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Effect of nutrients sources on spring maize (*Zea mays*) and its residual effect on succeeding basmati rice (*Oryza sativa*)

GOVIND PRASAD[1], PARVEEN KUMAR[2], RAN SINGH RINWA[3], ABHINAW KUMAR SINGH[4] and K D SHARMA[5]

CCS Haryana Agricultural University, Hisar, Haryana, India

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ABSTRACT

A two-year field experiment was carried out at Regional Research Station, Karnal during 2016 and 2017 to study the effect of different nutrient sources on spring maize (*Zea mays* L.) and succeeding basmati rice (*Oryza sativa* L.) utilizing four organic manures [pressmud @7.5 t ha^{-1}, vermicompost @ 7.5 t ha^{-1}, farmyard manure @15 t ha^{-1} and control] and six fertilizer levels [135 , 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]. The results of the study revealed that the application of pressmud and vermicompost applied each at 7.5 t ha^{-1} recorded the higher dry matter accumulation, cob length, cob girth, number of kernels/cob, test weight and yield (grain and biological) of spring maize over no organic manure treatment. Increase in grain and biological yield of maize with application of pressmud over farmyard manure was 8.4 and 10.1%, and 7.97 and 9.61% during 2016 and 2017, respectively. Among fertilizer levels, application of 100% RDF being at par with 75% RDF and 180 kg Nha^{-1} + 30 kg P_2O_5 ha^{-1} recorded the higher dry matter accumulation, yield attributes and yield of maize.The residual effect of 100% RDF being at par with 75% RDF and 180 kg N ha^{-1}+ 30 kg P_2O_5 ha^{-1} was found superior over 135 kg N ha^{-1} with respect to yield attributes and yield of basmati rice.

Key words: Basmati rice, Maize, Pressmud, Regression, Vermicompost, Yield

Maize (*Zea mays* L.) is a versatile crop grown in sequence or as companion crop with a range of crops under different production systems and contributes more than 9% to national food basket. It can be grown round the year due to its photo-thermo-insensitive character. In India,the common maize can be replaced by QPM to meet quality protein needs of human population. 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. Inclusion of maize as spring crop can form new potential cropping systems, i.e. maize-basmati rice-potato and sugarcane-maize. Basmati rice (*Oryza sativa* L.) is one of the important cash crops in Haryana which is mostly grown under irrigated condition on an area of about 6.3 lakh ha with production of 21.4 lakh tonnes (APEDA 2018).

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). Profit-motivated intensified cropping system, which has high turnover of nutrients, poor recycling of organic sources and application of imbalanced fertilizers caused deficiency of several micronutrients in soil and also leads to environmental pollution (Choudhary and Suri 2014). The gap between nutrient removal and supply through fertilizers is likely to widen further as the huge amount of food grains and other agricultural commodities will be needed for projected population of 1.5 billion by the turn of century. Therefore, there is a need to improve the nutrient supply system integrating chemical fertilizers in conjunction with organic manures (Choudhary and Suri 2018a,b). Moreover, the erratic fertilizer's use pattern besides poor or no organic manure additions has caused much greater drain of native soil fertility with poor production levels (Rana *et al.* 2018; Choudhary and Rahi 2018). Neither chemical fertilizers nor organic sources alone can achieve production sustainability. Incorporation of high organic matter content to the soil through organic manure favors the growth and proliferation of beneficial soil microorganisms. Therefore, there is need

[1]Senior Research Fellow (Email: govindb0041@gmail.com), KVK, Yamunanagar, [2]Assistant Professor, [3]Principal Scientist (Retd), [5]Principal Scientist, Department of Agronomy, CCS Haryana Agricultural University, Hisar, Haryana; [4]Assistant Professor, Department of Agronomy, KNIPSS, Sultanpur, Uttar Pradesh.

to improve the nutrient supply system, involving the use of chemical fertilizers in conjunction with organic manures. Under such circumstances, application of different organic-inorganic sources was found very effective in realizing high yield, better economy (Rana *et al.* 2018; Rajanna *et al.* 2012) and improved residual fertility of the soil (Choudhary and Suri 2014) that too on cropping system basis. Thus, application of organic and inorganic sources of nutrients in a preceding crop and their residual effect on the succeeding crop may be one of the agronomic strategies to harness the maximum production with improved quality of grain for higher premium. Keeping these points in view, an experiment was conducted to study the response of organic and inorganic nutrient sources in spring maize and their residual effects on succeeding basmati rice.

MATERIALS AND METHODS

The field experiment was conducted during 2016 and 2017 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 m above mean sea level).The soil of the 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 (148.5 kg ha^{-1}), phosphorus (9.3 kg ha^{-1}) and medium in available potassium(172.5 kg ha^{-1}). The mean weekly maximum and minimum temperature fluctuated between 6.6 and 41.6 ^{o}C during 2016 and 7.3 and 40.6 ^{o}C during 2017 crop season. The total rainfall was recorded to be 627.5 mm and 319.3 mm during the crop seasons of 2016 and 2017, respectively. In general, the weather conditions were quite favourable for luxuriant growth of maize and basmati rice during both the seasons.

The experiment was laid out in split-plot design with four organic manures, *viz.* pressmud @ 7.5 t ha^{-1}, vermicompost @ 7.5 t ha^{-1}, farmyard manure @ 15 t ha^{-1} and no organic manure assisted 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 (N180 P60 K60 Zn25 kg ha^{-1}) in sub plot with three replications. Bulk samples of well decomposed farmyard manure, vermicompost and pressmud were oven dried and were analyzed for moisture, nitrogen, phosphorus and potassium content (Table 1). Farmyard manure, vermicompost and pressmud were applied 15 days before sowing as organic nutrient sources and urea (46% N), diammonium phosphate (18% N and 46% P_2O_5), muriate of potash (60% K_2O) and zinc sulphate (21% Zn) as inorganic nutrient sources were used as sources to supply nitrogen, phosphorus, potassium and zinc as per treatments.

The sowing of single cross maize hybrid HQPM-1 was done by manual dibbling with 20 kg ha^{-1} seed rate, sown at a depth of 5-6 cm in the first week of February. For keeping the weeds under check atrazine 50 WP @1.0 kg ha^{-1} was applied as pre emergence followed by manual hand weeding/hoeing at 20 and 45 DAS. Crop was irrigated as per crop demand. Four week old basmati rice seedlings (Pusa Basmati-1121) were transplanted at 20 × 15 cm spacing and rrecommended dose of nutrients (90 kg N + 30 kg P +25 kg Zn ha^{-1}) was applied. One third dose of nitrogen and full dose of phosphorous and zinc were applied as basal dose and remaining dose of nitrogen was applied at 21 and 42 days after transplanting. The maize crop was sown on 02-02-2016 and 07-02-2017, whereas basmati rice was transplanted on 04-07-2016 and 05-07-2017, respectively during first and second year. The maize crop was harvested on 09-06-2019 and 10-06-2017, whereas basmati rice on 07-11-2016 and 10-11-2017 at proper maturity. The growth components, yield attributes and yield were recorded as per the prescribed standard procedure (Rana *et al.* 2014). All the experimental data were statistically analyzed by the method of analysis of variance (ANOVA). The significance of treatment effects was computed with the help of ‘F’ (variance ratio) test.

RESULTS AND DISCUSSION

Spring maize crop

Among the manures, the significantly higher drymatter accumulation was recorded with the application of pressmud @ 7.5 t ha $^{-1}$ over no organic manure and FYM @ 15 t ha^{-1} at 40 and 80 days after sowing, however, it did not differ significantly from the treatment where vermicompost was applied @ 7.5 t ha^{-1} (Table 2). The more pronounced effect of organic maures over no manure might be due to the improved physico-chemical properties and slow release of nutrients over longer period with the use of organic sources which led to better growth of maize crop (Paul *et al.* 2014; Choudhary and Rahi 2018). Similarly, among the fertilizers levels, the significantly higher dry matter accumulation was recorded with the application of recommended dose of fertilizers over 135N + 30 P, 180 N

Table 1 Chemical composition of organic sources (on oven dry weight basis)

Component	Per cent content					
	Farmyard manure (FYM)		Vermicompost (VC)		Pressmud (PM)	
	2016	2017	2016	2017	2016	2017
Moisture	55.8	56.7	39.6	44.6	49.1	50.9
Nitrogen	0.62	0.69	1.56	1.72	1.81	2.0
Phosphorus	0.38	0.45	0.61	0.65	1.03	1.01
Potassium	0.65	0.75	0.87	0.96	1.06	1.12

Table 2 Effect of organic and inorganic nutrient sources on dry matter accumulation and yield attributes of spring maize

Treatment	Dry matter accumulation (g^{-2})				Number of grains row^{-1}		Number of kernels cob^{-1}		Cob girth (cm)		Ear height (cm)	
	40 DAS		80 DAS									
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Organic sources												
No-OM	220.1	228.3	920.3	938.7	28.7	28.3	403.7	395.9	3.0	2.8	87.7	88.2
FYM (15 t ha^{-1})	249.7	283.8	1003.2	1090.6	30.5	30.3	434.6	429.3	3.3	3.1	95.7	97.3
VC (7.5 t ha^{-1})	282.7	303.7	1055.2	1151.2	30.8	30.8	438.6	435.9	3.5	3.4	98.7	100.5
PM (7.5 t ha^{-1})	295.8	311.3	1083.7	1191.1	31.1	31.1	442.7	446.1	3.9	3.8	99.4	101.4
CD (P= 0.05)	16.4	16.6	56.9	58.9	NS	NS	24.3	27.8	0.3	0.5	4.4	4.3
NPK levels (kg ha^{-1})												
135 – 0 – 0	222.2	236.5	923.6	986.0	28.9	28.9	406.7	404.6	3.1	3.0	91.2	92.5
180 – 0 – 0	244.5	261.5	951.0	1014.3	29.5	29.4	416.1	414.4	3.2	3.1	93.3	94.8
135 – 30 – 0	256.6	281.4	990.3	1098.1	30.3	30.2	430.3	427.7	3.4	3.3	95.5	97.3
180 – 30 – 0	274.0	296.3	1057.2	1132.9	30.7	30.5	436.8	433.1	3.5	3.4	96.7	98.0
75% RDF	282.5	297.9	1078.0	1154.4	30.9	30.6	441.1	436.4	3.6	3.5	97.4	99.0
100% RDF	292.6	314.6	1094.4	1171.1	31.3	31.1	448.3	444.7	3.7	3.6	98.3	99.5
CD (P= 0.05)	22.0	21.6	67.0	41.5	NS	NS	23.4	23.4	0.2	0.4	3.7	4.2

and 135 N, however , it was ststistically at par with 180 N + 30 P and 75% recommended dose of fertilizers at 40 and 80 days after sowing during both the years of study. The increase in dry matter accumulation at different stages with application of chemical fertilizers might be attributed to the increase in plant height and increase in leaf area index thereby resulting in better light interception by crop which accumulated more photosynthates and thus produced more dry matter (Varatharajan *et al.* 2019a, b).

Neither the organic sources nor the fertilizer levels affected the number of grain rows per cob and numbers of grains per row significantly (Table 2). The different organic manures did not differ significantly in respect of number of kernels per cob. Although more number of kernels per cob was recorded under pressmud treatment as compared to vermicompost and FYM application. Among fertilizer levels, significantly higher numbers of kernels per cob was recorded under the treatment where 100% RDF was applied over 135 and 180 kg N, but statistically at par with 135 kg N +30 P, 180 Kg N+ 30 P and 75% RDF. Among the organic sources and fertilizers levels maximum cob girth and ear height was recorded under the treatment pressmud @ 7.5 t ha^{-1} and 100% RDF, respectively. The pressmud has been advocated as good organic manure, application of which significantly increased the availability of nitrogen in soil and thus resulted in better yield attributes like cob length and cob girth in maize (Gunjal and Chitodkar 2017). The significant improvement in yield attributes of maize might be due to increased leaf area index which resulted in better interception, absorption and utilization of radiant energy leading to higher photosynthetic rate and finally more accumulation of dry matter by the plants (Varatharajan *et al.* 2019a, b). The overall improvement of crop growth reflected into better source-sink relationship, which in turn enhanced the yield attributes of maize (Gunjal and Chitodkar 2017).

Significantly higher grain and biological yields were recorded with the application of pressmud @7.5 t ha^{-1} over FYM @ 15 t ha^{-1} and no organic manure. The treatment receving pressmud @ 7.5 t ha^{-1} and vermicompost @ 7.5 t ha^{-1} did not differ significantly in respect of grain and biological yield (Table 3). The increase in grain and biological yields with application of pressmud over farmyard manure was 8.4, 10.1% and 7.97, 9.61 % during 2016 and 2017, 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). Further average increase in biological yield with application of 100% RDF was 11.0% over 135 N. It might be due to adequate and readily availability of nutrients, which resulted in greater assimilation, production and partitioning of dry matter.Neither the organic sources nor the fertilizer levels affected the harvest index significantly. Fig 1 and 3 revealed that grain yield and cob girth has high coefficient of determination that is 0.890 and 0.858,

Table 3 Effect of organic and inorganic nutrient sources on yield of spring maize and succeeding basmati rice

Treatment	Maize						Basmati rice			
	Grain yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest index (%)		Grain yield (t ha^{-1})		Biological yield (t ha^{-1})	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Organic sources										
No-OM	6.07	5.86	14.92	14.36	40.7	40.8	3.82	4.02	9.36	9.83
FYM (15 t ha^{-1})	6.98	7.16	17.05	17.48	40.9	41.0	4.53	4.76	10.96	11.53
VC (7.5 t ha^{-1})	7.34	7.55	17.90	18.43	41.0	41.0	4.63	4.93	11.27	12.00
PM (7.5 t ha^{-1})	7.57	7.89	18.41	19.16	41.1	41.2	4.85	5.13	11.77	12.46
CD (P= 0.05)	0.55	0.40	0.64	0.63	NS	NS	0.26	0.30	0.62	0.69
NPK levels (kg ha^{-1})										
135-0-0	6.46	6.56	16.01	16.23	40.3	40.3	4.03	4.19	9.83	10.30
180-0-0	6.77	6.88	16.67	17.02	40.6	40.4	4.31	4.62	10.43	11.20
135-30-0	6.98	7.13	17.09	17.44	40.8	40.9	4.51	4.67	11.02	11.40
180-30-0	7.14	7.27	17.39	17.70	41.1	41.1	4.58	4.86	11.13	11.77
75% RDF	7.22	7.35	17.50	17.73	41.2	41.4	4.66	4.93	11.29	11.98
100% RDF	7.37	7.52	17.76	18.02	41.5	41.7	4.67	4.97	11.30	12.00
CD (P= 0.05)	0.31	0.37	0.56	0.63	NS	NS	0.28	0.24	0.68	0.58

respectively, which shows that 89% and 85.8% variation in grain yield is explained by cob girth for the year 2016 and 2017, respectively. Similarly, Fig 2 and 4 reveals that grain yield and ear height has high coefficient of detemination that is 0.990 and 0.986 respectively which shows that 99 percent and 98.6% variation in grain yield is explained by ear height for the year 2016 and 2017, respectively.

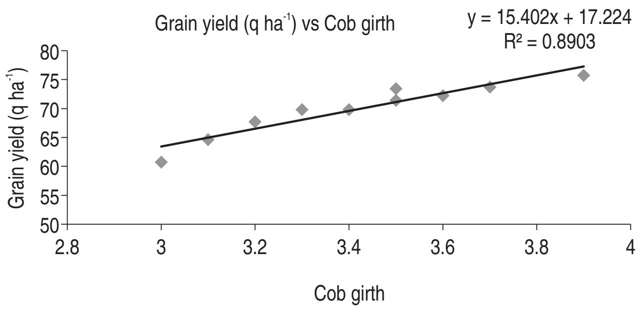

Fig 1 Linear regression line: Grain yield (q ha^{-1}) and cob girth for the year 2016.

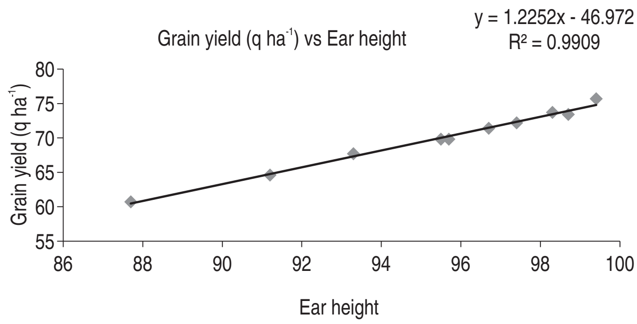

Fig 2 Linear regression line: Grain yield (q ha^{-1}) and ear height for the year 2016.

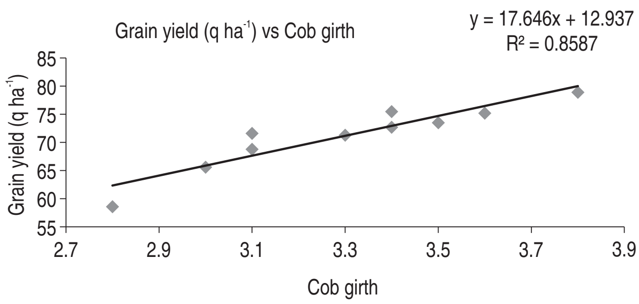

Fig 3 Linear regression line: Grain yield (q ha^{-1}) and cob girth for the year 2017.

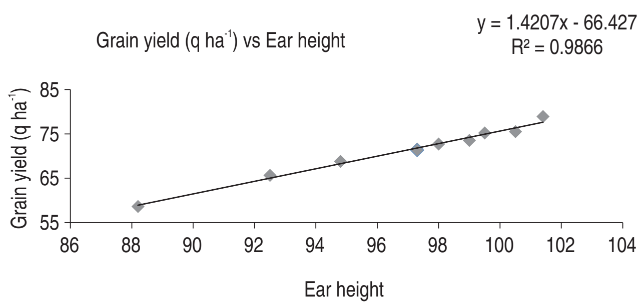

Fig 4 Linear regression line: Grain yield (q ha^{-1}) and ear height for the year 2017.

Residual effect on basmati rice: The highest grain and biological yields were recorded under the residual fertility of pressmud @ 7.5 t ha^{-1} which remained at par with vermicompost @ 7.5 t ha^{-1} and significantly higher over FYM @ 15 t ha^{-1} and no organic manure.The average increase in grain and biological yields recorded under residual fertility of pressmud @ 7.5 t ha^{-1} was 27.3 and 26.4% over no organic manure. In general, grain and biological yields of rice were higher during second year in comparison to first year. Moreover, the residual effect of organic nutrient source on succeeding crop may be due to the presence of highly persistent materials which take long time for complete decomposition. Thus, nutrients released from organic manures for long period notably benefited the succeeding crop (Paul *et al.* 2014; Choudhary and Rahi 2018). The residual effect of inorganic fertility levels of 100% RDF (90 kg N + 30 kg P +25 kg Zn ha^{-1}) gave the highest grain, straw and biological yields which were statistically at par with 75% RDF and 180 N + 30 P and significantly higher over 135 N + 30 P, 180 N and 135 N during 2016 as well as 2017. Higher quantity of residue associated with the greater nutrient content at higher fertility level enriched the soil physical and chemical characters which were reflected in higher yields (Rana *et al.* 2018).

Conclusion

Application of pressmud @ 7.5 t ha^{-1} being statistically at par with vermicompost @ 7.5 t ha^{-1} had significant effect on dry matter accumulation, yield attributes and yield of spring maize over FYM @ 15 t ha^{-1} and no organic manure.

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