maturity period extended due to increased fertility levels and consistent availability of nutrient released from organic sources.

Growth parameter: The different manures and fertility levels significantly influenced growth parameters, viz. plant height, leaf area and leaf area index (Table 1). The PM @ 7.5 t ha^{-1} recorded the higher plant height (191.77 cm) but was statistically at par with VM @ 7.5 t ha^{-1}, but was significantly superior than FYM @ 15 t ha^{-1} and No-OM. Similar trend for leaf area and leaf area index, under organic manures. Increase in plant height might be attributed to accelerated meristematic cell division, cell elongation, adequate moisture and increased availability of essential nutrients to the maize plants thereby resulting in increased growth components *viz*. number of leaves per plant, leaf area and LAI under the PM treated plots (Gunjal and Chitodkar 2017, Raman and Suganya 2018). Similarly, higher plant height, leaf area and leaf area index were in 100% RDF, 75% and 180 N + 30 P as compared to 135 N, 180 N and 135 N + 30 P. The increase in plant height might be due to the higher nitrogen availability that accelerated cell division and enlargement, which together with the adequate quantity of potassium and phosphorus helps in the rapid cell division and better development of the cell size (Wailare et al 2017, Kumar et al 2017 and Singh et al 2017, Raman and Suganya 2018). The increase in LAI with increasing fertilizer levels was because of increased amount of cellular constituents, mainly

Table 1. Effect of organic and inorganic nutrient sources on phenological stages and growth parameters of spring maize (Pooled data over 2 years)

Treatment	Phenological phases and growth parameters					
	Days to 50% tasseling	Days to 50% silking	Days to maturity	Plant height (cm) at harvest	Leaf area (cm^2/plant) at 80 DAS	Leaf area Index at 80 DAS
Organic sources						
No-OM	71.89^{A}	75.19^{A}	108.18^{B}	175.14^{C}	6384.0^{C}	5.32^{C}
FYM (15 t ha^{-1})	70.92^{AB}	73.57^{B}	110.51^{A}	182.49^{BC}	6645.0^{C}	5.55^{B}
VM (7.5 t ha^{-1})	70.31^{B}	73.12^{B}	111.28^{A}	188.78 ^{AB}	6989.4^{A}	5.83^{A}
PM (7.5 t ha^{-1})	69.9^{B}	72.73^{B}	111.92^{A}	191.77^{A}	7082.8^{A}	5.91^{A}
CD (p=0.05)	1.11	1.47	2.03	8.33	182.93	0.14
NPK levels (kg ha^{-1})						
135-0-0	72.03^{A}	75.34^{A}	108.67^{c}	175.85^{C}	6471.0^{D}	5.4^{D}
180-0-0	71.5^{AB}	74.47^{AB}	109.50^{BC}	180.40^{BC}	6638.3^{C}	5.54^{C}
135-30-0	70.72^{BC}	73.59^{BC}	110.25^{abc}	185.07^{AB}	6760.0^{BC}	5.64^{BC}
180-30-0	70.61BCD^{bcd}	73.56^{BC}	111.00^{AB}	187.08^{AB}	6872.5^{AB}	5.74^{AB}
75% RDF	70.09^{CD}	72.67^{c}	111.40^{A}	188.75^{A}	6897.0^{AB}	5.74^{AB}
100% RDF	69.6^{d}	72.29^{c}	112.01^{A}	190.13^{A}	7013.0^{A}	5.86 ^{A}
CD (p=0.05)	1.06	1.4	1.89	6.88	164.25	0.13

protoplasm and due to promotion of cell division, cell enlargement, cell differentiation and cell multiplication (Singh et al 2017, Kumar et al 2017).

Yield: Significantly, higher cob yield (with and without husk) of spring maize was recorded under various organic manure sources and fertilizer levels over the No-OM during both years pooled analysis. Among the organic manures, significantly higher cob yield with and without husk was with the application of PM @7.5 t ha^{-1}and VM (@ 7.5 t ha^{-1}over the application of FYM @ 15 t ha^{-1} and No-OM. The PM @ 7.5 t ha^{-1} and VM @ 7.5 t ha^{-1} did not differ significantly in respect of cob yield with and without husk (Table 2). However, magnitude of increase in cob yield (with and without husk) of maize with application of PM @ 7.5 t ha^{-1} over farmyard manure@ 15 t ha^{-1} was 8.7 and 7.9%, respectively. This pronounced increase might be due to the application of pressmud which led to better amelioration and improvement in physical, chemical and biological properties of soil resulting in increased supply as well as uptake of nutrients that led to better growth of plants and simultaneously higher grain and biological yields (Rana et al 2018). Among fertilizers levels, significantly higher cob yield (with and without husk) was with the application of 100% RDF, 75% RDF and180 N + 30P over 135 N, 180 N and 135 N + 30 P. The treatment receiving 100% RDF registered 17.8 and 13.0% higher cob yield (with and without husk) over 135 N. Non-significant differences were noted for shelling percentage (Table 2). The different organic manures did not differ significantly in respect of shelling percentage. Although the higher shelling percentage cob was recorded under PM treatment as compared to VM and FYM application. Among the fertilizer levels, higher shelling percentage was recorded under the treatment where 100% RDF was applied as compared to rest of treatments. It might be due to adequate and readily availability of nutrients, which resulted in greater

Table 2. Effect of organic and inorganic nutrient sources cob yield and shelling percentage of spring maize (Pooled data over 2 years)

Treatment	Cob yield with husk (q ha^{-1})	Cob yield without husk (q ha^{-1})	Shelling (%)
Organic sources			
No-OM	87.06^{C}	74.85^{C}	79.65
FYM (15 t ha^{-1})	101.94^{B}	86.91^{B}	81.35
VM (7.5 t ha^{-1})	108.01^{A}	91.41^{AB}	81.49
PM (7.5 t ha^{-1})	110.77^{A}	93.79^{A}	82.39
CD (p=0.05)	5.32	4.83	NS
NPK levels (kg ha^{-1})			
135-0-0	92.06^{D}	80.58^{D}	80.64
180-0-0	98.19^{C}	84.1^{C}	81.01
135-30-0	101.78^{BC}	86.93^{BC}	81.04
180-30-0	104.9^{AB}	88.37^{AB}	81.50
75% RDF	106.21^{AB}	89.39^{AB}	81.41
100% RDF	108.49^{A}	91.07^{A}	81.73
CD (p=0.05)	4.63	3.38	NS

assimilation, production and partitioning of dry matter. Application of NPK fertilizers at different levels also had significant effect on the yields of maize (Banik and Sharma 2009, Kolawole and Joyce 2009).

CONCLUSION

The sole use of chemical fertilizers without organic manure had negative impact on soil health and productivity. Integration of organic and inorganic nutrient sources resulted in improvement in soil physico-chemical properties. Application of PM @ 7.5 t ha^{-1} being statistically similar with VM @ 7.5 t ha^{-1} and significantly effected phenological, growth and cob yield (with and without husk) of spring maize over FYM @ 15 t ha^{-1} and No-OM. Therefore, integrated application of organic and inorganic nutrient is crucial for long lasting crop cultivation.

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