Influence of different fertilizers and nematicides on number of nematode galls and yield of okra in summer season in Chitwan, Nepal

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Article Info

ABSTRACT

A field experiment was conducted at the Horticulture Farm of Agriculture and Forestry University, to determine the influence of different fertilizers and nematicides on the number of nematode galls (*Meloidogyne* spp.) and yield of okra (var. Arka Anamika) in summer season in Chitwan, Nepal. This experiment was carried out in a completely randomized block design (RCBD) which includes 7 treatments and 3 replications. The treatment included: goat manure, sesame (til) cake, mustard seed cake, poultry manure, Furacron (carbofuran), vermicompost and untreated control including only chemical fertilizer (NPK). All treatments were added to provide a sufficient amount of nitrogen required for the crop as per the recommendation. The remaining amount of required phosphorous and potassium was supplied by adding single super phosphate and muriate of potash, respectively. All treatments, except poultry manure had significantly superior germination at 7 days after seeding (DAS). Similarly, all treatments compared with control had significantly less gall index at 70 DAS; Furacron had least gall index at both 60DAS and 70DAS. The highest net profit was found in the case of poultry manure while the highest incremental cost-benefit ratio was obtained in Furacron. The highest yield (20 t ha⁻¹) and least number of galls were obtained in poultry manure which was as effective as a Furacron treatment. This experiment suggests the use of either poultry manure or Furacron, both of which will provide higher economic return and decrease the root-knot nematode in okra. However, use of carbofuran has recently been banned in Nepal.

Keywords:

furacron, galls manures, nematode, okra

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench 2n=2x=130) is one of the important fruit vegetable crops majorly grown in tropical and sub-tropical regions. It is popular and grown in Terai, Inner Terai and lower Hills of Nepal as summer vegetable crop (Acharya and Shakya 2004). The various names of okra in English speaking countries are ladies finger, bindi, bamiya, onchro or gumbo and the crop belongs to the flowering plant of the mallow family (Khabdaker et al. 2017). In Nepal, it forms one of the major vegetables and is grown in different parts of country mostly in Makwanpur (22.4 mt ha⁻¹), Lalitpur (20 mt ha⁻¹), Kavre (15.6 mt ha⁻¹), Surkhet (15.7mt ha⁻¹), Dang (14 mt ha⁻¹), Taplejung (14 mt ha⁻¹), Bardia (15 mt ha⁻¹) and Jhapa (14.5 mt ha⁻¹) (MOAD 2016/17). The occurrence of root-knot nematodes (*Meloidogyne* spp.) in Nepal was first reported by Amatya and Shrestha in 1969 on tomato, eggplant, okra and chilly and the nematodes known to infect more than 2000 species of plants (Kafle 2013). The nematode is known to cause irregular growth, reduced and delayed growth with above ground chlorosis, stunting, delayed recovery with improved soil moisture conditions and gall formation below ground (Noling 2009). The affected plant becomes weak and prone to attack by many other disease causing organisms and pests (Kafle 2013). In Chitwan district, nematode reduces yield and quality of okra and other crops because farmers do not apply effective measures on account of their small landholding (Bhardwaj and Hogger, 1984). *Meloidogyne* species are the major damaging nematodes, of them *M. arenaria, M. incognita, M. javanica* and *M. hapla* represent 95% of the nematode species found in cultivated soil (Carneiro et al. 2016). Root-knot nematodes can be
suppressed in various ways: nematicides, soil solarization, fertilizers and manures (Habash and Al-Banna 2011). Animal manures have been used as local fertilizers in many developing countries (Gulshan et al. 2013) and their uses are inevitable practice for sustainable agriculture (Premsekhari and Rajashekar 2009). Some fertilizers and nematicides are known to inhibit hatching of nematode egg and cause complete mortality of 2nd stage juvenile i.e. destructive phase of nematode (Habash and AlBanna 2011). Nematicides are mostly used and known to cause harm in the environment and human health, so effective alternatives are emphasized that do not pollute the environment and effectively control nematode (Pakeerathan et al. 2009). Chicken manure is reported to decrease the number of nematodes (Kaplan and Noe 1993). Likewise, different organic manures could be used to control nematodes and improve soil health. This study aims to study the nematode population under different fertilizers and nematicide treatments and their effect on the yield of okra.

MATERIALS AND METHODS

Experimental Site and design

This experiment was carried out at the Horticultural Farm of Agriculture and Forestry University (AFU) on okra (var. Arka Anamika) from April 7, 2018 to July 2, 2018. The experiment field lies at the geographical location of 27°37′ latitude and 84°25′ longitude and at an altitude of 256 meters above sea level (Thapa and Dongol 1988). Soil type is sandy loam. The okra variety ‘Arka Anamika’, resistant to the yellow vein mosaic virus was used for the experiment. *Brassica oleracea* var. *botrytis* was grown last season in the research field.

The experiment was laid out in a randomized complete block design (RCBD) containing 7 different treatments replicated 3 times. Seeds were sown at spacing 50 cm*30 cm and 2 seeds were placed per planting hole. Ten days after seeding (DAS), they were thinned to maintain a single plant per planting hole. The area for each plot was 2.5m*1.8m (4.5m²) and consisted of 30 plants in each plot. The border was 1m wide around the field and 75cm between the blocks and treatments.

Treatment and Trial Management

There were seven different treatments used in this experiment viz: T1 (Goat manure), T2 (Sesame (til) cake), T3 (Mustard seed cake), T4 (Control) i.e. NPK, T5 (Poultry manure), T6 (Furacron) and T7 (Vermicompost). Seeds were sown 5 days after fertilizer application. The seeds were soaked in water for 24 hours prior to sowing to enhance the germination. Fertilizer was applied on the recommended dose (MOAD 2018) ie. 90:81:27 g NPK per 4.5 m². The recommended dose of nitrogen was fulfilled by respective treatments and the recommended dose of phosphorus and potassium was fulfilled by adding supplements of NPK fertilizers.

The NPK content of different organic fertilizers was determined in the animal science laboratory of AFU. Goat manure contained 3% N, 1% P and 2% K. The recommended level of nitrogen was fulfilled by applying 3 kg of goat manure. Here, the required level of phosphorus was fulfilled by adding 318.75 g single super phosphate (SSP) and potassium level was fulfilled by goat manure itself. Likewise, sesame (til) cake contained 6.61 %N, 2.1%P and 1.1%K. Here, 1.361kg sesame (til) cake was used to meet the nitrogen level. To meet the required dose of phosphorus and potassium, 327.56 g and 20.03 g SSP and muriate of potash (KCl) were used. Mustard seed cake contained 4.52%N, 1.78%P and 1.4%K. Here, 4.52 kg mustard seed cake was used to meet the nitrogen level. To meet the required dose of phosphorus, 284.75 g SSP was used and potassium was fulfilled by mustard seed cake itself. Poultry manure contained 1.2%N, 0.45%P and 0.8%K. Here, 7.5kg poultry manure was used. To meet the phosphorus level, 295.31 g SSP was used and potassium was fulfilled by poultry manure itself. Likewise, vermicompost contained 2.35%N, 1.6%P and 1.5%K. Here, 3.829kg vermicompost was used to meet the nitrogen level. To meet the required dose of phosphorus, 123.25g SSP was used and the potassium level was fulfilled by vermicompost itself. Similarly, Furacron at the rate of 1kg per 508.5 m² with NPK fertilizers was used as one treatment. Furacron (carbofuran 3%) in a granulated form, was used as synthetic nematicide as a part of our treatments.

Data Collection

Data were collected for evaluating the growth and yield parameters by taking 5 sample plants from each plot, excluding the border plants.

Germination

Two seeds were dropped per planting hole and the numbers of the germinated plants were counted at 7 DAS.

Plant height

Plant height was measured in every 10 days starting from 10 DAS and continued upto 60 DAS. It was measured with the help of measuring tape from the crown region to the tip of the plant.

Stem base diameter

The diameter of the stem was measured in every 10 days starting from 20 DAS and continued
upto 60 DAS using Vernier Caliper near the 1st bottom node of the plant.

**Leaf number**

The total number of fully opened leaves was counted in every 10 days starting from 10 DAS and continued till 60 DAS.

**Yield**

Okra fruits were picked every 3 days from 45DAS till 12 pickings. The weight of fruits was taken using weighing balance.

**Galls counting and Gall indexing**

Five plants were uprooted at 60DAS, 70DAS and 80DAS excluding the plants sampled for taking growth and yield parameters. The total number of galls was counted on each uprooted plants.

The gall index was calculated using the root evaluation chart given by Bridge and Page (1980) as cited in Martinez (2014). According to this chart, the root system was ranked from 0-10; 0 = no knots at all, 1 = few small knots which are difficult to find, 2 = clearly visible small knots but the main roots is clean, 3 = presence of some larger knots but the main root is clean, 4 = large knots predominates whereas the main root is clean, 5 = 50% of the root is infested and knotting can be seen on parts of main roots with reduced root system, 6 = knotting on main roots, 7 = majority of the root is knotted, 8 = majority of the root system is knotted and only a few clean roots are visible, 9 =all roots are severely knotted and are in the state of dying, 10 = all roots are severely knotted with no root system and the plant is dying.

**Root number, Root length and Root diameter**

These parameters were taken during the time of uprooting. Root number includes lateral roots and they were counted, too. Root length i.e. tap root was measured with the help of a ruler. Vernier Caliper was used to measure root diameter.

**Statistical Analysis**

The collected data were recorded in MS-excel and analyzed using analysis of variance (ANOVA) to determine if the treatments have any significant differences with each other. The data were analyzed according to One way ANOVA using software R-Stat.

**Economic Analysis**

For the economic analysis, the cost of fertilizers was calculated which included the cost of treatments i.e. cost of fertilizers and their supplements if essence to fulfill the recommend dose. Cost of different fertilizers were: goat manure: $0.05 kg⁻¹, sesame(til) cake: $0.25kg⁻¹, mustard seed cake:$0.30kg⁻¹, poultry manure: $0.05kg⁻¹, vermicompost: $0.17kg⁻¹, urea (nitrogen source): $0.2kg⁻¹, muriate of potash: $0.38kg⁻¹, single super phosphate: $0.18kg⁻¹ and nematicide i.e. Furacron: $1.6kg⁻¹ and the market price of okra: $0.3kg⁻¹. Similarly, the cost of treatments was subtracted from the additional income of respective treatments to find out the net profit. The incremental cost benefit-i was calculated separately for each treatment according to the following formula:

\[
\text{Incremental Cost-Benefit ratio (ICBR)} = \frac{\text{Cost of treatment Net profit} - 1}{\text{Chejara 2013}}
\]

**RESULTS AND DISCUSSION**

**Climatic condition during the Biometric Observation**

National Maize Research Program (NMRP), Rampur, Chitwan provided the required meteorological data of the cropping period. It is located 250m far from the research site. The total rainfall was 385mm during the entire cropping period. The vegetative stage received the least rainfall (35.1mm) i.e. in April and the fruiting period received the highest rainfall (212.2mm) i.e. in June. The maximum temperature ranged from 27.2°C to 38.1°C and the minimum temperature ranged from 27.2°C to 29.8°C (Figure 1).

![Figure 1. Climatic condition during biometric observation](image)

**Effect on seed germination**

The effect of different manures on seed germination was found significant at 5% level of significance among the treatments. However, all treatments except poultry manure were not statistically different (Table 1). Furacron-treated plot had 21.72% more germination than in control (NPK) plot. There was considerably low germination in poultry manure-treated plot (less by 20.43%). That could be due to the high water-absorbent nature causing dryness in the field. Sarma and Gogoi (2015) reported maximum germination in vermicompost.
Effects on number of galls formation

The effect of different types of fertilizers and nematicide on number of galls was found highly significant at 5% level of significance. Each individual plant was found infested by gall. Though Furacron, followed by goat manure, poultry manure, mustard seed cake and sesame (til) seed cake, was seemed to be superior at both 60DAS and 70 DAS its effect was not significantly different with other treatments except vermicompost and control (NPK) at 60 DAS, and control at 70 DAS (Table 2). However, at 80 DAS, the number of galls was found non-significant as the numbers tend to increase and the crop life period was about to complete. After that, there was a decrease in the number of galls as the roots started decaying. Tanimola and Akarekor (2014) also found poultry manure and carbofuran effective to control nematodes.

Effect on the number of leaves, plant height, diameter, root diameter, root length, number of lateral roots and yield of okra

At 10, 20, 30 and 40 DAS, the effect on number of leaves was found non-significant. At 50 and 60 DAS, the effect was significant at 1%, and 0.1% level of significance, respectively (Table 3). The number of leaves was found to be superior in poultry manure followed by vermicompost, Furacron, goat manure, sesame (til) cake, mustard seed cake and control at 50 DAS; and followed by sesame (til) cake, goat manure, Furacron, vermicompost, mustard seed cake and control at 60 DAS.

The plant height was found non-significant at 10, 20, 30 and 40 DAS, and was significant at 50 and 60 DAS (Table 4). At 50 DAS, poultry manure, Furacron, vermicompost and goat manure was found superior followed by sesame (til) cake, mustard seed cake and control at 1% level of significance. At 60 DAS, poultry manure and Furacron were found superior followed by sesame seed cake, vermicompost, goat manure, mustard oilcake and control (NPK) at 5% level of significance. Miglani et al. (2017) also reported similar results, but in their case farm yard manure (not included in our experiment) was found superior to poultry manure.

At 20, 30 and 40 DAS, the plant diameter was found non-significant (Table 5). It was significant at 50 and 60 DAS at 5% level of significance. Poultry manure was found to be superior followed by vermicompost, sesame (til) cake, Furacron, goat manure, mustard seed cake and control at 50 DAS; and followed by goat manure, vermicompost, sesame (til) cake, mustard seed cake, Furacron and control (NPK) at 60 DAS.

Table 1. Effect of different fertilizers on seed germination

| Treatments      | Number of seed germinated 7 DAS | SEM (±) | LSD (0.05) | CV | F-test |
|-----------------|---------------------------------|---------|------------|----|--------|
| Furacron        | 93.33333 ×                     | 4.39    | 16.4       | 11.2|        |
| Goat manure     | 92.66667 ab                    |         |            |    |        |
| Vermicompost    | 86.66667 ab                    |         |            |    |        |
| Sesame (til) cake| 82.66667 ab                    |         |            |    |        |
| Mustard Oilcake | 81.66667 a                     |         |            |    |        |
| Control (NPK)   | 76.66667 ab                    |         |            |    |        |
| Poultry Manure  | 61b                            |         |            |    |        |

Note: Same letter in the means do not differ significantly at p=0.05 by DMRT, SEM= Standard error of mean, LSD= Least significant difference, CV = Coefficient of variation. ×= Significant at 5% level

Table 2. Effect of different fertilizers on number of galls formation

| Treatments      | 60 DAS  | 70 DAS  | 80 DAS  |
|-----------------|---------|---------|---------|
| Furacron        | 2.333333a | 2.866667a | 4.933333 |
| Goat manure     | 2.666667 ab | 3.066667a | 5.133333 |
| Poultry Manure  | 3.333333 ab | 4.266667a | 5.866667 |
| Mustard seed cake| 3.466667 ab | 4.466667a | 6.266667 |
| Sesame (til) cake| 4.200000abc | 4.533333a | 6.266667 |
| Vermicompost    | 4.666667 abc | 4.933333ab | 6.466667 |
| Control (NPK)   | 6.266667 c  | 7.133333c  | 7.266667 |
| SEM (±)         | 0.4      | 0.36     | 0.43     |
| LSD (0.05)      | 2.33     | 2.21     | 4.11     |
| CV              | 34.1     | 27.9     | 38.7     |
| F-test          | ×        | ×        | NS       |

Note: Same letter in the means do not differ significantly at p=0.05 by DMRT, SEM= Standard error of mean, LSD= Least significant difference, CV = Coefficient of variation, ×= Significant at 5% level and NS=Non-Significant
Table 3. Effect of different fertilizers on number of leaves

| Treatments        | 10 DAS  | 20 DAS  | 30 DAS  | 40 DAS  | 50 DAS  | 60 DAS  |
|-------------------|---------|---------|---------|---------|---------|---------|
| Vermicompost      | 3.066667| 5.600000| 8.666667| 17.46667| 24.93333| 31.73333|
| Sesame(Til) cake  | 3.000000| 5.266667| 7.466667| 14.80000| 19.73333| 35.66667|
| Control (NPK)     | 3.000000| 5.600000| 8.333333| 14.20000| 15.60000| 25.40000|
| Goat manure       | 2.933333| 5.466667| 8.466667| 15.00000| 22.06667| 34.86667|
| Mustard oilcake   | 2.933333| 5.400000| 7.466667| 15.53333| 18.80000| 29.60000|
| Poultry manure    | 2.933333| 5.866667| 8.666667| 17.13333| 26.73333| 44.60000|
| Furacron          | 2.933333| 5.866667| 8.133333| 18.93333| 23.66667| 31.80000|

**SEM (±)**

|            | 0.02    | 0.1     | 0.2     | 0.8     | 0.97    | 1.43    |
|------------|---------|---------|---------|---------|---------|---------|
| LSD (0.05) | 0.162   | 0.907   | 1.62    | 6.46    | 4.73    | 5.48    |
| CV         | 3.06    | 9.14    | 11.2    | 22.5    | 12.3    | 9.23    |

**F test**

|            | NS      | NS      | NS      | NS      | **      | ***     |

Note: Same letter in the means do not differ significantly at p=0.05 by DMRT, SEM= Standard error of mean, LSD= Least significant difference, CV = Coefficient of variation **= Significant at 1% level, ***= Significant at 0.1% level and NS=Non-Significant

Table 4. Effect of different fertilizers on plant height

| Treatments        | 10 DAS  | 20 DAS  | 30 DAS  | 40 DAS  | 50 DAS  | 60 DAS  |
|-------------------|---------|---------|---------|---------|---------|---------|
| Goat manure       | 7.300000| 14.20000| 26.26667| 60.20000| 84.66667| 109.3333|
| Furacron          | 7.300000| 14.23333| 27.06667| 56.46667| 87.46667| 119.8667|
| Sesame (til) cake | 6.800000| 13.10000| 26.13333| 61.40000| 84.20000| 117.7333|
| Vermicompost      | 6.733333| 13.06667| 25.13333| 53.66667| 87.13333| 111.6667|
| Poultry manure    | 6.600000| 12.23333| 24.90000| 59.20000| 88.33333| 119.9333|
| Control (NPK)     | 6.400000| 13.70000| 26.93333| 60.86667| 74.53333| 102.5333|
| Mustard Oilcake   | 6.333333| 14.73333| 26.93333| 55.33333| 77.46667| 107.1333|

**SEM (±)**

|            | 0.16    | 0.38    | 0.52    | 1.26    | 1.32    | 1.83    |
|------------|---------|---------|---------|---------|---------|---------|
| LSD (0.05) | 1.14    | 2.53    | 4.73    | 11.3    | 6.79    | 10.5    |
| CV         | 9.49    | 10.4    | 10.1    | 10.9    | 4.57    | 5.24    |

**F test**

|            | NS      | NS      | NS      | NS      | **      | *       |

Note: Same letter in the means do not differ significantly at p=0.05 by DMRT, SEM= Standard error of mean, LSD= Least significant difference, CV = Coefficient of variation, NS=Non-significant, **= Significant at 1% level *= Significant at 5% level

Table 5. Effect of different fertilizers on plant diameter

| Treatments        | 20 DAS  | 30 DAS  | 40 DAS  | 50 DAS  | 60 DAS  |
|-------------------|---------|---------|---------|---------|---------|
| Goat manure       | 0.5400000| 0.6133333| 1.240000| 1.586667| 1.936667|
| Furacron          | 0.566667| 0.683333| 1.206667| 1.673333| 1.700000|
| Sesame (til) cake | 0.550000| 0.800000| 1.280000| 1.746667| 1.773333|
| Vermicompost      | 0.513333| 0.606667| 1.193333| 1.833333| 1.846667|
| Poultry manure    | 0.566667| 0.700000| 1.273333| 1.960000| 2.200000|
| Control (NPK)     | 0.613333| 0.706667| 1.280000| 1.933333| 1.406667|
| Mustard seed cake | 0.586667| 0.726667| 1.266667| 1.500000| 1.740000|

**SEM (±)**

|            | 0.01    | 0.02    | 0.03    | 0.07    | 0.06    |
|------------|---------|---------|---------|---------|---------|
| LSD (0.05) | 0.0961  | 0.15    | 0.223   | 0.377   | 0.341   |
| CV         | 9.6     | 12.5    | 10      | 12.9    | 10.7    |

**F test**

|            | NS      | NS      | NS      | *       | *       |

Note: Same letter in the means do not differ significantly at p=0.05 by DMRT, SEM= Standard error of mean, LSD= Least significant difference, CV = Coefficient of variation, NS=Non-significant *= Significant at 5% level

At 60 DAS, root diameter was found significant at 5% level of significance (Table 6). Poultry manure, mustard seed cake and goat manure were found superior followed by sesame (til) cake, Furacron, vermicompost and control (NPK). The root diameter was non-significant at 70 and 80 DAS.

At 60 and 70 DAS, the root length was found significant at 5% level of significance in which poultry manure was found superior (Table 7). The root length was non-significant at 80 DAS.

The number of lateral roots was found non-significant at 60 DAS (Table 8) though it was found maximum in case of poultry manure followed by mustard seed cake, sesame(til) cake,
furacron, vermicompost, goat manure and control (NPK).

The fruit yield was significant at 0.1% level of significance (Table 8). Poultry manure was found superior followed by vermicompost, goat manure, sesame (til) cake, Furacron, mustard seed cake and control (NPK). Other researchers also have reported an increase in yield of okra with poultry manure as compared to sheep, cow and a combination of these 3 treatments (Yahaya and Fagwalawa 2016 and Tiamiyu et al. 2012), and cow dung and synthetic NPK fertilizer (Uka et al. 2013). Similarly, Attigah et al. (2013) and Nweke et al. (2013) also reported similar results.

The present results show that the poultry manure enhanced the vegetative growth of the plants and thereby increased the production. The above results are in the agreement with the findings of Aniefiok et al. (2013) and Tswanya et al. (2017) for increased okra production with poultry manure. Also, poultry manure has very high nitrogenous contents and it leads to the formation of ammonia gas which contains nematicidal properties (Rodryguez- Kabana 1986). This ammonia gas is toxic to root-knot nematodes. Generally, using organic manures enhances the microbial activities in soil, which might cause reduction in nematode population by antagonistic effects.

### Economics of different fertilizers

Amongst all the fertilizer treatments, the highest net profit of $1407.92 was found in case of poultry manure (Table 9) followed by goat manure ($1077.5), Furacron ($742.67), vermicompost ($566.67), sesame (til) cake (-$152.62), and mustard seed cake (-$874.6). However, highest incremental cost/benefit ratio was obtained in Furacron (1:2.63) followed by goat manure (1:2.26), poultry manure (1:1.5), vermicompost (1:0.14), sesame (til) cake (1:0.09) and mustard seed cake (1:0.58).

### CONCLUSIONS

Okra responded well to the different organic manures in terms of plant growth, nematode control and fruit yield. Among the organic manures evaluated poultry manure was found superior to other treatments excluding germination and incremental cost-benefit ratio (ICBR). The yield attributing characters and fruit yield was found superior in the poultry manure-treated plot than the plot treated with synthetic fertilizers. All organic manures, except mustard seed cake yielded

#### Table 6. Effect of different fertilizers on root diameter

| Treatments      | Root diameter(cm) |
|-----------------|-------------------|
|                 | 60 DAS            | 70 DAS            | 80 DAS            |
| Furacron        | 1.653333<sup>a</sup> | 2.013333<sup>b</sup> | 2.246667<sup>b</sup> |
| Vermicompost    | 1.566667<sup>b</sup> | 1.740000<sup>b</sup> | 2.046667<sup>b</sup> |
| Goat manure     | 1.820000<sup>a</sup> | 1.920000<sup>a</sup> | 2.453333<sup>a</sup> |
| Sesame cake     | 1.704000<sup>b</sup> | 1.920000<sup>b</sup> | 2.186667<sup>b</sup> |
| Poultry Manure  | 1.833333<sup>a</sup> | 1.960000<sup>a</sup> | 2.506667<sup>a</sup> |
| Mustard seed cake | 1.820000<sup>a</sup> | 1.840000<sup>a</sup> | 2.140000<sup>a</sup> |
| Control (NPK)   | 1.520000<sup>b</sup> | 1.700000<sup>b</sup> | 1.966667<sup>b</sup> |

F test: * NS

| SEM(±)          | 0.05 | 0.05 | 0.07 |
|-----------------|------|------|------|
| LSD(0.05)       | 0.191| 0.368| 0.501|
| CV              | 6.31 | 11.1 | 12.7 |
| F test          | * NS |      |      |

Note: Same letter in the means do not differ significantly at p=0.05 by DMRT, SEM= Standard error of mean, LSD= Least significant difference, CV = Coefficient of variation, NS=Non-significant *= Significant at 5% level

#### Table 7. Effect on root length

| Treatments      | Root length(cm) |
|-----------------|-----------------|
|                 | 60 DAS           | 70 DAS           | 80 DAS           |
| Poultry Manure  | 17.96667<sup>a</sup> | 18.36667<sup>a</sup> | 19.13333<sup>a</sup> |
| Vermicompost    | 17.94667<sup>a</sup> | 18.16667<sup>a</sup> | 18.26667<sup>a</sup> |
| Goat manure     | 16.90000<sup>ab</sup> | 17.70000<sup>b</sup> | 18.13333<sup>a</sup> |
| Sesame (til) cake | 16.19333<sup>ab</sup> | 16.40000<sup>a</sup> | 16.76667<sup>a</sup> |
| Furacron        | 17.83333<sup>a</sup> | 17.70000<sup>b</sup> | 18.46667<sup>a</sup> |
| Mustard seed cake | 15.25333<sup>b</sup> | 15.46667<sup>b</sup> | 15.66667<sup>b</sup> |
| Control (NPK)   | 15.16667<sup>b</sup> | 15.20000<sup>b</sup> | 15.40000<sup>b</sup> |
| SEM(±)          | 0.34 | 0.35 | 0.59 |
| LSD (0.05)      | 2.06 | 2.27 | 4.66 |
| CV              | 6.92 | 7.5  | 15.1 |
| F test          | * NS |      |      |

Note: Same letter in the means do not differ significantly at p=0.05 by DMRT, SEM= Standard error of mean, LSD= Least significant difference, CV = Coefficient of variation, NS=Non-significant *= Significant at 5% level
significantly higher yield than the control (NPK). Of them, poultry manure seemed to be the most effective in our experiment. Sanni et al. (2015) recommends 25tha⁻¹ as a suitable dose whereas Tswanya et al. (2017) recommends 15tha⁻¹ for LD88 variety. Further research should be carried out to demonstrate the suitable dose of poultry manure for increased production under different field conditions.

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**CONFLICT OF INTEREST**

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

**ORCID**

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**Table 8. Effect of different fertilizers on lateral roots and yield**

| Treatments              | Number of lateral roots | Average Yield (mt ha⁻¹) |
|-------------------------|-------------------------|-------------------------|
|                         | 60 DAS                  |                         |
| Furacron                | 36.7333                 | 14.6133bc              |
| Vermi compost           | 36.0000                 | 17.3867ab              |
| Goat manure             | 33.4000                 | 16.7289ab              |
| Sesame cake             | 38.2000                 | 16.6222ab              |
| Poultry Manure          | 44.8000                 | 20.0000a               |
| Mustard seed cake       | 39.4000                 | 12.97778d              |
| Control(NPK)            | 30.1333                 | 10.50667               |

**Table 9. Economics of different fertilizer**

| S.N. | Treatments              | Cost of Treatments ($ha⁻¹) | Yield (Mt ha⁻¹) | Average yield of Produce ($ha⁻¹) | Gross return over control ($ha⁻¹) | Net Profit over control ($ha⁻¹) | ICBR       |
|------|-------------------------|---------------------------|-----------------|----------------------------------|----------------------------------|--------------------------------|------------|
| 1.   | Goat Manure+Supplements | 333.33+141.67=475         | 16.72           | 4180                             | 1552.5                           | 1077.5                         | 1:2.26     |
| 2.   | Sesame (Til Cake)+Supplements | 1548.56+126.56=1675.12    | 16.62           | 4150                             | 1522                             | -152.62                        | -1:0.09    |
| 3.   | Mustard Seed Cake+Supplements | 1326.67+162.44=1489.10    | 12.97           | 3242                             | 614.5                            | -874.6                         | -1:0.58    |
| 4.   | Poultry Manure+Supplements | 833.33+131.25=964.58      | 20              | 5000                             | 2372.5                           | 1407.92                        | 1:1.5      |
| 5.   | Furacron+ NPK            | 32+250.33=282.33          | 14.61           | 3652.50                          | 1025                             | 742.67                         | 1:2.63     |
| 6.   | Vermicompost+Supplements | 1445.76+54.78=1500.54    | 17.38           | 4345                             | 1717.5                           | 216.96                         | 1:0.14     |
| 7.   | Control(NPK)i.e.RDF     | 30.1333                  | 10.51           | 2627.50                          | -                                | -                              | -          |

Note: Negative sign(-) indicates loss  
ICBR: Incremental Cost Benefit Ratio
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