Impact of Organic, Inorganic and Biofertilizers on Crop Yield and N, P and K Uptake under Rainfed Maize-Wheat Cropping System

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Abstract

Integrated effect of organic, inorganic and biofertilizers on crop yield and N, P and K uptake under rainfed maize-wheat cropping system and available nutrients during 2015-2016 is being studied in sandy loam at Jammu under the INM maize-wheat trial. The results revealed that the application of recommended levels of NPK to maize-wheat with FYM, VC and biofertilizers (Azotobacter and phosphate solubilizing bacteria) resulted in grain 66.53 per cent and straw 13.00 per cent increase over control in maize and wheat yields, respectively. Increasing levels of 50% N + recom. P + K + S + Zn + B + Vermicompost + Azotobacteria + Phosphorus Solubilizing Bacteria significantly increased the yield of both the crops. Integrated use of organic, inorganic and biofertilizers improved the soil status of available N, P, K, S, (116.09, 14.22, 124.61, 9.41kg ha⁻¹), Zn and B (0.56 and 0.48mg kg⁻¹), over the initial values. A declining trend (N 70.05, P 9.14, K110.13, S 8.14 kg ha⁻¹ Zn 0.36 mg kg⁻¹ and 0.34 kg ha⁻¹) from the initial value of available nutrients. Increasing level of total uptake in maize N, P, K, S, Zn and B. This indicates a considerable mining of INM from the soil and suggest the need to adopt judicious organic, inorganic and biofertilizers.

Keywords
Maize-wheat cropping system, Integrated nutrient management, Crop yield and Nutrient uptake

Introduction

Rain fed agriculture contributes 58% of global food basket and constitutes 66% of the net sown area in India. Site specific nutrient management has received considerable attention due to potential benefits of increasing input use efficiency, improving economic margins of crop production and reducing environmental risks. Hence, a comprehensive understanding of spatial variability of soil properties is becoming increasingly essential in agriculture as soil properties vary from field to a large region scale and are influenced by geology, topography climate as well. The Kandi belt consisting of sub mountainous area of Jammu region arising from Punjab plains with gentle
slope of nearly three degrees and touching with low hilly Siwalik system of rocks lies in the outer Himalayas of Jammu region. The soils of this region are of lithosols type having undulated topography and scrub forest. Loss of organic matter, whether by erosion or high temperature in the rainfed agro-ecosystem, adds to improvement of soil resources of several elements essential for plants growth. A decline in organic matter multiplies nutrient deficiency, it falls by the two-thirds symbolizes a serious suppression in nutrient availability. In addition, fertilizer consumption in rainfed areas is very low. The challenge of improving productivity in rainfed areas can be addressed by efficient utilization of available nutrients. Efficient nutrient management demands understanding the pathways of nutrient losses through gaseous loss, leaching loss, erosion and runoff losses and developing technologies to minimize these losses. Many water-soluble nutrients are lost through run off during intense rainfall and nutrients absorbed on the surface of soil particles-clays and silts and soil organic matter are lost when the top soil is eroded by water or wind. These losses of nutrients are not merely economic losses but may cause serious environmental problems and hence must be controlled by developing appropriate site-specific technologies. The native available nutrients should be optimally allocated among the crops to get maximum returns by allowing optimization of nutrient production functions which relate the crop responses to applied nutrients under given soil, climate, and management factors under rainfed conditions. To avoid any risk, the fertilizer recommendation in the rainfed region should be made only in the linear response range. Fertilizer allocation to crops based on soil test and crop correlation under rainfed condition for achieving targeted yield can help in improving nutrient use efficiency by crops. The yield targets can be decided based on availability of water other inputs and financial condition of the farmer depending on the inherent particular nutrient status of the soils (Sharma et al., 2017).

Materials and Methods

The present investigation is a part of an ongoing experiment with maize-wheat cropping system in progress since kharif and rabi 2015 and 2016 at Advance center for rainfed Agriculture Rakh Dhainsar, SKUAST-Jammu and Department of Soil Science and Agricultural Chemistry, Chatha, Jammu Jammu and Kashmir (32°39’ N and 74°58’ E). Dhainsar, Jammu has a sub-tropical climate with a characteristic feature dry and cold winter. In winter season i.e. Oct to March the temperature 2 to 20 0c and the relative humidity 41 to 65%. Generally, dry and warm weather prevails during the months of March to June. The temperature in the month of May reaches as high as 48 0C. Monsoon season extends from first of July to mid-September. Total annual rainfall varies from 1049.2 mm to 1304 mm with the mean value of around mm. The length of growing period of both the crops ranges from 200 to 210 days. The soil of the experimental field is sandy loam in texture having pH (6.67), Bulk density(1.64 Mg m-3), Water holding capacity (11.01%), Cation exchange capacity (8.14 C mol(p+) (kg-1)), organic carbon 2.05 g kg-1 and available nitrogen (N) (70 kg ha-1), Phosphorus (P) (9.14), Potassium (K) 110.13 kg ha-1 were, Sulphur (S) (8.14 kg ha-1) and Zinc (Zn) (0.36 mg kg-1), Boron (B) (0.34 mg kg-1), respectively. There were eleven treatments viz., T1, Control, T2. Recommended NPK, T3 Reco. NPK+ S + Zn + B, T4 50% N + Reco. P + K + S + Zn + B + 50% N through FYM, T5 50%N + Reco. P + K + S + Zn + B + 50% N through VC, T6 75% N + Reco. P + K + S + Zn + B + 25% N through FYM, T7 75% N + Reco. P + K + S + Zn + B + 25% N through VC, T8 50% N + Reco. P + K + S + Zn + B + 50% N through FYM, T9 50% N + Reco. P + K + S + Zn + B + 25% N through VC, T10 50% N + Reco. P + K + S + Zn + B + 25% N through VC, T11 50% N + Reco. P + K + S + Zn + B + 25% N through VC.
FYM + Azot + PSB, T9 50% N + Reco. P + K + S + Zn + B+ 50% N through VC + Azot + PSB, T10 75% N + Reco. P + K + S, Zn + B+ 25% N through FYM + Azot + PSB, T11 75% N + Reco. P + K + S, Zn + B+ 25% N through VC + Azot + PSB. Each treatment was replicated thrice in a randomized block design. The recommended P, K, S, Zn and B doses, based on initial soil test, were 70.05 kg ha\(^{-1}\), 9.14 kg ha\(^{-1}\), 110.13 kg ha\(^{-1}\), 8.14 kg ha\(^{-1}\), 0.36 mg kg\(^{-1}\), 0.34 mg kg\(^{-1}\), kg ha\(^{-1}\), maize and wheat. The sources of N through FYM and VC were incorporated treatment. (Sowing time) in the soil sowing time of maize and wheat during kharif and rabi season since 2015-16. Treatments T8, T9, T10 and T11 involved inoculation by Azotobacter and PSB culture (@ 5g kg\(^{-1}\) seed). Maize-wheat varieties used were Vivak Maize-25 and PBW-175 respectively, maize in general was sown on the set of monsoon (third week of July) as rainfed crop during kharif and wheat in the to fourth week of October as irrigation crop during rabi. The maturity and yield data were recorded after harvested at maturity and yield data were recorded after threshing. Soil samples from 0-15 cm depth were collected after harvest of maize in the 2th cropping year (2015-16 and 2017) and were analyzed for available N by alkaline permanganate method (Subbiah and Asija, 1956), available P (Olsen et al., 1954) and available K (ammonium acetate extract). All observations were recorded for both the crops and soil properties were analyzed statistically.

1. Grain yield (kg ha\(^{-1}\)) =

Yield obtained from net plot (kg) × 10,000

Area of net plot

2. Nutrient uptake (kg ha\(^{-1}\)) =

Nutrient content (%) × dry matter accumulation (kg ha\(^{-1}\))

Results and Discussion

The highest grain and straw yield of maize during 2015-16 was recorded in T\(_9\) (28.51) to lowest in T\(_1\) (17.12) and T\(_9\) (87.90) and lowest in T\(_1\) (77.79). The higher yield under T\(_9\) might be due to faster mineralization of VC and beneficial effects of Azotobacter and PSB application for seed treatment might be due to balanced addition of NPK, N, P, K, S, Zn, B under T\(_2\) (24.23) and T\(_3\) (25.63) and integrated effect of organic, inorganic and biofertilizer which enhanced nutrients availability and resulted improvement grain yield in T\(_3\) (26.54) and T\(_3\) (27.87). These observations are in line with those reported by Khandre et al., 2015. Beneficial effects of Azotobacter and PSB application in wheat and have been reported by Singh and Prasad 2011, Madhu et al., 2012 also obtained similar observation. However low yield in T\(_1\) could be due to scanty availability of nutrients which resulted lead to lower yield in both years.

The grain and straw yield of wheat found significantly highest in T\(_9\) (19.90) to lowest in T\(_1\) (8.03) and T\(_9\) (37.95) to lowest in T\(_1\) (18.62). It might be due to speedy mineralization of vermicompost and potential role of azotobacter and PSB. Whereas lowest grain yield in T\(_1\) (8.03) could be due to less availability of nutrients. Khandare et al., 2015 reported similar increases in grain yield due to Azotobacter and PSB application in combination with organic and inorganic and might be due to balanced addition of NPK and integrated uses of organic, inorganic and biofertilizers which influenced the availability of nutrients resulted in continuous improvement in grain yield of wheat. These observations are similar to those reported by Thakur et al., (2011).

The highest uptake of N in grain and straw uptake of maize was found in T\(_9\) (49.95) to lowest in T\(_1\) (22.05) and straw of maize was
observed in T\(_9\) (51.20) and lowest in T\(_1\) (23.23) it might be due to balanced addition of NPK, N, P, K, S, Zn, B and combined uses of organics, inorganics and biofertilizers which directly add the nutrient and solubilized native form of nutrient. These observations were supported by Thangasamy et al., (2017) and Mishra et al., (2008) while studying N uptake in maize-wheat cropping system. However, N uptake under treatment T\(_3\), T\(_4\), T\(_5\), T\(_7\), T\(_8\) and T\(_11\) were observed at par to each other. It may be due to poor mineralization of N in soil resulted low uptake. These findings supported by Thangasamy et al., (2017). The highest total uptake of N in grain plus straw of maize was recorded in T\(_9\)(101.15) to lowest in T\(_1\)(45.28). The highest to uptake of total N in grain plus straw might be due to combined addition of organic (VC) inorganic and biofertilizer which contributes nitrogen as well as solubilized native form of nutrient from soil. However, lowest uptake of N in grain plus straw may be due to scanty amount of N in the treatment (Chaterjee et al., 2017).

The highest N uptake in grain yield of wheat was obtained in T\(_9\)(17.82) to lowest in T\(_1\)(8.99) and The highest total N uptake in grain plus straw of wheat was found in T\(_9\)(51.02) and lowest in T\(_1\)(21.39). The highest total N uptake in grain plus straw might be due to integrated addition of organic, inorganic and biofertilizers which enhanced N availability in soil other by increased N uptake. Similar finding was also reported by Biswas et al., (2017).

The highest P uptake in grain yield of maize was observed in T\(_9\) (12.93) to lowest in T\(_1\)(5.19) and The highest P uptake in straw yield of maize has been observed in T\(_9\)(17.30) to lowest in T\(_1\)(12.89). The total P uptake in grain plus straw yield of maize had been observed highest in T\(_9\)(30.23) and lowest in T\(_1\)(18.08), The highest P uptake in grain plus straw in T\(_9\) due to combined addition of organic, inorganic and biofertilizer including VC and PSB which directly add the same nutrient as well as influenced its availability by solubilizing native form in soils thereby enhanced P uptake. These results support the observation of Thangasamy et al., (2017).

The highest P uptake in grain yield of wheat was observed in T\(_9\)(17.82) to lowest in T\(_1\)(8.99) and The highest P uptake in straw yield of wheat was noticed in T\(_9\)(33.20) to lowest in T\(_1\)(12.40) The highest P uptake in grain plus straw in wheat was recorded in T\(_9\)(51.02) to lowest in T\(_1\)(21.39). The highest P uptake in grain plus straw in T\(_9\)(51.02) might be due to combined addition of organic, inorganic and biofertilizers including Azotobacter, PSB which directly adds and influenced its availability thereby resulted increased uptake. Whereas, lowest P uptake in T\(_1\)(21.39) can be due to its low availability, thereby decreased its uptake. These observations are in agreement with those reported by Thangasamy et al., (2017), Chesti et al., (2013).

The highest P uptake in grain yield of maize was observed in T\(_9\) (17.82) to lowest in T\(_1\)(5.19) The highest P uptake in straw yield of maize has been observed in T\(_9\)(17.30) and lowest in T\(_1\)(12.89), The total P uptake in grain plus straw yield of maize had been observed highest in T\(_9\)(30.23) and lowest in T\(_1\)(18.08), The highest P uptake in grain plus straw in T\(_9\) due to combined addition of organic, inorganic and biofertilizer including VC and PSB which directly add the same nutrient as well as influenced its availability by solubilizing native form in soils thereby enhanced P uptake. These results support the observation of Thangasamy et al., (2017).

The highest P uptake in grain yield of wheat was observed in T\(_9\)(17.82) to lowest in T\(_1\)(8.99) and The highest P uptake in straw
yield of wheat was noticed in T₀ (33.20) to lowest in T₁ (12.40) The highest P uptake in grain plus straw in wheat was recorded in T₀ (51.02) to lowest in T₁ (21.39).

The highest P uptake in grain plus straw in T₀ (51.02) might be due to combined addition of organic, inorganic and biofertilizers including Azotobacter, PSB which directly adds and influenced its availability thereby resulted increased uptake. Whereas, lowest P uptake in T₁ (21.39) can be due to its low availability, thereby decreased its uptake. These observations are in agreement with those reported by Thangasamy et al., 2017, Chesti et al., 2013. The highest total K uptake in grain plus straw of maize was noticed in T₉ (128.80) to lowest in T₁ (92.36) and the highest K uptake in grain yield of wheat was observed in T₀ (55.02) and lowest in T₁ (20.85).

The total K uptake in grain plus straw was highest in T₀ (177.62) and lowest in T₁ (74.83) The highest K uptake in grain yield of maize and wheat may be due to integrated addition of organic, inorganic and biofertilizers which influenced its availability in soil (Fig. 1–5 and Table 1–8).

Table 1 Integrated effect of inorganic, organic and biofertilizers on grain and straw yield (q ha⁻¹) after harvesting of maize crop

| Sr.No | Treatments                                                                 | I¹ year  | II² year | Overall | I¹ year | II² year | Overall |
|-------|----------------------------------------------------------------------------|----------|----------|---------|---------|----------|---------|
|       |                                                                            | (q ha⁻¹) | (q ha⁻¹) | (q ha⁻¹) | (q ha⁻¹) | (q ha⁻¹) | (q ha⁻¹) |
| T1    | Control                                                                    | 17.12    | 18.25    | 17.69   | 77.79   | 80.86    | 79.33   |
| T2    | Recommended NPK                                                            | 24.23    | 25.13    | 24.68   | 79.12   | 83.29    | 81.21   |
| T3    | Reco. NPK+S + Zn + B                                                      | 25.63    | 26.34    | 25.99   | 84.74   | 86.38    | 85.56   |
| T4    | 50% N + Reco. P + K + S + Zn + B + 50% N through FYM                      | 25.50    | 26.74    | 26.12   | 84.90   | 86.25    | 85.58   |
| T5    | 50% N + Reco. P + K + S + Zn + B + 50% N through VC                       | 26.54    | 27.46    | 27.00   | 85.62   | 88.49    | 87.06   |
| T6    | 75% N + Reco. P+ K +S +Zn + B+50% N through FYM                          | 25.50    | 26.74    | 26.12   | 83.58   | 84.38    | 83.98   |
| T7    | 75% N + Reco. P +K +S +Zn +B+25% N through VC                            | 25.99    | 27.29    | 26.64   | 83.44   | 85.24    | 84.34   |
| T8    | 50% N+ Reco. P+ K +S +Zn + B +50% N through FYM +Azot +PSB               | 27.87    | 28.66    | 28.27   | 86.33   | 89.03    | 87.68   |
| T9    | 50% N + Reco. P +K +S +Zn +B+ 50% N through VC + Azot + PSB               | 28.51    | 29.35    | 28.93   | 87.90   | 89.86    | 88.88   |
| T10   | 75%N+Reco.P +K +S +Zn+ B+ 25% N through FYM +Azot +PSB                   | 27.56    | 28.53    | 28.05   | 85.21   | 85.60    | 86.41   |
| T11   | 75% N + Reco. P + K +S, Zn + B+ 25% N through VC + Azot +PSB              | 27.16    | 27.47    | 27.32   | 85.95   | 86.92    | 86.44   |
|       | ± S.E.(m)                                                                  | 0.23     | 0.23     | 0.14    | 0.35    | 0.39     | 0.57    |
|       | C.D. (P=0.05)                                                              | 0.67     | 0.70     | 0.45    | 1.04    | 1.18     | 1.81    |
Table 2 Integrated effect of inorganic, organic and biofertilizers on grain and straw yield (q ha\(^{-1}\)) after harvesting of wheat crop

| Sr.No | Treatments | I\(^{\text{st}}\) year | II\(^{\text{nd}}\) year | Overall | I\(^{\text{st}}\) year | II\(^{\text{nd}}\) year | Overall |
|-------|------------|----------------|----------------|---------|----------------|----------------|---------|
|       |            | (q ha\(^{-1}\)) | (q ha\(^{-1}\)) |         | (q ha\(^{-1}\)) | (q ha\(^{-1}\)) |         |
| T1    | Control    | 7.31           | 8.03           | 7.67    | 18.62          | 20.29          | 19.46    |
| T2    | Recommended NPK | 13.78         | 14.61         | 14.20    | 24.89          | 31.36          | 28.13    |
| T3    | Reco. NPK + S + Zn + B | 14.76         | 15.63         | 15.20    | 31.05          | 34.19          | 32.62    |
| T4    | 50% N + Reco. P + K + S + Zn + B + 50% N through FYM | 15.29         | 16.40         | 15.85    | 34.20          | 35.59          | 34.90    |
| T5    | 50% N + Reco. P + K + S + Zn + B + 50% N through VC | 16.63         | 17.25         | 17.19    | 37.04          | 36.20          | 36.62    |
| T6    | 75% N + Reco. P + K + S + Zn + B + 25% N through FYM | 14.47         | 15.68         | 15.08    | 37.07          | 34.89          | 35.98    |
| T7    | 75% N + Reco. P + K + S + Zn + B + 25% N through VC | 14.87         | 15.96         | 15.42    | 37.95          | 37.01          | 37.48    |
| T8    | 50% N + Reco. P + K + S + Zn + B + 50% N through FYM + Azot + PSB | 17.45         | 18.50         | 17.98    | 37.27          | 38.75          | 38.01    |
| T9    | 50% N + Reco. P + K + S + Zn + B + 50% N through VC + Azot + PSB | 19.04         | 19.90         | 19.47    | 38.00          | 40.39          | 39.20    |
| T10   | 75% N + Reco. P + K + S + Zn + B + 25% N through FYM + Azot + PSB | 14.24         | 15.38         | 14.63    | 35.50          | 37.43          | 36.47    |
| T11   | 75% N + Reco. P + K + S, Zn + B + 25% N through VC + Azot + PSB | 15.02         | 16.23         | 15.63    | 37.37          | 39.84          | 38.61    |

± S.E.(m) 0.34 0.32 0.09 1.90 0.38 1.24
C.D. (P=0.05) 1.01 0.95 0.27 6.06 1.13 3.96
Table 3: Integrated effect of inorganic, organic and biofertilizers on nitrogen uptake (kg ha\(^{-1}\)) in grain, straw and total uptake after harvesting of maize crop

| Sr.No | Treatments | Grain (I\(^{st}\) year) (kg ha\(^{-1}\)) | Straw (I\(^{st}\) year) (kg ha\(^{-1}\)) | Total uptake | Grain (II\(^{nd}\) year) (kg ha\(^{-1}\)) | Straw (II\(^{nd}\) year) (kg ha\(^{-1}\)) | Total uptake |
|-------|------------|-------------------------------------|-------------------------------------|-------------|-------------------------------------|-------------------------------------|-------------|
| T1    | Control    | 22.05 23.23 45.28                  | 24.39 23.72 48.11                  | 22.05 23.23 |
| T2    | Recommended NPK | 33.51 23.99 57.50 | 35.55 26.09 61.64 | 33.51 23.99 |
| T3    | Reco. NPK+ S + Zn + B | 41.60 32.17 73.77 | 43.29 33.35 76.64 | 41.60 32.17 |
| T4    | 50% N + Reco. P + K + S + Zn + B + 50% N through FYM | 45.78 39.67 85.45 | 48.63 40.99 89.62 | 45.78 39.67 |
| T5    | 50% N + Reco. P + K + S + Zn + B + 50% N through VC | 47.95 45.85 93.80 | 48.87 48.31 97.18 | 47.95 45.85 |
| T6    | 75% N + Reco. P+ K +S +Zn + B+25% N through FYM | 44.88 40.88 85.76 | 46.63 42.06 88.89 | 44.88 40.88 |
| T7    | 75% N + Reco. P +K +S +Zn +B+25% N through VC | 46.57 44.03 90.60 | 47.56 51.19 98.75 | 46.57 44.03 |
| T8    | 50% N+ Reco. P+K+S+Zn+B+ 50% N through FYM +Azot +PSB | 45.89 47.23 93.12 | 47.51 51.82 99.33 | 45.89 47.23 |
| T9    | 50% N+ Reco. P+K+S+Zn+B+ 50% N through VC +Azot +PSB | 49.95 51.20 101.15 | 50.67 53.12 103.79 | 49.95 51.20 |
| T10   | 75% N+Reco.P+K+S+Zn+B+ 25% N through FYM +Azot +PSB | 42.51 43.85 86.36 | 46.49 47.08 93.57 | 42.51 43.85 |
| T11   | 75% N + Reco. P +K+S, Zn + B+ 25% N through VC + Azot +PSB | 47.25 47.16 94.41 | 47.21 49.83 97.04 | 47.25 47.16 |
|       | ± S.E.(m)  | 0.88 1.07 1.95 | 0.69 0.77 1.45 | 0.88 1.07 |
|       | C.D. (P=0.05) | 2.62 3.16 5.77 | 2.03 2.28 4.30 | 2.62 3.16 |
Table 4 Integrated effect of inorganic, organic and biofertilizers on nitrogen uptake (kg ha\(^{-1}\)) in grain, straw and total uptake after harvesting of wheat crop

| Sr.No | Treatments                                                                 | Grain (I\(^{st}\) year) | Straw (I\(^{st}\) year) | Total uptake | Grain (II\(^{nd}\) year) | Straw (II\(^{nd}\) year) | Total uptake |
|-------|----------------------------------------------------------------------------|--------------------------|--------------------------|--------------|--------------------------|--------------------------|--------------|
|       |                                                                            | (kg ha\(^{-1}\))        | (kg ha\(^{-1}\))        |              | (kg ha\(^{-1}\))        | (kg ha\(^{-1}\))        |              |
| T1    | Control                                                                    | 8.99                     | 12.40                    | 21.39        | 8.38                     | 13.71                    | 22.09        |
| T2    | Recommended NPK                                                            | 14.42                    | 23.74                    | 38.16        | 13.97                    | 25.13                    | 39.1         |
| T3    | Reco. NPK + S + Zn + B                                                     | 15.84                    | 25.82                    | 41.66        | 15.57                    | 27.19                    | 42.76        |
| T4    | 50% N + Reco. P + K + S + Zn + B + 50% N through FYM                       | 17.16                    | 27.05                    | 44.21        | 17.65                    | 28.92                    | 46.57        |
|       |                                                                            |                          |                          |              |                          |                          |              |
| T5    | 50% N + Reco. P + K + S + Zn + B + 50% N through VC                         | 16.30                    | 29.54                    | 45.84        | 18.09                    | 30.82                    | 48.91        |
| T6    | 75% N + Reco. P + K + S + Zn + B + 50% N through FYM                       | 15.70                    | 24.02                    | 39.72        | 16.11                    | 26.95                    | 43.06        |
| T7    | 75% N + Reco. P + K + S + Zn + B + 50% N through VC                         | 17.40                    | 26.02                    | 43.42        | 17.42                    | 27.82                    | 45.24        |
| T8    | 50% N + Reco. P + K + S + Zn + B + 50% N through FYM + Azot + PSB           | 17.82                    | 30.69                    | 49.94        | 18.36                    | 32.87                    | 51.23        |
| T9    | 50% N + Reco. P + K + S + Zn + B + 50% N through VC + Azot + PSB            | 19.25                    | 33.20                    | 52.45        | 19.74                    | 34.83                    | 52.57        |
| T10   | 75% N + Reco. P + K + S + Zn + B + 25% N through FYM + Azot + PSB           | 17.35                    | 24.65                    | 42.00        | 16.66                    | 26.76                    | 43.42        |
| T11   | 75% N + Reco. P + K + S, Zn + B + 25% N through VC + Azot + PSB             | 17.35                    | 24.65                    | 42.00        | 16.66                    | 26.76                    | 43.42        |
|       | ± S.E.(m)                                                                  | 0.23                     | 0.71                     | 0.94         | 0.77                     | 0.59                     | 1.37         |
|       | C.D. (P=0.05)                                                              | 16.82                    | 25.91                    | 42.73        | 17.51                    | 28.07                    | 45.58        |
### Table 5
Integrated effect of inorganic, organic and biofertilizers on phosphorus uptake (kg ha\(^{-1}\)) in grain, straw and total uptake after harvesting of maize

| Sr.No | Treatments                                                                 | Grain (I\(^{st}\) year) | Straw (I\(^{st}\) year) | Total uptake | Grain (II\(^{nd}\) year) | Straw (II\(^{nd}\) year) | Total uptake |
|-------|----------------------------------------------------------------------------|--------------------------|--------------------------|--------------|--------------------------|--------------------------|--------------|
| T1    | Control                                                                    | 5.19                     | 12.89                    | 18.08        | 5.96                     | 13.75                    | 19.71        |
| T2    | Recommended NPK                                                            | 7.84                     | 13.27                    | 21.11        | 8.80                     | 14.27                    | 23.07        |
| T3    | Reco. NPK + S + Zn + B                                                     | 8.12                     | 16.90                    | 25.02        | 9.48                     | 17.42                    | 26.90        |
| T4    | 50% N + Reco. P + K + S + Zn + B + 50% N through FYM                       | 10.36                    | 15.91                    | 26.27        | 11.54                    | 16.30                    | 27.84        |
| T5    | 50% N + Reco. P + K + S + Zn + B + 50% N through VC                         | 12.23                    | 16.09                    | 28.32        | 12.67                    | 16.10                    | 28.77        |
| T6    | 75% N + Reco. P + K + S + Zn + B + 25% N through FYM                       | 10.57                    | 16.49                    | 27.06        | 11.56                    | 17.19                    | 28.75        |
| T7    | 75% N + Reco. P + K + S + Zn + B + 25% N through VC                         | 10.21                    | 17.19                    | 27.40        | 11.22                    | 18.87                    | 30.09        |
| T8    | 50% N + Reco. P + K + S + Zn + B + 50% N through VC + Azot + PSB            | 11.71                    | 16.19                    | 27.90        | 13.12                    | 17.67                    | 30.79        |
| T9    | 50% N + Reco. P + K + S + Zn + B + 50% N through VC + Azot + PSB            | 12.93                    | 17.30                    | 30.23        | 12.52                    | 18.43                    | 30.95        |
| T10   | 75% N + Reco. P + K + S + Zn + B + 25% N through VC + Azot + PSB            | 12.31                    | 15.40                    | 27.71        | 12.56                    | 16.07                    | 28.63        |
| T11   | 75% N + Reco. P + K + S, Zn + B + 25% N through VC + Azot + PSB             | 11.59                    | 12.89                    | 24.48        | 11.82                    | 13.75                    | 25.57        |

± S.E.(m) | 0.24 | 1.13 | 1.35 | 0.28 | 0.83 | 1.16 | 0.24 | 1.13

C.D. (P=0.05) | 0.71 | 0.38 | 1.09 | 0.81 | 0.30 | 1.11 | 0.71 | 0.38
Table 6 Integrated effect of inorganic, organic and biofertilizers on phosphorus uptake (kg ha\(^{-1}\)) in grain, straw and total uptake after harvesting of wheat

| Sr.No | Treatments | Grain (I\(^{st}\) year) | Straw (I\(^{st}\) year) | Total uptake | Grain (II\(^{nd}\) year) | Straw (II\(^{nd}\) year) | Total uptake |
|-------|------------|--------------------------|--------------------------|--------------|--------------------------|--------------------------|--------------|
| T1    | Control    | 8.99                     | 12.40                    | 21.39        | 8.38                     | 22.09                    | 8.99         |
| T2    | Recommended NPK | 14.42                    | 23.74                    | 38.16        | 13.97                    | 25.13                    | 14.42        |
| T3    | Reco. NPK+ S + Zn + B | 15.84                    | 25.82                    | 41.66        | 15.57                    | 27.19                    | 15.84        |
| T4    | 50% N + Reco. P + K + S + Zn + B + 50% N through FYM | 17.16                    | 27.05                    | 44.21        | 17.65                    | 28.92                    | 17.16        |
| T5    | 50% N + Reco. P + K + S + Zn + B + 50% N through VC | 16.30                    | 29.54                    | 45.84        | 18.09                    | 30.82                    | 16.30        |
| T6    | 75% N + Reco. P + K + S + Zn + B + 25% N through FYM | 15.70                    | 24.02                    | 39.72        | 16.11                    | 26.95                    | 15.70        |
| T7    | 75% N + Reco. P + K + S + Zn + B + 25% N through VC | 17.40                    | 26.02                    | 43.42        | 17.42                    | 27.82                    | 17.40        |
| T8    | 50% N+ Reco. P + K + S + Zn + B + 50% N through FYM + Azot + PSB | 19.25                    | 30.69                    | 49.94        | 18.36                    | 32.87                    | 19.25        |
| T9    | 50% N + Reco. P + K + S + Zn + B + 50% N through VC + Azot + PSB | 17.82                    | 33.20                    | 50.12        | 17.74                    | 34.83                    | 17.82        |
| T10   | 75%N+Reco.P + K + S + Zn + B+ 25% N through FYM + Azot + PSB | 17.35                    | 24.65                    | 42.00        | 16.66                    | 26.76                    | 17.35        |
| T11   | 75% N + Reco. P + K + S, Zn + B+ 25% N through VC + Azot + PSB | 17.35                    | 24.65                    | 42.00        | 16.66                    | 26.76                    | 17.35        |

± S.E.(m) 0.23 0.71 0.94 0.77 0.59 1.37 0.23 0.71
C.D. (P=0.05) 16.82 25.91 42.73 17.51 28.07 45.58 16.82 25.91
**Table 7** Integrated effect of inorganic, organic and biofertilizers on potassium uptake (kg ha\(^{-1}\)) in grain, straw and total uptake after harvesting of maize

| Sr.No | Treatments                                                                 | Grain (I\(^{st}\) year) | Straw (I\(^{st}\) year) | Total uptake | Grain (II\(^{nd}\) year) | Straw (II\(^{nd}\) year) | Total uptake |
|-------|---------------------------------------------------------------------------|--------------------------|--------------------------|-------------|--------------------------|--------------------------|-------------|
|       |                                                                           | (kg ha\(^{-1}\))        | (kg ha\(^{-1}\))        | (kg ha\(^{-1}\)) | (kg ha\(^{-1}\))        | (kg ha\(^{-1}\))        | (kg ha\(^{-1}\)) |
| T1    | Control                                                                   | 4.72                     | 87.64                    | 92.36        | 4.93                     | 90.03                    | 94.96       | 4.72        |
| T2    | Recommended NPK                                                           | 6.92                     | 95.20                    | 102.12       | 7.89                     | 93.98                    | 101.87      | 6.92        |
| T3    | Reco. NPK+S+Zn+B                                                          | 8.37                     | 97.99                    | 106.36       | 10.03                    | 99.91                    | 109.94      | 8.37        |
| T4    | 50% N + Reco. P + K + S + Zn + B + 50% N through FYM                     | 11.55                    | 99.03                    | 110.58       | 11.97                    | 100.87                   | 112.84      | 11.55       |
| T5    | 50% N + Reco. P + K + S + Zn + B + 50% N through VC                       | 12.44                    | 103.31                   | 115.75       | 12.39                    | 106.64                   | 119.03      | 12.44       |
| T6    | 75% N + Reco. P + K + S + Zn + B + 25% N through FYM                      | 12.21                    | 100.12                   | 112.33       | 12.07                    | 104.64                   | 116.71      | 12.21       |
| T7    | 75% N + Reco. P + K + S + Zn + B + 25% N through VC                       | 12.20                    | 105.82                   | 118.02       | 12.52                    | 109.71                   | 122.23      | 12.20       |
| T8    | 75% N + Reco. P + K + S + Zn + B + 50% N through FYM + Azot + PSB         | 13.34                    | 108.41                   | 121.75       | 12.97                    | 110.53                   | 123.50      | 13.34       |
| T9    | 75% N + Reco. P + K + S + Zn + B + 25% N through VC + Azot + PSB          | 14.26                    | 114.54                   | 128.8        | 14.99                    | 115.13                   | 130.12      | 14.26       |
| T10   | 75% N + Reco. P + K + S + Zn + B + 25% N through FYM + Azot + PSB         | 12.40                    | 107.72                   | 120.12       | 12.86                    | 108.36                   | 121.22      | 12.40       |
| T11   | 75% N + Reco. P + K + S, Zn + B + 25% N through VC + Azot + PSB           | 12.87                    | 108.52                   | 121.39       | 13.42                    | 109.57                   | 122.99      | 12.87       |
|       | ± S.E.(m)                                                                 | 0.32                     | 1.78                     | 2.09         | 0.49                     | 1.81                     | 2.30        | 0.32        |
|       | C.D. (P=0.05)                                                             | 0.95                     | 5.26                     | 6.21         | 1.02                     | 5.38                     | 6.40        | 0.95        |

2556
Table 8: Integrated effect of inorganic, organic and biofertilizers on potassium uptake (kg ha\(^{-1}\)) in grain, straw and total uptake after harvesting of wheat

| Sr. No | Treatments                                                                 | Grain (I\(^\text{st}\) year) | Straw (I\(^\text{st}\) year) | Total uptake | Grain (II\(^\text{nd}\) year) | Straw (II\(^\text{nd}\) year) | Total uptake |
|--------|-----------------------------------------------------------------------------|-------------------------------|-------------------------------|--------------|-------------------------------|-------------------------------|--------------|
|        |                                                                             | (kg ha\(^{-1}\))             | (kg ha\(^{-1}\))             |              | (kg ha\(^{-1}\))             | (kg ha\(^{-1}\))             |              |
| T1     | Control                                                                     | 20.85                         | 53.98                         | 74.83        | 23.04                         | 58.02                         | 81.06        |
| T2     | Recommended NPK                                                             | 39.25                         | 88.31                         | 127.56       | 42.23                         | 90.09                         | 132.32       |
| T3     | Reco. NPK + S + Zn + B                                                     | 42.15                         | 99.14                         | 141.29       | 44.99                         | 98.93                         | 143.92       |
| T4     | 50% N + Reco. P + K + S + Zn + B + 50% N through FYM                       | 47.57                         | 112.58                        | 160.15       | 50.79                         | 108.92                        | 159.71       |
| T5     | 50% N + Reco. P + K + S + Zn + B + 50% N through VC                         | 49.57                         | 119.68                        | 169.25       | 52.03                         | 118.27                        | 170.30       |
| T6     | 75% N + Reco. P + K + S + Zn + B + 25% N through FYM                        | 41.92                         | 104.15                        | 146.07       | 47.80                         | 104.56                        | 152.36       |
| T7     | 75% N + Reco. P + K + S + Zn + B + 25% N through VC                         | 45.6                          | 118.6                         | 164.2        | 46.86                         | 113.12                        | 159.98       |
| T8     | 50% N + Reco. P + K + S + Zn + B + 50% N through FYM + Azot + PSB           | 54.3                          | 116.97                        | 171.27       | 57.99                         | 117.39                        | 175.38       |
| T9     | 50% N + Reco. P + K + S + Zn + B + 50% N through VC + Azot + PSB            | 55.02                         | 122.6                         | 177.62       | 60.74                         | 126.81                        | 187.55       |
| T10    | 75% N + Reco. P + K + S + Zn + B + 25% N through FYM + Azot + PSB           | 42.35                         | 104.26                        | 146.61       | 45.17                         | 110.56                        | 155.73       |
| T11    | 75% N + Reco. P + K + S, Zn + B + 25% N through VC + Azot + PSB             | 43.43                         | 110.11                        | 153.54       | 48.25                         | 108.20                        | 156.45       |
|        | ± S.E.(m)                                                                   | 1.22                          | 1.93                          | 3.16         | 0.97                          | 1.73                          | 2.69         |
|        | C.D. (P=0.05)                                                               | 3.61                          | 5.76                          | 9.37         | 2.87                          | 5.13                          | 8.00         |
Fig.1 Integrated effect of inorganic, organic and biofertilizers on N uptake (kg ha\(^{-1}\)) of maize-wheat cropping system during 2015-16 and 2016-17
Fig. 2 Integrated effect of inorganic, organic and biofertilizers on P uptake (kg ha\(^{-1}\)) of maize-wheat cropping system during 2015-16 and 2016-17.
Fig. 3 Integrated effect of inorganic, organic and biofertilizers on K uptake (kg ha\(^{-1}\)) of maize-wheat cropping system during 2015-16 and 2016-17
Fig. 4 Integrated effect of inorganic, organic and biofertilizers on grain and straw yield (q ha\textsuperscript{-1}) of maize crop during 2015-16.
Fig. 5 Integrated effect of inorganic, organic and biofertilizers on grain and straw yield (q ha⁻¹) of wheat crop during 2016-17

Whereas, lowest K uptake in T₁ (20.85) might be due to scanty availability of K thereby results decreased its uptake, could be due to balanced application of N P K, N, P, K, S, Zn, B and mixed uses of organic, inorganic and biofertilizers which directly influenced the availability of K in soils thereby increased K uptake in all the treatments. These results are line with those reported by Chesti et al., (2013), Khandare et al., (2015) and Thangasamy et al., (2017).

In conclusion, the result of the study concluded with respect to the grain and straw yield of maize influenced significantly due to integration of organic, inorganic and biofertilizers. The values of nutrients uptake viz, N, P, K, S, Zn, B observed highest under T₉ consisting integrated uses of organic, inorganic and biofertilizers.

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