Effect of Different Levels of Organic and Inorganic Fertilizers on Maize (Zea mays L.)

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ABSTRACT
A field experiment was carried out in randomized block design, consists of seven treatments with three replications at Agricultural Research Farm, Lovely Professional University, Jalandhar, Punjab during kharif season of year 2016. The combined application of FYM, vermicompost and chemical fertilizers (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) gives significantly higher results in growth parameters (plant height 238.47 cm, stem girth 12.3 cm, number of green leaves 15.33 and number of internodes 18.10) and yield attributes (1.33 cobs per plant, cob length 15.72 cm and 459 grains per cob) as well as yield (grain yield 5400 kg ha⁻¹) as compared to rest of treatments as well as control.

Key words: Farm yard manure, Integrated nutrient management, Maize, Vermicompost.

INTRODUCTION
Cultivation of maize originated in Mexico, Central America, from where it is believed that it spread to Argentina in south to Canada in north. But today, it is cultivated throughout the world making it an important cereal worldwide. Maize is not only used for consumption of human but it is also used for the feed and fodder of cattle and raw material for industries. The scenario of India, cultivation of maize comes more than four percent of net area sown in the country. In India, about 28% of produced maize is used for food purpose, livestock feed about 11%, poultry feed as 48%, 12% in wet milling industry (starch and oil production) and 1% as seed (Anonymous, 2007). After Independence, India has shown increase in production of maize as in 1950-51 it was 1.7 million tonnes and in year 2003-04, from 7.4 million hectares of land, India produced 14.7 MT of maize with an average grain yield of 1963 kg per hectare. In 2014-2015, the production of maize raised to 24.35 MT. (Anonymous, 2014). Maize grains have great nutritional value as they contain 72% starch, 10% protein, 4.8% oil, 8.5% fibre, 3.0% sugar and 1.7% ash. Zea mays is the most important cereal fodder and grain crop under both irrigated and rain-fed agricultural systems in the semi-arid and arid tropics.

The use of inorganic mineral fertilizers has been increased by five folds since 1960. Inorganic fertilizers had significantly supported food requirement of world population by increasing yield. (Smil, 2002) estimates that in past 50 years nitrogen based fertilisers had increased per capita food production by approximately 40 per cent. Over reliance on mineral nutrients result into soil degradation by deteriorate the chemical and physical properties of soil (Hepperly et al., 2009). Such environmental concern and economic constraints has warned that nutrient requirement should not be fulfil by solely through inorganic fertilisers. So, the solution to this problem is Integrated Nutrient Management (INM).

The efficient use of all available nutrient sources such as, organic sources, mineral sources, bio-fertilisers and recyclable waste for the sustainable farming. Highest productivity of crops in sustainable manner could be achieved only by applying appropriate combination of different organic and inorganic sources of nutrients without deteriorating the condition of soil and other natural resources (Chandrashekara et al., 2000). The integrated use of inorganic fertilizers with organic manures is a sustainable approach for efficient nutrient usage which enhances efficiency of the chemical fertilizers while reducing nutrient losses. The optimum yield level of maize production can’t be achieved by using only organic manures because of their low nutrient content. The jointly using chemical fertilizers along with various organic sources results in improving quality of soil and higher crop productivity on long- term basis. Therefore the present study was planned with the objectives as to study the effect of organic and inorganic fertilizers on growth and yield attributes of maize and to identify the best combination of organic and inorganic fertilizers.

MATERIALS AND METHODS
A field experiment is conducted in randomized block design, consists of seven treatments with three replications at Agricultural Research Farm, Lovely Professional University, Jalandhar, Punjab during kharif season of year 2016. The
treatments were T1 (Control), T2 (100% Recommended Dose of NPK), T3 (50% Recommended Dose of NPK + 50% Vermicompost), T4 (100% Vermicompost), T5 (100% Farm Yard Manure), T6 (50% Recommended Dose of NPK + 50% Farm Yard Manure) and T7 (50% Recommended Dose of NPK + 25% FYM + 25% Vermicompost). The site has an average annual temperature of 23.9°C. The maximum precipitation is obtained in month of July, August and September. Inorganic source of NPK were supplied through urea, DAP and MOP. Maize crop is sown on ridges to avoid impact of water logging. So, to make ridges field must be cultivated finely and loosen up to 25 – 30 cm in depth. P3396 high yielding variety of maize was used for cultivation. The crop was sown on June 18, 2016 with seed rate of 20 kg per hectare. The plot size was 2x3 m². The spacing was 60 cm row to row and 22.5 cm plant to plant. Seed was placed at depth of 3 cm. The seed were treated with fungicide captan @ 3 g/kg and insecticide Imidacloprid to protect seed from insects. Different growth parameters were recorded on 30, 60 and 90 days after sowing and yield parameters were recorded at the time of harvesting the crop.

The soil samples of 0-15 cm were collected randomly from field for knowing the initial fertility status of soil. The details about the physico-chemical properties of field were given on Table 1 (Initial). The standard procedure for analysis were used. Statistical analysis was performed by SPSS™ 16 software. SPSS™ 16 was used to know significant level at 95%. The mean followed by different alphabets are significantly different at the p<0.05, according to Duncun’s multiple range test (DMRTC) for separation of means. Critical difference between different variables was calculated to estimate significance treatment mean under the F-test of one way ANOVA.

**Table 1:** Physiochemical properties of soil of experimental field (Initial).

| Physiochemical properties | Content       |
|---------------------------|---------------|
| Sand content (%)          | 75            |
| Silt content (%)          | 10.3          |
| Clay content (%)          | 14.7          |
| Soil texture              | Sandy loam    |
| Soil pH                   | 7.8           |
| Soil Electrical Conductivity (ds/m) | 0.56          |
| Soil Organic carbon (%)   | 0.58          |
| Available Nitrogen (kg ha⁻¹) | 220          |
| Available Phosphorus (kg ha⁻¹) | 16.2         |
| Available Potassium (kg ha⁻¹) | 240          |

The treatment T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) had significantly higher number of green leaves (11.33) followed by T2 (100% Recommended dose of NPK) and T3 (50% Recommended dose of NPK + 50% Vermicompost) which were 10.45 cm and 9.9 cm, respectively. The stem girth of treatment T1 (control) was least, about 7.09 cm. The treatment T6 (50% Recommended dose of NPK + 50% Farm Yard Manure) recorded thicker stem girth followed by T3 (50% Recommended dose of NPK + 50% vermicompost) and least at T1 (control) at 60 DAS. The stem girth at 90 DAS was thicker (12.3 cm) in T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) compared to other treatments as well as control (Table 3). The treatment T2 (100% Recommended dose of NPK), T3 (50% Recommended dose of NPK + 50% Vermicompost), T4 (100% Vermicompost), T5 (100% Farm Yard Manure) and T6 (50% Recommended dose of NPK + 50% Farm Yard Manure) were significantly thicker than control but almost similar to each other. Least stem girth (10.16 cm) was recorded in treatment T6 (50% Recommended dose of NPK + 50% Farm Yard Manure).

**Table 2:** Effect of Integrated Nutrient Management on plant height (cm) of maize at 30, 60 and 90 days after sowing.

| Treatments                        | 30 DAS | 60 DAS | 90 DAS |
|----------------------------------|--------|--------|--------|
| T1 (control)                     | 24.60±0.33 | 123.42±2.76 | 130.25±6.53 |
| T2 (100% Recommended dose of NPK)| 65.72±0.58 | 186.51±4.36 | 195.51±5.66 |
| T3 (50% Recommended dose of NPK + 50% Vermicompost) | 44.39±2.65 | 160.15±5.53 | 166.52±5.96 |
| T4 (100% Vermicompost)           | 44.36±0.76 | 160.06±2.25 | 177.79±6.81 |
| T5 (100% Farm Yard Manure)       | 44.66±2.04 | 153.16±1.33 | 159.2±1.61 |
| T6 (50% Recommended dose of NPK + 50% Farm Yard Manure) | 73.10±1.74 | 194.12±1.11 | 203.34±3.61 |
| T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) | 80.99±0.82 | 233.92±4.36 | 238.47±4.25 |

**RESULTS AND DISCUSSION**

**Plant height (cm)**

The plant height at 30 DAS was maximum under T7 (50% recommended dose of NPK + 25% FYM + 25% Vermicompost) followed by T6 (50% recommended dose of NPK + 50% Farm Yard Manure) with a plant height of 80.99 cm and 73.10 cm, which were 69.62% and 59.88 % higher than control. T1 (control) recorded lowest plant height (24.60 cm) as compared to rest of the treatment combinations. Similar trend were observed at 60 DAS and 90 DAS showing 47.23% and 45.38 % higher plants height in treatment T7, than control (Table 2).

**Stem girth (g)**

The stem girth at 30 DAS was thicker in T2 (100% Recommended dose of NPK) and T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) which were 10.45 cm and 9.9 cm, respectively. The stem girth of treatment T1 (control) was least, about 7.09 cm. The treatment T6 (50% Recommended dose of NPK + 50% Farm Yard Manure) recorded thicker stem girth followed by T3 (50% Recommended dose of NPK + 50% vermicompost) and least at T1 (control) at 60 DAS. The stem girth at 90 DAS was thicker (12.3 cm) in T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) compared to other treatments as well as control (Table 3). The treatment T2 (100% Recommended dose of NPK), T3 (50% Recommended dose of NPK + 50% Vermicompost), T4 (100% Vermicompost), T5 (100% Farm Yard Manure) and T6 (50% Recommended dose of NPK + 50% Farm Yard Manure) were significantly thicker than control but almost similar to each other. Least stem girth (10.16 cm) was recorded in treatment T6 (50% Recommended dose of NPK + 50% Farm Yard Manure).

Stem girth plays an important role in ease of transportation of product of photosynthesis, minerals and water. Wider the stem girth will result in higher ease to transportation through xylem and phloem. The vermicompost gives better plant growth due to presence of growth hormones, enzymes and other secretion of earthworms which stimulates the development and growth of plant.

**Number of green leaves**

The treatment T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) had significantly higher number of green leaves (11.33) followed by T2 (100% Recommended dose of NPK).
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Recommended dose of NPK) with mean value 10.22. T1 (control) has least number of green leaves (6.86) than other treatments. The treatment T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) had 39.45 % more number of green leaves than control. Treatment T2 (100% Recommended dose of NPK) had 32.87% more green leaves than control.

At 60 days after sowing it was found that treatment T2 (100% Recommended dose of NPK) and treatment T6 (50% Recommended dose of NPK + 50% Farm Yard Manure) were significantly better than control. It was followed by T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) and T5 (100% Farm Yard Manure). Least number of green leaves were recorded in control (12.55). The treatment T2 (100% Recommended dose of NPK) had 15.55 mean green leaves, which is 19.29 % higher than control. The treatment T6 (50% Recommended dose of NPK + 50% Farm Yard Manure) had 16.10 green leaves, which is 22.04% higher than control.

Number of internodes

At 90 days after sowing the plants had less number of green leaves than 60 days after sowing. The treatment T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) and T2 (100% Recommended dose of NPK) were higher mean number of green leaves of 10.33 and 9.99, respectively. Control has least number of green leaves (6.99). The treatment T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has 32.33 % more number of green leaves than control. The treatment T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost), T4 (100% Vermicompost) and T2 (100% Recommended dose of NPK) were similar to each other and significantly higher than control (Table 4).

Humic acid is present in vermicompost which improves morphological traits of the plant. It also increases the plant height. Albayrak and Camas (2005) was found that humic acid increases leaf expansion and leaf area index. Slow availability of nitrogen through FYM and vermicompost for longer period helps the plants to have higher number of green leaves.
The number of cobs per plant found that most of the plants have one fully developed cob and one immature cob. In some case, there were two fully developed cobs. The treatment T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has highest number of cobs per plant, mean value (1.33). Vermicompost and FYM provides nitrogen for longer period it result in same number of cobs.

Cob length

It was found that treatment T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has higher cob length (Table 7). Higher the cob length will result in higher grain yield. The combination of FYM, vermicompost and inorganic sources gives better result. It proves that if integrated nutrient management is performed in field, quantitative and qualitative needs of maize crop can be meet. Inorganic source provides quick nitrogen to the plant, when it needs in abundance amount. Otherwise, organic sources like FYM and vermicompost provides nutrients on slow basis. Loss through leaching by inorganic sources can be reduced. By using organic source such as vermicompost, with inorganic sources, it has positive result on assimilates remobilization. With integrated nutrient management, nutrition is balanced and adequate supply of photosynthesis is there for development of sink (Sujatha, 2008).

### Table 6: Effect of different level of organic and mineral fertilizers on number of cobs per plant of maize.

| Treatments                                           | No. of cobs per plant |
|------------------------------------------------------|-----------------------|
| T1 (control)                                         | 1±0                   |
| T2 (100% Recommended dose of NPK)                     | 1±0                   |
| T3 (50% Recommended dose of NPK + 50% Vermicompost)  | 1±0                   |
| T4 (100% Vermicompost)                               | 1±0                   |
| T5 (100% Farm Yard Manure)                           | 1±0                   |
| T6 (50% Recommended dose of NPK + 50% Farm Yard Manure) | 1±0                   |
| T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) | 1.33±0               |

### Table 7: Effect of different level of organic and mineral fertilizers on cob length of maize (cm).

| Treatments                                           | Cob length |
|------------------------------------------------------|------------|
| T1 (control)                                         | 10.10±0.05 |
| T2 (100% Recommended dose of NPK)                     | 14.02±0.24 |
| T3 (50% Recommended dose of NPK + 50% Vermicompost)  | 12.83±0.09 |
| T4 (100% Vermicompost)                               | 13.81±0.7  |
| T5 (100% Farm Yard Manure)                           | 13.1±0.14  |
| T6 (50% Recommended dose of NPK + 50% Farm Yard Manure) | 15.33±0.5  |
| T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) | 15.72±0.63 |

### Table 8: Effect of different level of organic and mineral fertilizers on number of grains per cob of maize.

| Treatments                                           | Grains per cob |
|------------------------------------------------------|----------------|
| T1 (control)                                         | 230.77±4.61    |
| T2 (100% Recommended dose of NPK)                     | 363.65±17.11   |
| T3 (50% Recommended dose of NPK + 50% Vermicompost)  | 331.22±10.4    |
| T4 (100% Vermicompost)                               | 339.11±10.96   |
| T5 (100% Farm Yard Manure)                           | 330.44±1.23    |
| T6 (50% Recommended dose of NPK + 50% Farm Yard Manure) | 381.22±15.8    |
| T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) | 459±15.53     |

**Number of grains per cob**

The treatment T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has higher number of grains in single cob. It has 459 grains in single cob, which is 49.72% higher number than control. It was followed by treatment T6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T2 (Recommended dose of NPK) with grains number 381.22 and 363, respectively (Table 8).

The field is treated with combination of all available resources. In this case vermicompost, FYM and inorganic source resulted in more number of grains per cob. The FYM when applied in combination to inorganic also had significant results.

**Test weight**

It was found that treatment T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has higher test weight (Table 9). It was similar to treatment T2 (Recommended dose of NPK), T6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T4 (100% Vermicompost). This result proves that grain size and grain weight is not much affected by different sources. Vermicompost when applied in full dose, it has no impact on test weight. Also, FYM when used in combination has good results.
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Table 9: Effect of different level of organic and mineral fertilizers on test weight (g) (1000 grains).

| Treatments                                      | Test weight |
|-----------------------------------------------|-------------|
| T1 (control)                                  | 192c±8.32   |
| T2 (100% Recommended dose of NPK)             | 214.33ab±1.2|
| T3 (50% Recommended dose of NPK + 50% Vermicompost) | 197c±5.68   |
| T4 (100% Vermicompost)                        | 205.33abc±2.6|
| T5 (100% Farm Yard Manure)                    | 204.67bc±2.02|
| T6 (50% Recommended dose of NPK + 50% Farm Yard Manure) | 213.33ab±1.66|
| T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) | 219a±3.05   |

Table 10: Effect of different level of organic and mineral fertilizers on grain yield of maize (kg ha
-1).

| Treatments                                      | Kg ha
-1 |
|-----------------------------------------------|------|
| T1 (control)                                  | 1183f±317  |
| T2 (100% Recommended dose of NPK)             | 4983b±217  |
| T3 (50% Recommended dose of NPK + 50% Vermicompost) | 2433e±233  |
| T4 (100% Vermicompost)                        | 3317d±133  |
| T5 (100% Farm Yard Manure)                    | 3500d±167  |
| T6 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) | 4250c±450  |
| T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) | 5400a±67   |

Grain yield

The treatment T7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has higher grain yield as compared to control as well as rest of the treatments (Table 10). The higher cob length, more number of grains per cob and more grains per plant results in higher grain yield. Inorganic source provide NPK in good amount and other micronutrients as well as macro nutrients were fulfilled by vermicompost and FYM.

The vermicompost plays an important role in supplying the easily assimilated micro and macronutrients to plant and transporting the unavailable nutrients into available form. The FYM is applied with inorganic sources, it provides higher uptake of NPK. Increased mineralization of nitrogen and constant release of N due to higher transformation process in FYM. Similar result was found by Choudhary and Jat (2006). Vermicompost and FYM indirectly improves the physical condition of soil and provides better aeration to plant roots and helps in the absorption of water (Manivannan, 2009).

CONCLUSION

Integrated use of FYM, vermicompost and chemical fertilizer (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) was found to be the most suitable dose to be adopted as it given significantly higher performance in growth parameters (plant height, stem girth, number of green leaves and number of internodes), yield attributes (cobs per plant, cob length and grains per cob) and yield aspects (test weight and grain yield).

The cultivation of maize under agro-climatic condition of Punjab with combined application of FYM, vermicompost and chemical fertilizer (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) will achieve higher productivity and best choice of sources for integrated nutrient management.

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