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Effect of Integrated Nutrient Management on Growth and Yield Parameters of Maize (*zea mays* l.) As well as Soil Physico-chemical Properties

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Abstract

A field experiment was conducted during the winter season of 2013 at a main research field of the School of Agriculture Lovely Professional University, Phagwara, Punjab (India) to study the influence of integrated nutrient management on growth and yield parameters of maize (*Zea mays* l.) as well as soil physico-chemical properties. The growth parameters (plant height and leaf area) were found to be highest under INM (Integrated Nutrient Management) of poultry manure (PM) or farm yard manure (FYM)and recommended dose of fertilizers (RDF) which are statistically on par but comparatively higher than T_1 (100% RDF). The yield parameters (number of grains per cob, cobs weight per plant, Test weight and stover yield) were significantly higher under INM compared to T_1 (100% RDF). Furthermore, post harvest soil physico-chemical properties (organic carbon and available nitrogen) were significantly improved under T_3 (5t PM + 50% RDF), whereas soil available phosphorus was recorded maximum under T_5 (5t PM + 100% RDF) compared to control and rest of the treatments combination. Therefore, the integration of 50% RDF along with either 5 t/ha FYM or PM or both resulted in maximum maize productivity on par compared with sole used of 100% RDF.

Keywords: Nutrients management; Organic farming; Poultry manure; Farmyard manure; Maize

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crop in the world agriculture as food, feed and industrial raw material which ranked third largest cereals following rice and wheat respectively [1,2]. In India, it is grown in more than 8.33 m. ha, having a production of 16.68 mt and average productivity of 2002Kg ha^{-1} [3]. It is grown across a wide range of agro ecological zones, due to its wider adaptability. In India, Andhra Pradesh was reported to be the largest producer of maize among the producing state contributing 21 per cent (%) of total production, followed by Karnataka 16%, Rajasthan 10%, Bihar and Maharashtra 9% each as well as Uttar Pradesh and Madhya Pradesh each contribute 6% [4].

Majorly poor management of fertilizer has key role to play in obtaining low yield productivity, so in order to achieve optimum crop productivity management of nutrients through judicious application of organic sources, bio-fertilizers and micro-nutrients are required [5]. Furthermore, the fertilizer management is one of the most important factors that influence the growth and yield of maize crop. Maize is considered as most exhaustive crop after sugar cane and requires both micro and macro nutrients to obtain high growth and yield potentials. In fact, organic nutrients not only provide plant with nutrients but also improve and or sustain the soil health. The micronutrients content in organic manure may be sufficient enough to meet the crop production requirement but problem of low soil fertility is one of the obstacles to maintain and sustain agricultural production and productivity [6-8]. Integrated nutrient management (INM) is a judicious use of organic and inorganic sources of nutrient to crop fields for sustaining and maintaining soil productivity. However, the use of appropriate and conjunctive use of application of suitable nutrients through organic and inorganic solely or in combination can provide the solutions to the problems such as increase in the price of inorganic fertilizers and deterioration effect of soil fertility and productivity. Hence, judicious application of these combinations can sustain the soil fertility and productivity.

However, due to above points the main purpose of this research is to study the effect of INM on growth and yield parameters of hybrid maize and physico-chemical properties before and after cultivation of hybrid maize.

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Material and Methods

A field experiment was conducted during the winter (*Rabi*) season of 2013 at a main research field of the school of Agriculture, opposite 34 block of Lovely Professional University, Phagwara (India), situated at 31.25°N latitude and 75.70°E longitude and at an altitude of 105.5 m above sea level, to study the "Influence of integrated nutrients management and early sowing on growth, yield, quality parameters of maize (*Zea mays* L.) as well as soil physic-chemical properties at harvest." The soil in the trial field was found to be Sandy clay loam in texture with slightly alkaline pH (7.90) having a medium status of available nitrogen and phosphorus (314.66 kg/ha and 13.14 kg/ha respectively) as well as high status of soil available potassium (393.00 kg/ha). The data on weather parameters such as rainfall (mm), mean maximum and minimum temperature (°C) as well as relative humidity (%) from the month of October, 2013 up to the month of April, 2014 was collected from Amritsar weather forecast meteorological station. However, the data shows a monthly record of rainfall (mm), relative humidity (%), minimum and maximum temperature (^{0}C) during the period of INM field trial on hybrid maize crop and it shows that the total amount of rainfall received during the crop growing period is 204 mm while the average relative humidity received during the growing period is ranging from a maximum of 89.1% to a minimum of 49.5% and the minimum temperature was received in the month of January, 2013 (4.4^{0}C) followed by month of February, 2013 (5.8^{0}C), December, 2013 (6.2^{0}C), whereas maximum temperature was recorded in the month of April, 2014 (34.8^{0}C) followed by October, 2013 (30.5^{0}C).

The field was laid out in randomize complete block design (RCBD) which is replicated three (3) times on a gross plot size of 5.0 m × 4.2 m and net plot size of 4.8 m × 3.6 m. The organic nutrient sources used are poultry manure (PM) and farm yard manure (FYM) whereas the inorganic sources are Urea, Di-ammonium phosphate (DAP) and Muriate of potash (MOP). Eight (8) treatments involving a combination of various nutrients from different sources (organic and inorganic) were used which include: T_1 (100% RDF), T_2 (5t FYM + 50% RDF), T_3 (5t PM + 50% RDF), T_4 (5t FYM + 100% RDF), T_5 (5t PM + 100% RDF), T_6 (5t each of FYM & PM + 50% RDF), T_7 (2.5t each of FYM & PM + 50% RDF) and T_8 (2.5t each of FYM & PM + 100% RDF). Maize hybrid variety (DuPont Pioneer-31Y45) was used as experimental material for sowing purpose at a depth of 3-5 cm using a spacing of 60 cm × 15 cm using 25 kg/ha recommended dose of sowing seed.

The recommended dose of organic fertilizer (PM and FYM) used was 5 t/ha and this were uniformly incorporated into the soil at the same day 35 days before sowing as per treatments in each plot. Furthermore, the recommended dose of inorganic fertilizer (RDF) used was 120:60:40 NPK kg/ha, whereas half (1/2) of urea along with complete DAP and MOP were applied at sowing time as basal doses and the rest of the urea was applied as top dressed at 36 and 70 days after sowing (DAS) respectively as a split doses. Plant height (cm) and leaf area (LA) were measured and recorded, whereas at maturity period the yield parameters like number of grains per cob, test weight (g), weight of cob per plant (g) and Stover yield (t/ha) were measured and recorded. However, after crop harvesting the soil sample from trial field was analyzed for determination of soil physic-chemical properties (organic carbon and NPK) and the measured data were subjected to Analysis of variance (ANOVA) and their means was separated using Duncan multiple Range Test (DMRT) at 5% level of significance.

Results and Discussion

Plant height (cm)

Table 1: Effect of INM on growth parameters at various growing stage of maize crop.

	30 DAS			60 DAS	At Harvest	
Treatments	Plant Height (cm)	Leaf Area LA (cm^2)	Plant Height (cm)	Leaf Area LA (cm^2)	Plant Height (cm)	Leaf Area LA (cm^2)
T_1	24.6^a	69.0^b	35.3^a	233.6^a	132.1^b	426.1^{bd}
T_2	20.6^{ab}	85.1^a	36.7^a	225.9^a	144.9^{ab}	430.0^d
T_3	22.9^{ab}	92.7^a	38.6^a	265.7^a	142.5^{ab}	531.0^a
T_4	20.0^b	82.3^a	36.7^a	231.5^a	142.5^b	451.0^b
T_5	23.2^{ab}	81.7^a	37.7^a	235.2^a	131.9^b	463.9^{ab}
T_6	19.9^b	75.6^{ab}	38.8^a	209.5^a	144.8^{ab}	546.2^a
T_7	24.8^a	72.1^{ab}	34.3^a	218.1^a	153.4^a	357.1^d
T_8	24.1^a	79.0^{ab}	37.9^a	235.2^a	133.4^b	471.6^{ab}
CD @ 5%	3.5	11.3	NS	NS	22.0	79.4
S.E m (±)	1.2	3.7	3.3	21.8	7.3	26.2

Mean followed by same letter(s) within a column are not significantly different at 5% level of significance using Duncan Multiple Range Test (DMRT), DAS= Days after Sowing; RDF= recommended dose of fertilizer (NPK); FYM= farm yard manure; PM= poultry manure; T_1= 100% RDF; T_2= 5t FYM +50% RDF; T_3= 5t PM + 50%RDF; T_4=5t FYM + 100% RDF; T_5= 5t PM + 100% RDF; T_6= 5t FYM + 5t PM + 50% RDF; T_7= 2.5t FYM + 2.5t PM + 50% RDF; T_8= 2.5t FYM + 2.5t PM + 100% RDF

Plant height was found to be significantly different at 30 DAS among all the treatments used in the trial due to the availability of sunshine at early growing stage which is essential for proper growth of maize crop with T_7 (2.5 t/ha each of PM and FYM along with 50% RDF) having higher plant height (24.8 cm) followed by T_1 (100% RDF) with a plant height of 24.6 cm and the least plant height (19.9 cm) was obtained on T_6 (5 t/ha each of PM and FYM + 50% RDF). At 60 DAS the plant height was recorded maximum (38.6 cm each) under T_3 (5 t/ha PM + 50% RDF) and T_6 whereas the least was recorded under T_7 although the effect of the treatments on plant were found to be statistically same. The plant height at harvest was recorded maximum (153.4 cm) under T_7 followed by T_2 (5 t/ha FYM + 50% RDF) with a plant height of 144.9 cm and lowest plant height of 131.9 cm was recorded under T_5 (5 t/ha PM + 100% RDF) and the reason for insignificance different among the treatments used at 60 DAS and at harvest were due to the onset of winter or early sowing and this resulted in problems like less sunshine hours, high humidity, lower temperature below 10^0C and improper metabolic functioning which is prerequisite for proper growth of maize crop, whereas in the case of first month (30 DAS) after sowing the crop started to grown well due to availability of such prerequisite for proper functioning of crop which show significant differences among the treatments used in the trial but the subsequent months during the crop growth shows similar effect among the treatments (Table 1). This result was found to be in contrary with [7,9,10] finding who were reported that significant increased in plant height was observed among treatments with a combination of organic and inorganic sources.

Leaf area LA (cm^2)

Leaf area (LA) explains how efficiently the nutrients were use for metabolic activities by growing crop in the field. At 30 DAS the effect of the treatments on LA was recorded to be significantly different with T_3 (5 t/ha PM + 50% RDF) recorded to have higher LA (92.7 cm^2/plant), followed by T_2 (5 t/ha FYM + 50% RDF) with a LA of 85.1 cm^2/plant whereas, T_1 (100% RDF) was recorded to have lowest LA (69 cm^2/plant) at 30 DAS due to the effect of the treatments used in the trial. At 60 DAS, the effect of treatments on LA was found to be not significant as a result of the onset of the winter season one month after sowing which affect the nutrients uptake and proper functioning of the maize crop whereas, the effect of treatments on LA at harvest were significantly different with T_6 (5 t/ha each of PM and FYM + 50% RDF) recorded having highest LA of 546.2 cm^2/plant, followed by T_3 (5 t/ha PM + 50% RDF) recorded with the second highest LA of 531 cm^2/plant whereas, T_7 (2.5 t/ha each of FYM and PM + 50% RDF) was recorded with lowest leaf area LA of 357.1 cm^2/plant compare with the rest of the treatments used in the trial (Table 1). However, the results obtained regarding LA except at 60 DAS are in line with the finding reported by [7,9,11] who were reported that significant increase in LA were observed due to the effect of integrated nutrient management more than sole application of recommended dose of fertilizer.

Number of grains per cob

The grains number per cob was recorded to be highly significant among the treatments used in the trial with T_6 (50% RDF + 5 t/ha each of FYM and PM) was found to produced more number of grains per cob (423 grains/cob), followed by T_3 (5t/ha PM + 50% RDF) was also found to produced 416 grains per cob, whereas T_1 (100% RDF) was found to produced least grains number per cob (341 grains/cob) among the rest of the treatments used in the trial (Table 2). The result of the analysis was in line with the report shown by [12] who reported that the grains number was found to be significantly increased in treatment with PM along with RDF together, whereas [3,13] were reported that significant increased in grains yield was observed due to combined effect of organic and inorganic fertilizer which are resulted as a result of significant increased in grains number per cob. Furthermore, [7,14,15] were also reported similar results. This was as a result of continuous supply of nutrients to plant in plots under integrated nutrients management over plots with recommended dose of fertilizer alone.

Test weight TW (g)

Table 2: Effect of INM on yield parameters of maize and soil properties after harvest.

Treatments	No. of grains per cob	Test Weight (g)	(g) Cob weight per plant	Stover Yield (t/ha)	Soil Available N (kg/ha)	Soil Available P (kg/ha)	(%) Soil Organic Carbon
T_1	340.7^{b}	28.3^{b}	850.0^{b}	8.32^{d}	385.22^{c}	9.39^{d}	0.66^{d}
T_2	370.7^{ab}	28.3^{b}	934.6^{ab}	9.80^{bd}	499.39^{ab}	13.36^{c}	0.87^{c}
T_3	416.3a	35.9^{a}	1171.3^{a}	13.84^{a}	565.45^{b}	14.97^{b}	1.54^{a}
T_4	369.7^{ab}	30.9^{ab}	893.5^{ab}	10.68^{b}	443.54^{bc}	12.31^{c}	1.32^{b}
T_5	359.7^{b}	33.0^{ab}	890.3^{ab}	9.63^{bd}	457.86^{b}	19.64^{a}	1.32^{b}
T_6	423.0^{a}	35.3^{a}	1059.2^{a}	12.86^{a}	484.63^{b}	15.54^{b}	1.51^{a}
T_7	405.3^{a}	32.7^{ab}	749.5^{b}	8.53^{d}	530.40^{b}	9.80^{d}	0.84^{c}
T_8	361.0^{b}	25.9^{b}	813.7^{b}	8.74^{bd}	558.12^{a}	13.35^{c}	1.43^{ab}
CD @ 5%	41.4	5.1	204.9	1.97	69.91	1.48	0.15
S.E m (±)	13.7	1.7	67.5	0.12	20.92	0.44	0.04

Mean followed by same letter(s) within a column are not significantly different at 5% level of significance using Duncan Multiple Range Test (DMRT); DAS= Days after Sowing; RDF= recommended dose of fertilizer (NPK); FYM= farm yard manure; PM= poultry manure; T_1= 100% RDF; T_2= 5t FYM +50% RDF; T_3= 5t PM + 50%RDF; T_4=5t FYM + 100% RDF; T_5= 5t PM + 100% RDF; T_6= 5t FYM + 5t PM + 50% RDF; T_7= 2.5t FYM + 2.5t PM + 50% RDF; T8= 2.5t FYM + 2.5t PM + 100% RDF

The 100 grains weight or TW revealed that, significant different exist among the treatments effect on TW of hybrid maize crop with T_3 (5 t/ha PM + 50% RDF) recorded to have grains with highest TW (35.9 g/ 100 grains), followed by T_6 (50% RDF + 5 t/ha each of FYM and PM) was recorded to produced the grains with second highest TW (35.3 g/100 grains) whereas, T_1 (100% RDF) was recorded with lowest grains weight (28.3 g/100 grains) compared with the rest of the treatments used in the trial (Table 2). However, the result obtained are same line with the finding reported by [7,16-18] who were reported that application of INM through organic (PM or FYM or vermicompost) and inorganic RDF produced significantly higher grains weight over sole application of 100% RDF.

Weight of cobs per plant (g)

The cob weight per individual plant revealed that, significant different occurred among the different treatments used in the trial with T_3 (5 t/ha PM + 50% RDF) was recorded with highest total cobs weight per plant (1171.3 g/plant) followed by T_6 (5t/ha each of FYM and PM + 50% RDF) with a total cobs weight per plant of 1059.2 g/plant due to the effect INM on maize crop cobs which are statistically same, whereas T_7 was recorded with lowest total cobs weight per plant (749.5 g/plant) compare with the rest of the treatments (Table 2). This result recorded due to the continuous availability of nutrients throughout the growing period of the plant. The result obtained is in line with what [2,19] who were reported that the effect of INM from different sources resulted with highest economic and biological yield of maize, whereas [9,14,15] were reported that application of 50% RDF along with PM or FYM or goat manure resulted in significant increased in yield parameters than sole application of 100% RDF.

Stover yield (t/ha)

Stover yield was found to be highly significant different among the treatments effect on maize stover. T_3 (5 t/ha PM + 50% RDF) was recorded to produce highest stover yield (13.843 t/ha), followed by T_6 (50% RDF + 5 t/ha each of PM and FYM) with a stover yield of 12.861 t/ha more than rest of the treatments applied whereas, T_1 (100% RDF) was found to produced lowest stover yield (8.321 t/ha) compare with the rest of the treatments used in the trial (Table 2) and This significance result was obtained owing to continuous supply of nutrients to the plant throughout growing period in the field due to integration of organic as well as inorganic source which sustain and increase the crop productivity and due to availability of sunlight some days prior to harvesting time as well as dual nature of the sowing material. However, the result are in line with the finding [20] who were reported that significant increased in straw yield was observed due to integration of 50% RDF along with 10t FYM over sole application of either 100% RDF or 10t FYM and in similar report by [13] who were reported that INM treatments produced significant higher stover yield than sole application of either of them.

Soil available nitrogen SAN (kg/ha)

The soil available nitrogen represents a fraction of the total nitrogen susceptible to absorption by plant. Nitrogen is generally taken up by the plant in the form of nitrate $N0_3$ form under aerobic and as NH_4 ions under anaerobic condition of plant growth [21]. Highly significant different was recorded among the treatments used in the trial on soil available nitrogen after maize harvest. Compare to control T_1 (100% RDF) which was recorded with the lowest SAN (385.2 kg/ha) and other treatments after harvest, T_3 (5t/ha PM + 50% RDF) was recorded with the highest SAN (565.4 kg/ha), followed by T_8 (2.5t/ha each of FYM and PM + 100% RDF) with SAN of 558.1 kg/ha which contains a combination of organic and inorganic sources of nutrients and they are statistically same in term of their effects on soil available N improvement (Table 2). The above result are in similar position with [22] who reported that application of FYM along with RDF increases overall land productivity than sole use of inorganic fertilizer and [23] revealed that integration of organic and inorganic sources of nutrient improved soil fertility status.

Soil available phosphorus SAP (kg/ha)

The available soil P performed so many function including root development, carbohydrate metabolism, flowers, seeds and fruit formation, formation of high energy bond in ATP and so on [21]. Highly significant different was recorded due to effect of INM on SAP after harvest. Compared with the rest of the treatments used in this trial T_1 (100% RDF) was found to have lowest SAP (9.4 kg/ha) whereas, T_5 (5 t/ha PM + 100% RDF) was recorded with highest SAP (19.6 kg/ha) more than any of the treatments used, followed by T_6 (50% RDF + 5 t/ha each of FYM and PM) with SAP of 15.5 kg/ha which are found to be statistically the same with T_3 (5 t/ha PM + 50% RDF) in their action towards improvement of SAP (Table 2). The result obtained are in similar position with [22] who reported that application of FYM along with RDF increases overall land productivity than sole use of inorganic fertilizer as well as [23] who shows that integration of organic and inorganic sources of nutrient improved soil fertility status.

Soil Organic Carbon SOC (%)

Carbon was considered as the major constituent of organic matter and the estimation of organic matter are carried out through organic carbon which is considered to be about 58% of soil organic matter [21]. Highly significant increased of SOC was observed due to the treatments effect on soil after harvest. The maximum increased of SOC (1.5% each) at harvest was observed in plot containing the T_3 (5 t/ha PM + 50% RDF) and T_6 (50% RDF + 5t/ha each of PM and FYM) which are statistically the same and these resulted in superior growth and development of crop in such plots during the period of the trial, whereas the lowest increased (0.7%) among the treatments was observed in T_1 where 100% RDF was used (Table 2). This result are similar to the reports shown by [13] who reported that replacement of 25% or 50% N with organic manure increases the organic matter content in the soil after harvest as well as [7] who shows that integration of organic and inorganic nutrients sources resulted in maximum organic carbon whereas [24,25] reported that soil organic matter increases when poultry litter was applied on wheat.

Conclusion

Therefore, it can be concluded that the integration of 50% RDF along with either 5 t/ha Poultry manure or farm yard manure or both resulted in not only maximum productivity of maize but also resulted in significant improvement of soil physic-chemical properties which are on par with result where 100% RDF was used.

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