# Studies on Influence of Organic Sources on Growth and Yield of Maize in Maize-Cowpea Cropping Sequence

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ABSTRACT

A field experiment was conducted at research and demonstration block of Research Institute on Organic Farming, UAS, GKVK, Bengaluru during 2020-21 to study the influence of organic sources on growth and yield of maize in maize-cowpea cropping sequence. The experiment was laid out in factorial randomised block design with three replications. The experiment consists of 15 treatment combinations of three levels of N equivalent and five organic sources along with absolute control and UAS-B package. The experimental soil was red sandy loam having low organic carbon (0.45 %) and medium in N (289.4 kg ha$^{-1}$), $P_2O_5$ (28.6 kg ha$^{-1}$) and $K_2O$ (235.2 kg ha$^{-1}$) content. The experimental results indicated that application of bio-compost at 125 % N equivalent resulted in higher plant height (221.5 cm), leaf area (7949 cm$^2$ plant$^{-1}$), total dry matter accumulation (201.1 g plant$^{-1}$) and kernel (107.47 q ha$^{-1}$) and stover yield of maize (154.60 q ha$^{-1}$) followed by poultry manure at 125 per cent N equivalent and found significantly superior over other treatments in the studies. However, UAS-B package (150:75:40 kg N: $P_2O_5$: $K_2O$ ha$^{-1}$) recorded significantly higher plant height (229.9 cm), leaf area (8197 cm$^2$ plant$^{-1}$), total dry matter accumulation (213.6 g plant$^{-1}$) and kernel (111.96 q ha$^{-1}$) and stover yield (161.13 q ha$^{-1}$) and was on par with application of bio-compost at 125 per cent N equivalent.

*Keywords* : Maize-cowpea cropping sequence, Organic sources, Bio-compost, Poultry manure, N equivalent

MAIZE (*Zea mays* L) is one of the most versatile crops grown throughout the tropical as well as temperate regions of the world. Globally, maize is known as 'Queen of cereals' because it has the highest genetic yield potential among the cereals. In India, it is cultivated in an area of 9.56 million hectare with a production 28.76 million tonnes and productivity of 3006 kg ha$^{-1}$.Karnataka alone contributes 14.88 per cent of the total maize production with an area of 1.42 million hectare and production of 4.4 million tonnes (Anonymous, 2021). About 85 per cent of the maize produced is consumed as human food and animal feed including poultry. Maize-cowpea cropping system has several advantages, such as improves of soil fertility, increase soil organic carbon (SOC), humus content, nitrogen and phosphorus availability, suppress weed growth through smothering effects, increase production per unit area, enhance land use efficiency, reduce runoff and soil loss, etc. Inclusion of legume provides sustainability to non-legume cereal component by enriching soil fertility and increasing system productivity and returns. Pulses are considered the key crops for intensification of rice and maize-fallows due to their short-duration, hardy and low-input requiring nature, hence offers a tremendous opportunity to utilize residual soil moisture and nutrients.

Over the years, health of Indian soils has deteriorated resulting in decline of organic carbon content, soil biodiversity and soil physico-chemical properties and build-up of multi-nutrient deficiencies over large area due to reduction in addition of organic manures, imbalanced use of fertilisers and mono cropping. It is reported that plant nutrient removal from soils by different crops annually is 10-12 million tonnes higher than addition from various sources, resulting in negative nutrient balance. Considering these disadvantages and escalation of fertiliser costs there is a paradigm shift from inorganic to organic farming. To sustain soil health addition of organic matter as source of nutrients is pivotal and in such situation organic agriculture plays a crucial role in Indian farming. Organic agriculture is a production system which avoids or largely excludes the use of synthetically compounded fertilisers, pesticides, growth regulators and livestock feed additives. To the maximum extent possible, organic farming system relies on crop rotations, crop residues, animal manures, legumes, green manures, on-farm organic wastes and aspects of biological pest control to maintain soil productivity and health. Keeping these points in view, the investigation was carried out at UAS, GKVK, Bengaluru to study the influence of organic sources on growth and yield of maize in maize-cowpea cropping sequence.

## Material and Methods

Field experiment was conducted at organic farming research and demonstration block of Research Institute on Organic Farming (RIOF), Gandhi Krishi Vignan Kendra (GKVK), University of Agricultural Sciences, Bangalore. It is situated in Eastern Dry Zone of Karnataka at latitude of 13° 09' North, longitude of 77° 57' East and an altitude of 924 m above mean sea level (MSL). Studies were conducted to know the influence of organic sources on growth and yield of maize during summer 2020 and to assess the residual effect on growth and yield of cowpea during *kharif* 2020 and the same sequence was followed during *rabi* 2020 and summer 2021. The experiment consists of 15 treatment combinations of three levels of N equivalent ($N_1$: 75 % N equivalent; $N_2$: 100 % N equivalent and $N_3$: 125 % N equivalent) and five organic sources [$F_1$: Farm Yard Manure; $F_2$: Bio compost; $F_3$: Vermicompost; $F_4$: Poultry Manure (pre cured); $F_5$: Jeevamrutha] along with absolute control and UAS-B package was laid out in factorial randomised block design with three replications. The experimental soil was red sandy loam with initial organic carbon content of of 0.45 per cent, medium in N (289.4 kg ha$^{-1}$), $P_2O_5$ (28.6 kg ha$^{-1}$) and $K_2O$ (235.2 kg ha$^{-1}$) content. The average rainfall received during crop growth period was 331.5 mm. The nutrient composition of organic manures used in the experiment is presented in Table 1.

Table 1

Nutrient composition of organic manures

| Organic manures | N (%) | $P_2O_5$ (%) | $K_2O$ (%) |
|---|---|---|---|
| Farm yard manure | 0.98 | 0.71 | 0.78 |
| Bio-compost | 2.03 | 1.57 | 1.84 |
| Vermicompost | 1.20 | 0.70 | 0.80 |
| Poultry manure | 2.23 | 1.77 | 0.57 |
| Jeevamrutha | 0.71 | 0.48 | 0.30 |

Maize hybrid MAH-14-5 was sown with a spacing of 60 x 30 cm and followed agronomic practices for raising crop. Nutrient sources *viz.,* bio-compost, poultry manure, vermicompost, farm yard manure and jeevamrutha were applied on N equivalent basis after analysing the nutrient content. Application of 10 t FYM ha$^{-1}$ is common for all the treatments as per package of practice except absolute control. Half the dose of N was supplied as basal through organic sources and remaining 50 per cent of recommended N was supplemented through jeevamrutha in equal splits at 30 and 60 DAS. Neem oil (10 ml l$^{-1}$) spray was taken against fall army worm in maize as and when noticed. Manual weeding at two times (at 20 and 45 DAS) and earthing up (at 30 DAS) were practiced to maintain weed free condition. Cowpea crop (KBC 9) was sown after harvesting maize at a spacing of 45 x 10 cm and crop was raised without application of organic nutrient sources following crop management practices. Neem oil (10 ml l$^{-1}$) was sprayed to control aphid infestation in cowpea during crop growth stages.

Biometric observations on growth parameters were recorded randomly on selected five plants at 30, 60, 90 days after sowing and at harvest in the net plot. Data related to yield was recorded at the time of harvest of the crop. Based on the observations, data were subjected to statistical analysis as per the procedure outlined by Gomez and Gomez (1984). To know the effect of individual factors and to compare treatment combinations with control treatments, statistical procedure of factorial randomised complete block design and randomised complete block design were followed, respectively.

## RESULTS AND DISCUSSION

### Plant Height (cm)

The pooled data of two seasons pertaining to plant height at different growth stages of maize as influenced by application of organic sources in maize-cowpea cropping sequence is presented in Table 2. Plant height of maize varied significantly at 30, 60, 90 DAS and at harvest as influenced by organic sources. Application of organic sources at 125 per cent N equivalent recorded significantly higher plant height (42.5, 110.2, 176.6 and 188.2 cm at 30, 60, 90 DAS and at harvest, respectively) followed by 100 per cent N equivalent (33.5, 86.4, 139.4 and 148.5 cm at 30, 60, 90 DAS and at harvest, respectively) and 75 per cent N equivalent (26.1, 67.0, 108.5 and 115.6 cm at 30, 60, 90 DAS and at harvest, respectively). Among organic sources, application of bio-compost resulted significantly higher plant height (39.9, 103.1, 166.0 and 176.9 cm at 30, 60, 90 DAS and at harvest, respectively), followed by poultry manure (36.5, 94.3, 151.8 and 161.7 cm at 30, 60, 90 DAS and at harvest, respectively), vermicompost (33.1, 85.6, 137.9 and 146.9 cm at 30, 60, 90 DAS and at harvest, respectively) and jeevamrutha (31.0, 80.1, 128.9 and 137.4 cm at 30, 60, 90 DAS and at harvest, respectively) and lower plant height was recorded in farm yard manure (29.5, 76.3, 122.9 and 130.9 cm at 30, 60, 90 DAS and at harvest, respectively) applied plots.

Interaction effect between organic sources and levels of nitrogen was found to be significant. Application of bio-compost at 125 per cent N equivalent recorded higher plant height (50.0, 129.7, 207.9 and 221.5 cm at 30, 60, 90 DAS and at harvest, respectively) which was on par with UAS-B package *i.e.*, 150:75:40 kg N: $P_2O_5$: $K_2O$ $ha^{-1}$ (51.9, 134.6, 215.8 and 229.9 cm at 30, 60, 90 DAS and at harvest, respectively). Lower plant height was observed in absolute control plot of no application of organic manures (21.4, 55.6, 87.2 and 90.3 cm at 30, 60, 90 DAS and at harvest, respectively). Bio-compost contains higher amount of nutrients and addition of jeevamrutha as top dress has enhanced in nutrient release from organic sources. Jeevamrutha is a rich source of beneficial microorganisms and contains growth promoting

TABLE 2

Plant height (cm) of maize at different growth stages as influenced by organic sources (pooled data of two seasons)

| Treatments | 30 DAS | 60 DAS | 90 DAS | At harvest |
|---|---|---|---|---|
| **Nitrogen equivalent levels (N)** | | | | |
| $N_1$ - 75 % N equivalent | 26.1 | 67.0 | 108.5 | 115.6 |
| $N_2$ - 100 % N equivalent | 33.5 | 86.4 | 139.4 | 148.5 |
| $N_3$ - 125 % N equivalent | 42.5 | 110.2 | 176.6 | 188.2 |
| S. Em ± | 0.60 | 1.55 | 2.48 | 2.65 |
| C.D. (p=0.05) | 1.69 | 4.38 | 7.03 | 7.49 |
| **Organic sources (F)** | | | | |
| $F_1$ – Farmyard manure | 29.5 | 76.3 | 122.9 | 130.9 |
| $F_2$ – Bio-compost | 39.9 | 103.1 | 166.0 | 176.9 |
| $F_3$ - Vermicompost | 33.1 | 85.6 | 137.9 | 146.9 |
| $F_4$ – Poultry manure | 36.5 | 94.3 | 151.8 | 161.7 |
| $F_5$ - Jeevamrutha | 31.0 | 80.1 | 128.9 | 137.4 |
| S. Em ± | 0.77 | 2.00 | 3.21 | 3.42 |
| C.D. (p=0.05) | 2.19 | 5.66 | 9.08 | 9.67 |
| **Interaction (NxF)** | | | | |
| $N_1F_1$ | 22.5 | 57.9 | 93.8 | 99.9 |
| $N_1F_2$ | 30.5 | 78.3 | 126.7 | 135.0 |
| $N_1F_3$ | 26.0 | 66.7 | 108.0 | 115.1 |
| $N_1F_4$ | 27.8 | 71.5 | 115.8 | 123.3 |
| $N_1F_5$ | 23.6 | 60.7 | 98.3 | 104.8 |
| $N_2F_1$ | 29.1 | 75.0 | 121.0 | 128.9 |
| $N_2F_2$ | 39.3 | 101.4 | 163.4 | 174.1 |
| $N_2F_3$ | 32.8 | 84.5 | 136.3 | 145.2 |
| $N_2F_4$ | 35.9 | 92.6 | 149.3 | 159.1 |
| $N_2F_5$ | 30.5 | 78.7 | 126.9 | 135.2 |
| $N_3F_1$ | 37.0 | 96.1 | 153.9 | 164.0 |
| $N_3F_2$ | 50.0 | 129.7 | 207.9 | 221.5 |
| $N_3F_3$ | 40.7 | 105.7 | 169.4 | 180.5 |
| $N_3F_4$ | 45.7 | 118.7 | 190.2 | 202.6 |
| $N_3F_5$ | 38.9 | 100.9 | 161.7 | 172.2 |
| $T_{16}$ | 21.4 | 55.6 | 87.2 | 90.3 |
| $T_{17}$ | 51.9 | 134.6 | 215.8 | 229.9 |
| S. Em ± 1.34 | 3.47 | 5.56 | 5.93 | |
| C.D. (p=0.05) | 3.78 | 9.79 | 15.71 | 16.74 |

substances such as auxins, gibberlins, cytokinins apart from having lower concentration of both macro and micro nutrients. This is in conformity with Devakumar *et al*. (2008 and 2011).

**Leaf Area (cm$^2$ plant$^{-1}$)**

Leaf area of maize differed significantly due to influence of organic sources in maize-cowpea cropping sequence (Table 3). Significantly higher leaf area was recorded with application of 125 per cent N equivalent (2480, 5407, 6895 and 6201 cm$^2$ plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) followed by 100 per cent N equivalent (1682, 3666, 4675 and 4204 cm$^2$ plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) and lower leaf area was observed in 75 per cent N equivalent (1371, 2990, 3813 and 3429 cm$^2$ plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively). Among organic sources, bio-compost application recorded significantly higher leaf area (2256, 4918, 6272 and 5640 cm$^2$ plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) followed by poultry manure (1950, 4251, 5421 and 4875 cm$^2$ plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) and found significantly superior over other treatments. However, lower leaf area of maize was recorded with application of farm yard manure (1560, 3400, 4336 and 3899 cm$^2$ plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively).

Interaction effect between organic sources and levels of nitrogen was found to be significant for leaf area. Application of bio-compost at 125 per cent N equivalent recorded higher leaf area (3180, 6932, 8840 and 7949 cm$^2$ plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) which was on par with UAS-B package *i.e.*, 150:75:40 kg N: $P_2O_5$: $K_2O$ ha$^{-1}$ (3279, 7148, 9115 and 8197 cm$^2$ plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively). Lower leaf area was recorded in absolute control plot (1091, 2378, 3033 and 2728 cm$^2$ plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively). Increased availability of nutrients in soil due to mineralization of organic nutrient sources could have triggered cell elongation and multiplication resulting in high growth rate of shoot in turn increase in leaf area of maize compared to control. The results are in line with Ashwini *et al.* (2015).

TABLE 3

Leaf area (cm 2 plant-1) of maize at different growth stages as influenced by organic sources (pooled data of two seasons)

| Treatments | 30 DAS | 60 DAS | 90 DAS | At harvest |
|---|---|---|---|---|
| **Nitrogen equivalent levels (N)** | | | | |
| N1 - 75 % N equivalent | 1371 | 2990 | 3813 | 3429 |
| N2 - 100 % N equivalent | 1682 | 3666 | 4675 | 4204 |
| N3 - 125 % N equivalent | 2480 | 5407 | 6895 | 6201 |
| S. Em ± | 58 | 126 | 161 | 145 |
| C.D. (p=0.05) | 164 | 357 | 456 | 410 |
| **Organic sources (F)** | | | | |
| F1 - Farmyard manure | 1560 | 3400 | 4336 | 3899 |
| F2 - Bio-compost | 2256 | 4918 | 6272 | 5640 |
| F3 - Vermicompost | 1835 | 4001 | 5102 | 4588 |
| F4 - Poultry manure | 1950 | 4251 | 5421 | 4875 |
| F5 - Jeevamrutha | 1621 | 3535 | 4507 | 4053 |
| S. Em± | 75 | 163 | 208 | 187 |
| C.D. (p=0.05) | 212 | 461 | 588 | 529 |
| **Interaction (NxF)** | | | | |
| N1F1 | 1174 | 2560 | 3265 | 2936 |
| N1F2 | 1629 | 3552 | 4530 | 4074 |
| N1F3 | 1383 | 3015 | 3844 | 3457 |
| N1F4 | 1455 | 3173 | 4046 | 3639 |
| N1F5 | 1215 | 2648 | 3377 | 3037 |
| N2F1 | 1504 | 3279 | 4182 | 3761 |
| N2F2 | 1959 | 4271 | 5447 | 4898 |
| N2F3 | 1659 | 3618 | 4613 | 4149 |
| N2F4 | 1823 | 3973 | 5067 | 4556 |
| N2F5 | 1463 | 3190 | 4068 | 3658 |
| N3F1 | 2000 | 4360 | 5560 | 5000 |
| N3F2 | 3180 | 6932 | 8840 | 7949 |
| N3F3 | 2463 | 5370 | 6848 | 6158 |
| N3F4 | 2572 | 5607 | 7151 | 6430 |
| N3F5 | 2186 | 4766 | 6077 | 5465 |
| T16 | 1091 | 2378 | 3033 | 2728 |
| T17 | 3279 | 7148 | 9115 | 8197 |
| S. Em ± | 153 | 333 | 425 | 382 |
| C.D. (p=0.05) | 432 | 941 | 1200 | 1079 |

**Total Dry Matter Accumulation (g plant$^{-1}$)**

Significantly higher total dry matter accumulation of maize (Table 4) was recorded with application of organic sources at 125 per cent N equivalent (8.15, 72.1, 118.1 and 150.7 g plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) followed by 100 per cent N equivalent (5.32, 48.1, 77.1 and 98.4 g plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) and 75 per cent N equivalent (4.10, 36.9, 59.5 and 75.9 g plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively). Significantly higher dry matter accumulation of maize was recorded in bio-compost applied plot (7.27, 65.0, 105.5 and 134.6 g plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) and was found to be statistically superior over poultry manure (6.48, 58.0, 94.0 and 119.9 g plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively), vermicompost (5.86, 52.4, 85.0 and 108.5 g plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively), jeevamrutha (5.09, 45.5, 73.7 and 94.1 g plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) and farm yard manure (4.57, 40.9, 66.3 and 84.6 g plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively).

Dry matter accumulation was found to be significant for the interaction between nitrogen equivalent levels and organic sources. Bio-compost application at 125 per cent N equivalent resulted significantly higher dry matter accumulation (10.87, 96.2, 157.6 and 201.1 g plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) compared to other treatments and was on par with UAS-B package *i.e.*, 150:75:40 kg N: $P_2O_5$: $K_2O$ ha$^{-1}$ (11.55, 103.5, 167.5 and 213.6 g plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively). Lower dry matter accumulation was observed in absolute control plot of no organic manure application (4.06, 36.5, 58.8 and 75.0 g plant$^{-1}$ at 30, 60, 90 DAS and at harvest, respectively). This is in conformity with Vishwajit and Devakumar (2018). Total dry matter production is a result of dry matter accumulation in plant parts, which depends on uptake of nutrients like N, P and K. Increase in dry matter was mainly due to increase in number of leaves produced per plant and better uptake of nutrients. Application of organic manures and jeevamrutha has increased biological efficiency and greater sink capacity in the crop which might have

TABLE 4

Total dry matter accumulation (g plant-1) of maize at different growth stages as influenced by organic sources (pooled data of two seasons)

| Treatments | 30 DAS | 60 DAS | 90 DAS | At harvest |
|---|---|---|---|---|
| **Nitrogen equivalent levels (N)** | | | | |
| N1 - 75 % N equivalent | 4.10 | 36.9 | 59.5 | 75.9 |
| N2 - 100 % N equivalent | 5.32 | 48.1 | 77.1 | 98.4 |
| N3 - 125 % N equivalent | 8.15 | 72.1 | 118.1 | 150.7 |
| S. Em ± | 0.13 | 1.18 | 1.92 | 2.45 |
| C.D. (p=0.05) | 0.37 | 3.34 | 5.44 | 6.93 |
| **Organic sources (F)** | | | | |
| F1 - Farmyard manure | 4.57 | 40.9 | 66.3 | 84.6 |
| F2 - Bio-compost | 7.27 | 65.0 | 105.5 | 134.6 |
| F3 - Vermicompost | 5.86 | 52.4 | 85.0 | 108.5 |
| F4 - Poultry manure | 6.48 | 58.0 | 94.0 | 119.9 |
| F5 - Jeevamrutha | 5.09 | 45.5 | 73.7 | 94.1 |
| S. Em± | 0.17 | 1.52 | 2.48 | 3.16 |
| C.D. (p=0.05) | 0.48 | 4.31 | 7.02 | 8.95 |
| **Interaction (NxF)** | | | | |
| N1F1 | 3.86 | 34.8 | 56.0 | 71.5 |
| N1F2 | 4.42 | 39.8 | 64.1 | 81.8 |
| N1F3 | 3.74 | 33.6 | 54.2 | 69.1 |
| N1F4 | 4.19 | 37.7 | 60.7 | 77.4 |
| N1F5 | 4.30 | 38.7 | 62.3 | 79.5 |
| N2F1 | 3.28 | 29.7 | 47.6 | 60.8 |
| N2F2 | 6.53 | 59.1 | 94.6 | 120.8 |
| N2F3 | 5.65 | 51.1 | 81.9 | 104.5 |
| N2F4 | 6.18 | 56.0 | 89.7 | 114.4 |
| N2F5 | 4.96 | 44.9 | 71.9 | 91.7 |
| N3F1 | 6.57 | 58.1 | 95.3 | 121.5 |
| N3F2 | 10.87 | 96.2 | 157.6 | 201.1 |
| N3F3 | 8.20 | 72.6 | 119.0 | 151.8 |
| N3F4 | 9.08 | 80.3 | 131.7 | 168.0 |
| N3F5 | 6.01 | 53.1 | 87.1 | 111.1 |
| T16 | 4.06 | 36.5 | 58.8 | 75.0 |
| T17 | 11.55 | 103.5 | 167.5 | 213.6 |
| S. Em ± | 0.29 | 2.60 | 4.21 | 5.37 |
| C.D. (p=0.05) | 0.82 | 7.35 | 11.89 | 15.17 |

helped in higher photosynthetic efficiency and absorption of nutrients (Roopashree *et al.*, 2019).

**Kernel and Stover Yield (q ha$^{-1}$)**

Kernel and stover yield of maize (Table 5) differed significantly due to influence of organic sources in maize-cowpea cropping sequence. Significantly higher kernel and stover yield of maize were obtained with application of 125 per cent N equivalent (89.36 and 129.37 q ha$^{-1}$, respectively) followed by 100 per cent N equivalent (71.22 and 98.28 q ha$^{-1}$, respectively) and lower yield was observed in 75 per cent N equivalent plots (63.19 and 75.23 q ha$^{-1}$, respectively). Among organic sources, application of bio-compost produced higher kernel and stover yield (84.29 and 113.87 q ha$^{-1}$, respectively) followed by poultry manure (79.17 and 106.61 q ha$^{-1}$, respectively), vermicompost (74.10 and 99.47 q ha$^{-1}$, respectively), jeevamrutha (68.06 and 92.95 q ha$^{-1}$, respectively) and lower kernel and stover yield was obtained in farm yard manure (67.34 and 91.90 q ha$^{-1}$, respectively).

Application of bio-compost at 125 per cent N equivalent (107.47 and 154.60 q ha$^{-1}$, respectively) recorded significantly higher kernel and stover yield and was on par with UAS-B package *i.e.*, 150:75:40 kg N: $P_2O_5$: $K_2O$ ha$^{-1}$ (111.96 and 161.13 q ha$^{-1}$, respectively). Lower kernel and stover yield was recorded in absolute control plot wherein no organic manures were applied (25.82 and 30.57 q ha$^{-1}$, respectively). The results are in line with Ananda and Sharanappa (2017). The increase in yield is mainly attributed to higher yield parameters like number of kernel rows, number of kernels per row and test weight. Combined application of manures and jeevamrutha ensure the release of readily available nutrients in adequate quantity to promote early growth as compared to sole organic manuring treatments, in which nutrients are available slowly over a long period of time. Higher growth and yield parameters could be attributed to availability of macronutrients and micronutrients from organic manure, which is very essential for plant growth and development (Boraiah *et al.*, 2017). The lower grain yield due to reduced availability of nutrients for the crop during early growth

TABLE 5

Kernel and stover yield of maize as influenced by organic sources (pooled data of two seasons)

| Treatments | Kernel yield (q ha$^{-1}$) | Stover yield (q ha$^{-1}$) |
|---|---|---|
| **Nitrogen equivalent levels (N)** | | |
| $N_1$ - 75 % N equivalent | 63.19 | 75.23 |
| $N_2$ - 100 % N equivalent | 71.22 | 98.28 |
| $N_3$ - 125 % N equivalent | 89.36 | 129.37 |
| S. Em± | 1.35 | 1.99 |
| C.D. (p=0.05) | 3.83 | 5.63 |
| **Organic sources (F)** | | |
| $F_1$ – Farmyard manure | 67.34 | 91.90 |
| $F_2$ – Bio-compost | 84.29 | 113.87 |
| $F_3$ - Vermicompost | 74.10 | 99.47 |
| $F_4$ – Poultry manure | 79.17 | 106.61 |
| $F_5$ - Jeevamrutha | 68.06 | 92.95 |
| S. Em± | 1.75 | 2.57 |
| C.D. (p=0.05) | 4.95 | 7.27 |
| **Interaction (N x F)** | | |
| $N_1F_1$ | 60.02 | 72.90 |
| $N_1F_2$ | 67.22 | 80.01 |
| $N_1F_3$ | 62.30 | 71.36 |
| $N_1F_4$ | 65.91 | 78.59 |
| $N_1F_5$ | 60.52 | 73.29 |
| $N_2F_1$ | 65.81 | 91.50 |
| $N_2F_2$ | 78.17 | 107.01 |
| $N_2F_3$ | 71.00 | 97.98 |
| $N_2F_4$ | 74.92 | 102.72 |
| $N_2F_5$ | 66.20 | 92.21 |
| $N_3F_1$ | 76.19 | 111.29 |
| $N_3F_2$ | 107.47 | 154.60 |
| $N_3F_3$ | 89.02 | 129.07 |
| $N_3F_4$ | 96.68 | 138.53 |
| $N_3F_5$ | 77.46 | 113.35 |
| $T_{16}$ | 25.82 | 30.57 |
| $T_{17}$ | 111.96 | 161.13 |
| S. Em± 2.88 | 4.28 | |
| C.D. (p=0.05) | 8.14 | 12.07 |

stages (vegetative period) and thus the crop might have starved of nutrients during later stage (reproductive stage), which might have affected the grain and stover yield (Urkurkar *et al.*, 2010).

Based on these studies it could be concluded that application of bio-compost at 125 per cent N equivalent resulted in better growth parameters, yield components and yield of maize and was on par with UAS-B package *i.e.*, application of 150:75:40 kg N: $P_2O_5$: $K_2O$ $ha^{-1}$.

**Available Nitrogen, Phosphorous and Potassium**

Application of organic sources at 125 per cent N equivalent recorded significantly higher available nitrogen (kg $ha^{-1}$), phosphorus (kg $ha^{-1}$) and potassium (kg $ha^{-1}$) in soil (332.83, 34.20 and 237.51 kg $ha^{-1}$, respectively) after harvest of maize (Table 6) followed by 100 per cent N equivalent (309.50, 31.12 and 222.27 kg $ha^{-1}$, respectively) and 75 per cent N equivalent (267.07, 26.99 and 195.26 kg $ha^{-1}$, respectively). Significantly higher available nitrogen, phosphorus and potassium in soil after harvest of maize was recorded in bio-compost applied plot (321.60, 32.88 and 229.69 kg $ha^{-1}$, respectively) and was found to be statistically superior over poultry manure (309.98, 31.65 and 223.37 kg $ha^{-1}$, respectively), vermicompost (302.28, 30.51 and 220.81 kg $ha^{-1}$, respectively), jeevamrutha (292.96, 29.69 and 212.26 kg $ha^{-1}$, respectively) and farm yard manure (288.85, 29.12 and 205.62 kg $ha^{-1}$, respectively).

Available nitrogen, phosphorus and potassium in soil after harvest of maize were found to be significant for the interaction between nitrogen equivalent levels and organic sources. Bio-compost application at 125 per cent N equivalent resulted significantly higher available nitrogen, phosphorus and potassium in soil after harvest of maize (358.44, 36.06 and 246.16 kg $ha^{-1}$, respectively) compared to other treatments and was on par with UAS-B package *i.e.*, 150:75:40 kg N: $P_2O_5$: $K_2O$ $ha^{-1}$ (357.58, 36.56 and 249.36 kg $ha^{-1}$, respectively). Lower available nitrogen, phosphorus and potassium in soil after harvest of maize was observed in absolute control plot (213.33, 22.25 and 153.97 kg $ha^{-1}$, respectively).

Table 6

Available nitrogen, phosphorus and potassium content of soil after harvest of maize as influenced by organic sources (pooled data of two seasons)

| Treatments | Available N (kg $ha^{-1}$) | Available $P_2O_5$ (kg $ha^{-1}$) | Available $K_2O$ (kg $ha^{-1}$) |
|---|---|---|---|
| **Nitrogen levels (N)** | | | |
| $N_1$ | 267.07 | 26.99 | 195.26 |
| $N_2$ | 309.50 | 31.12 | 222.27 |
| $N_3$ | 332.83 | 34.20 | 237.51 |
| S. Em ± | 1.14 | 0.18 | 1.05 |
| C.D. (p=0.05) | 3.22 | 0.50 | 2.96 |
| **Organic sources (F)** | | | |
| $F_1$ | 288.85 | 29.12 | 205.62 |
| $F_2$ | 321.60 | 32.88 | 229.69 |
| $F_3$ | 302.28 | 30.51 | 220.81 |
| $F_4$ | 309.98 | 31.65 | 223.37 |
| $F_5$ | 292.96 | 29.69 | 212.26 |
| S. Em± | 1.47 | 0.23 | 1.35 |
| C.D. (p=0.05) | 4.16 | 0.65 | 3.82 |
| **Interaction (N x F)** | | | |
| $N_1F_1$ | 247.14 | 24.38 | 178.65 |
| $N_1F_2$ | 287.47 | 30.17 | 214.54 |
| $N_1F_3$ | 264.26 | 26.32 | 192.31 |
| $N_1F_4$ | 280.11 | 28.96 | 202.36 |
| $N_1F_5$ | 256.38 | 25.14 | 188.44 |
| $N_2F_1$ | 296.35 | 30.38 | 215.49 |
| $N_2F_2$ | 318.88 | 32.43 | 228.37 |
| $N_2F_3$ | 315.30 | 30.74 | 221.46 |
| $N_2F_4$ | 318.81 | 31.43 | 224.80 |
| $N_2F_5$ | 298.16 | 30.63 | 221.22 |
| $N_3F_1$ | 323.07 | 32.61 | 222.71 |
| $N_3F_2$ | 358.44 | 36.06 | 246.16 |
| $N_3F_3$ | 327.27 | 34.47 | 248.64 |
| $N_3F_4$ | 331.02 | 34.56 | 242.96 |
| $N_3F_5$ | 324.34 | 33.29 | 227.12 |
| $T_{16}$ | 213.33 | 22.25 | 153.97 |
| $T_{17}$ | 357.58 | 36.56 | 249.36 |
| S. Em ± | 3.44 | 0.47 | 2.49 |
| C.D. (p=0.05) | 9.72 | 1.32 | 7.03 |

The reason for increase in available NPK may be due to the effect of different nutrient sources and jeevamrutha that might have increased the activity of beneficial micro-organisms which in turn enhanced the decomposition of organic matter fraction supplied through different organic manures and as a consequence there was higher availability of N, P and K in soil. Increase in available nitrogen in soil was due to mineralization of organic manures by the increased activity of soil micro organisms and reduced nitrogen loss from the soil. Higher available soil phosphorus could be attributed to increased solubility of native phosphorus due to release of organic acid during the decomposition of organic manures. The increase in available potassium might be due to release of potassium from organic sources and solubilisation of mineral bound K or native K (Singh and Chauhan, 2002).

**Nitrogen, Phosphorous and Potassium Uptake**

Nitrogen, Phosphorous and potassium uptake (kg $ha^{-1}$) by maize at harvest differed significantly due to influence of organic sources in maize-cowpea cropping sequence (Table 7). Significantly higher nitrogen, phosphorous and potassium uptake was recorded with application of 125 per cent N equivalent (175.8, 26.79 and 194.2 kg $ha^{-1}$, respectively) followed by 100 per cent N equivalent (114.8, 17.5 and 126.8 kg $ha^{-1}$, respectively) and lower nitrogen, phosphorous and potassium uptake was observed in 75 per cent N equivalent (88.5, 13.49 and 97.8 kg $ha^{-1}$, respectively). Among organic sources, bio-compost application recorded significantly higher nitrogen, phosphorous and potassium uptake (157.0, 23.92 and 173.4 kg $ha^{-1}$, respectively) followed by poultry manure (139.9, 21.32 and 154.6 kg $ha^{-1}$, respectively) and found significantly superior over other treatments. However, lower nitrogen, phosphorous and potassium uptake by maize was recorded with application of farm yard manure (98.7, 15.04 and 109.0 kg $ha^{-1}$, respectively).

The nitrogen, phosphorous and potassium uptake was found to be significant in interaction effect between organic sources and levels of nitrogen. Application of bio-compost at 125 per cent N equivalent recorded

TABLE 7

Nitrogen, phosphorus and potassium uptake by maize at harvest as influenced by organic sources (pooled data of two seasons)

| Treatments | N uptake (kg $ha^{-1}$) | $P_2O_5$ uptake (kg $ha^{-1}$) | $K_2O$ uptake (kg $ha^{-1}$) |
|---|---|---|---|
| **Nitrogen levels (N)** | | | |
| $N_1$ | 88.5 | 13.49 | 97.8 |
| $N_2$ | 114.8 | 17.50 | 126.8 |
| $N_3$ | 175.8 | 26.79 | 194.2 |
| S. Em ± | 2.86 | 0.44 | 3.16 |
| C.D. (p=0.05) | 8.09 | 1.23 | 8.94 |
| **Organic sources (F)** | | | |
| $F_1$ | 98.7 | 15.04 | 109.0 |
| $F_2$ | 157.0 | 23.92 | 173.4 |
| $F_3$ | 126.5 | 19.28 | 139.8 |
| $F_4$ | 139.9 | 21.32 | 154.6 |
| $F_5$ | 109.8 | 16.73 | 121.3 |
| S. Em± | 3.69 | 0.56 | 4.08 |
| C.D. (p=0.05) | 10.44 | 1.59 | 11.54 |
| **Interaction (N x F)** | | | |
| $N_1F_1$ | 83.4 | 12.71 | 92.1 |
| $N_1F_2$ | 95.5 | 14.55 | 105.5 |
| $N_1F_3$ | 80.6 | 12.29 | 89.1 |
| $N_1F_4$ | 90.3 | 13.77 | 99.8 |
| $N_1F_5$ | 92.7 | 14.13 | 102.4 |
| $N_2F_1$ | 70.9 | 10.80 | 78.3 |
| $N_2F_2$ | 140.9 | 21.47 | 155.6 |
| $N_2F_3$ | 121.9 | 18.58 | 134.7 |
| $N_2F_4$ | 133.4 | 20.33 | 147.4 |
| $N_2F_5$ | 107.0 | 16.30 | 118.2 |
| $N_3F_1$ | 141.8 | 21.61 | 156.6 |
| $N_3F_2$ | 234.6 | 35.75 | 259.2 |
| $N_3F_3$ | 177.1 | 26.98 | 195.6 |
| $N_3F_4$ | 196.0 | 29.87 | 216.5 |
| $N_3F_5$ | 129.6 | 19.75 | 143.2 |
| $T_{16}$ | 87.5 | 13.34 | 96.7 |
| $T_{17}$ | 249.2 | 37.98 | 275.4 |
| S. Em ± | 6.27 | 0.95 | 6.92 |
| C.D. (p=0.05) | 17.69 | 2.70 | 19.55 |

higher nitrogen, phosphorous and potassium uptake (234.6, 35.75 and 259.2 kg $ha^{-1}$, respectively) which was on par with UAS-B package *i.e.*, 150:75:40 kg N: $P_2O_5$: $K_2O$ $ha^{-1}$ (249.2, 37.98 and 275.4 kg $ha^{-1}$, respectively). Lower nitrogen, phosphorous and potassium uptake was recorded in absolute control plot (87.5, 13.34 and 96.7 kg $ha^{-1}$, respectively). Increase in uptake of NPK might be due to increased mineralisation, higher nutrient availability and release of nutrients which cope up with crop demand and combined application of organic manures and jeevamrutha acted as slow release nutrient sources. Such property of nutrient sources facilitates greater uptake of nutrients by the crop as reported by Latha and Sharanappa, 2014.

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