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Effect of vermicompost application on soil and growth of the plant *Sesamum indicum L.*

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ABSTRACT:

This paper aims in studying the effect of vermicompost on soil and growth of the plant *Sesamum indicum L.* by measuring the its various growth and yield components. For this purpose, a mixture of textile mill sludge, cow dung and saw dust have been mixed in different ratios to produce vermicompost by using the earthworm *Perionyx excavates* and was compared with inorganic (NPK) and organic fertilizer (FYM). The results of soil quality revealed that the porosity, water holding capacity (WHC), cation exchange capacity (CEC) and occurrence of macronutrients were significantly increased and the particle density were decreased in treatment with 100% vermicompost (VC) followed by soil treated with 50% VC + 50% NPK, on contrary, reduction in porosity, WHC, CEC were noted in NPK treated plots. The effect of vermicompost on plant growth components (root, shoot, leaf area index, branch, DMP) and yield components (pod number, weight, length, seed weight, number of seed, seed yield) were significantly higher in the plots treated with 50% VC + 50% NPK followed by 100% vermicompost than the plots treated only with FYM and NPK. The significant growth upon using vermicompost was accounted by its nutrients composition over other fertilizers.

Keywords: Vermicompost, Sesamum indicum L., Perionyx excavates, NPK Fertilizers, Farm yard Manure, plant growth components

INTRODUCTION

Fertilizers using worldwide enhances the soil quality and thus helps in agricultural practices however the inorganic fertilizers are tend to be accumulate various types of radio nuclides and heavy metals which may cause groundwater pollution and serious damages to the plant growth. Also these toxic components enter the food chain and affect the organisms on consumption of the plants (Savci 2012). To overcome these problems, many approaches had been used to increase the soil fertility and to promote the growth of plants without toxicity. The highest crop yield correlates with the quality of soil

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which could be obtained by supplementation of organic matters. The one of the effective means of increasing the soil fertility is the usage of compost obtained from non toxic wastes such as animal manures, agricultural waste, sewage sludge etc. (Norman et al. 2005). The advantages of composting over inorganic fertilizers includes prevention of nitrate leaching into underground water and also it controls the plant pathogens thus increases the crop production.

Vermicomposting is one of the biological process in which the organic wastes has been converted into nutrient rich manure by the action of earthworms. The characteristic feature of vermicompost such as high porosity and moisture holding capacity increases the growth of pathogen free plants (Yadav & Garg 2019). The process of vermicompost enhances the microbial enzyme activity which helps in degradation of waste material into stabilized organic manure. It also increases the basal respiration; total organic C and biomass C. Plants will readily uptake the nutrients from vermicompost in the form of soluble potassium, phosphorous, calcium, magnesium and other beneficial minerals (Atiyeh et al. 2000). The major factor contributing to plant growth is the occurrence of plant growth hormones and humic acid content in the vermicompost. The high yield and growth of the plants due to usage of vermicompost increases the commercial value and agricultural sustainability (Arancon et al. 2006; Ananthavallia et al. 2019).

Gingelly (*Sesamum indicum L.*) is the indigenous oil plant known and cultivated by Indian farmers for long time. It is still the world leading crop with the maximum production of oil seeds (Duhoon et al. 2003). At present per hectare productivity of *Sesamum indicum L.* in India is only 322 kg ha as against the maximum yield potential of around 2000 kg ha (Sundaresan et al. 1995). The Indian council of Medical research (ICMR) has recommended an intake of 20g of edible-oil per day for a person and at this rate, the total requirement by 2020 AD will be around 20.3 million tons. So, it is essential to increase the productivity of soil seeds crop like *Sesamum indicum L.* through modern crop production technology like integrated nutrient management, organic farming practices in order to meet the increasing demand of edible oil. Hence the present research aimed to utilize the textile mill sludge and saw dust to produce vermicompost by using the *Perionyx excavatus* and to study the various growth and yield components of plant *Sesamum indicum L.* due to application of vermicompost.

MATERIALS AND METHODOLOGY

Preparation of vermicompost:

Vermicompost generated from the mixture of 1:1, 2:1, 3:1 ratio of Textile mill sludge (TMS), Sawdust (SD) obtained from agro industrial waste, Effective microorganisms (EM) and Cow dung (CD) inoculum by the action of *Perionyx excavatus*. Harvested vermicompost was used to find out its effect on the soil fertility and growth of edible crop gingelly.

Experimental sites:

Field experiments were conducted in sandy loam soil at Vallampadugai village near Chidambaram, Tamil Nadu, India. The detailed field investigations are given in **Table 1**. Field experiments were conducted from June to august 2018, (75 to 80 days). The minimum and maximum

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temperature ranged between 15.6 to 31.1^{O}C and relative humidity ranged between 80-90%. These data were periodically collected from the agriculture metrological observatory, Annamalai University.

Table 1: Experiment details of Sesamum indicum L. cultivation

Sl .No	Experimental details	
1	Location	Farmer's field at vallampadugai village
2	Natural of soil	Sandy loam
3	Season	Summer,2016
4	Variety	CV TMV3
5	Duration	75-80 days
9	Date of sowing	10.06.2018
10	Date of harvesting	29.08.2018

Physico-chemical properties of soil:

The soil texture of the experimental field was sandy loam. Physico- chemical properties (Bragg & Chambers 1988; Gabriels et al. 1993) of sandy loam soil are presented in **Table 2**.

Table 2: Physico-chemical properties of soil

Properties of soil	Sandy loam soil
Physical properties	
Pore space (%)	31.44
Particle density (Mgm^{-3})	3.00
Bulk density (Mgm^{-3})	1.33
WHC (%)	60.00
CEC(C.mol/ CP+) Kg^{-1}	21.70
Chemical properties	
pH	7.05
EC(dsm^{-1})	0.54
OC (%)	0.28
Available nutrients	
N($Kg\ ha^{-1}$)	184
P($Kg\ ha^{-1}$)	11.9
K($Kg\ ha^{-1}$)	244
Total nutrients	
Ca (%)	1.97
Mg (%)	0.49
Na (%)	0.05
Fe (ppm)	18.75
Mn (ppm)	10.20
Zn (ppm)	1.18
Cu (ppm)	1.20

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Field layout and experimental design:

In the sandy loam field, the experiments were laid out in randomized block design (RBD) with three replicates. Micro plot was under for each treatment and each plot was 2m length and 2m width (Joshi et al. 2013). The layout plane of the experimental field is presented in **Figure 1**.

Sesamum indicum L. variety TMV3 was selected and used for the present study. Seed of *Sesamum indicum L.* variety TMV3 were obtained from the department of Horticulture, Faculty of Agriculture, Annamalai University. Seeds with similar color were chosen for the experiment.

Fig 1: The layout of an experimental field

Field preparation:

The field was prepared through repeated ploughing up to a satisfactory tilth condition. The clods were broken and field was leveled. The plots were formed as per the layout. A seed rate of 6 kg ha^{-1} was followed. The inter row spacing of 45cm with an intra-row spacing of 30cm was maintained. Irrigation was given immediately after sowing and the subsequent irrigation was given at 8-12 days interval or as and when required to the crop till its maturity. During thinning, the field was kept under sufficient moisture level. The first thinning was done on 15 Days keeping 2 seedlings per hill. The seedlings were thinned out once again on 30 days to maintain, 2 plants per hill. The matured crop was harvested plot wise, when the leaves, stem and the capsules began to turn yellow. Three sample plants for each treatment plot were selected at random and labeled for Biometric observations. The observations on growth and yield parameters were recorded at 30, 60, and 85 (harvest) days (Karmegam & Daniel 2008).

Growth and yield components:

Growth components of the plants such as shoot length, root length, leaf area index, number of shoot branches, dry root and shoot weight, dry matter production and yield components such as pod

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length and weight, number of pods per plant, number of seeds per pod, seed weight and seed yield were measured (Suthar 2009).

Comparative effect of fertilizers and vermicompost:

To understand the comparative effect of other fertilizers and vermicompost on the growth and yield components of gingelly, NPK (inorganic fertilizer) and FYM (farm yard manure traditional organic manure) were also selected for the present investigation. NPK was used in the form of urea (N), superphosphate (P), muriate of potash (K). FYM was collected from dairy yard at the Faculty of Agriculture, Annamalai University. The following treatments such as F1-control, F2-FYM, F3-NPK, F4-100% vermicomposting, F5-50% vermicompost supplement with 50% NPK were selected for the present Field investigation (Sinha 2010). The treatment details are given in **Table 3**.

Table 3: Different plots with various treatments

Treatment	Manure and vermicompost
F1	Control plot (without application of manure and fertilizer)
F2	Application of FYM (Organic manure)
F3	Plot - applied with recommended dose of N,P,K fertilizer 35:23:23kg/ha^{-1}
F4	Plots- applied recommended dose of vermicompost 5 ha^{-1}
F5	Plots – applied either 50% vermicompost supplemented with 50% N,P,K(w/w)

RESULTS AND DISCUSSIONS

The Influence effect of the application of inorganic fertilizers NPK, organic manure FYM, and vermicompost supplemented with 50% NPK on the growth components (Root length, Root dry weight, Shoot length, Shoot branch, Shoot dry weight, LAI, and DMP) of gingelly at 60, and 80 (harvest) days were studied and presented in **Table 4 and 5**. Further, yield components such as number of pods plant^{-1}, seed yield plant^{-1}, pod length, pod weight, number of seed pod^{-1}, seed yield plant^{-1}, and 1000 seeds weight also determined and presented in **Table 6**.

The statistical significance of the data on the basis of one way analysis of variance (ANOVA) was tested (Wilkinson 1986). ANOVA showed the existence of statistically significant ($P < 0.05$) differences between the control and experimental data for all the growth and yield components studied, further, for each parameter, minimum significant difference or critical difference (CD) at 5% level was also calculated and incorporated in all the tables, besides, the percent changes over control for each treatment and for every periods of study were also calculated and determined.

Generally, in all treatments for growth and yield components studies, the plant *Sesamum indicum L*. showed an increasing trend from 30 days to 80 days (harvest). Among the treatments, F5 plot (50% VC supplemented with 50% NPK) and F4 (100 %VC), the plant *Sesamum indicum L.* showed conspicuous effects and maximum response both in growth and yield components. On the other hand, in plots applied with NPK (F3) *Sesamum indicum L.* showed moderate response with reference to growth and yield components for all the periods of investigation.

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Growth parameters:

Growth components such as Root length, Root dry weight, Shoot length, Shoot branch, Shoot dry weight, LAI and DMP are all significantly enhanced in F5 (50% VC +50% NPK) as well as in F4 (VC) for all periods of study (**Figure 2 and 3**). The comparison of percentage value between the treatments F1-F5 clearly prove that plants grown in recommended doses of vermicompost alone (F4) and 50% VC supplemented with 50% NPK (F5) applied plots, showed roughly 30-100% enhancement in each growth parameters investigated. For example shoot length of *Sesamum indicum* plants cultivated in F5 increased by 42.23% on 30days, 93.67% on 60days, and 112.23% on 80 days. Root length of *Sesamum indicum* plant grown in F5 increased by 66.6%, 61.66%, 87.32% respectively on 30, 60 and 80days over control. Leaf area index (LAI) of the plant grown in F5 increased by 260%, 62.94%, 68.81% on 30, 60 and 80 days respectively over control. Dry weight of shoot of *Sesamum indicum* plants grown in F5 were increased by 130.52%, 80.1%, 91.76% respectively on 30 days, 60 days and 80 days over control. Dry weight of root of *Sesamum indicum L.* plants grown in F5 increased by 205.71%, 351%, 268% respectively, on different harvesting period.

Table 4: Effect of FYM, NPK, Vermicompost and 50% vermicomposting supplemented with 50% NPK on growth components of gingelly (*Sesamum indicum L.*) at 60 days

Table 4: Effect of FYM, NPK, Vermicompost and 50% vermicomposting supplemented with 50% NPK on growth components of gingelly (*Sesamum indicum L.*) at 60 days

Parameters	F1 (Control)	F2 (FYM)	F3 (NPK)	F4 (VC)	F5 (NPK+VC)	F	CD Value
Root length(cm) % change over control	10.8	10.95 (1.38)	12.42 (15)	14.27 (32.12)	17.46 (61.66)	63.12*	1.642
Root dry weight (g) % change over control	0.85	0.97 (14.11)	2.43 (185)	3.60 (323.5)	3.84 (351)	249.8*	0.42
Shoot length (cm) % change over control	64.2	66.24 (3.17)	75.30 (17.28)	86.41 (34.59)	93.67 (45.90)	81.75*	6.645
Shoot dry weight (g) % change over control	11.61	12.45 (7.23)	15.37 (32.38)	18.53 (59.60)	20.91 (80.10)	1131*	0.582
Number of branches % change over control	15	15 (0.0)	17 (13.33)	19 (26.66)	22 (46.66)	250*	0.42
Leaf area index (cm2)	2.24	2.54 (13.39)	2.96 (32.14)	3.27 (45.98)	3.63 (62.05)	890.2*	0.09

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% change over control							
Dry matter production (g) % change over control	2357	2543 (7.89)	2721 (15.44)	3982 (62.94)	4427 (87.82)	4698*	59.546

Values are mean of 3 observation ± S.E
Percent increases (+) increases or decreases (-) over control are given parameter
*Indicates the statistical significance at 1 % level (P< 0.01) NS- Not significant

CD- Critical difference
F1- Control (No fertilizer and no manure
F2- Recommended dose (35:23:23) of NPK
F3- Recommended dose (5t ha^{-1}) of vermicompost
F4- Recommended dose (12.5t ha^{-1}) of FYM
F5- Application of 50% of vermicompost + 50% NPK

Table 5: Effect of vermicompost, FYM, NPK and 50% vermicomposting supplemented with 50% NPK on growth components of gingelly (*Sesamum indicum L.*) at 80 days

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Parameters	**F1 (Control)**	**F2 (FYM)**	**F3 (NPK)**	**F4 (VC)**	**F5 (NPK+VC)**	**F**	**CD Value**
Root length(cm) % change over control	11.91	12.82 (7.64)	15.63 (31.23)	19.23 (61.46)	22.31 (87.32)	109.25*	5.824
Root dry weight (g) % change over control	1.52	19.87 (120.2)	3.48 (128)	5.31 (249)	5.45 (268)	350.4*	0.46
Shoot length (cm) % change over control	82.67	86.35 (4.45)	96.63 (16.88)	105.12 (27)	112.23 (35.75)	94.2*	5.891
Shoot dry weight (g) % change over control	12.26	13.27 (8.23)	16.43 (34.01)	20.14 (64.27)	23.51 (91.76)	312.3*	1.18
Number of branches % change over control	15	15 (0)	17 (13.33)	19 (26.66)	23 (53.33)	57.2*	1.976
Leaf area index (cm2) % change over control	2.02	2.24 (10.89)	2.68 (32.67)	3.08 (52.47)	3.41 (68.81)	1820*	0.095
Dry matter production (g)	2524	2981 (18.1)	3994 (58.24)	4251 (68.42)	4712 (86.68)	7051*	49.905

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% change over control							

Values are mean of 3 observation ± S.E
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*Indicates the statistical significance at 1 % level (P< 0.01) NS- Not significant

CD- Critical difference
F1- Control (No fertilizer and no manure
F2- Recommended dose (35:23:23) of NPK
F3- Recommended dose (5t ha^{-1}) of vermicompost
F4- Recommended dose (12.5t ha^{-1}) of FYM
F5- Application of 50% of vermicompost + 50% NPK

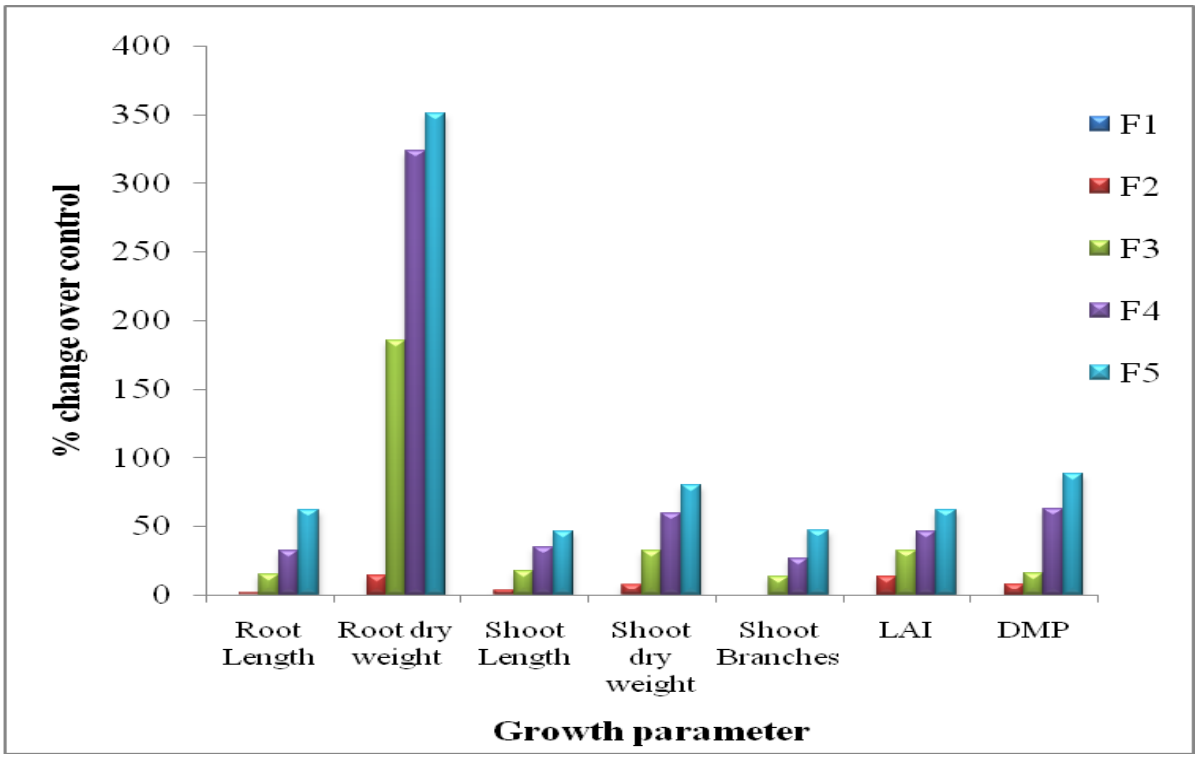

Fig 2: Effect of FYM, NPK, vermicompost and 50% vermicompost supplemented with 50% NPK on Root length, Root dry weight, Shoot length, Shoot branch, Shoot dry weight, LAI, DMP of (*Sesamum indicum.L*) at 60 days

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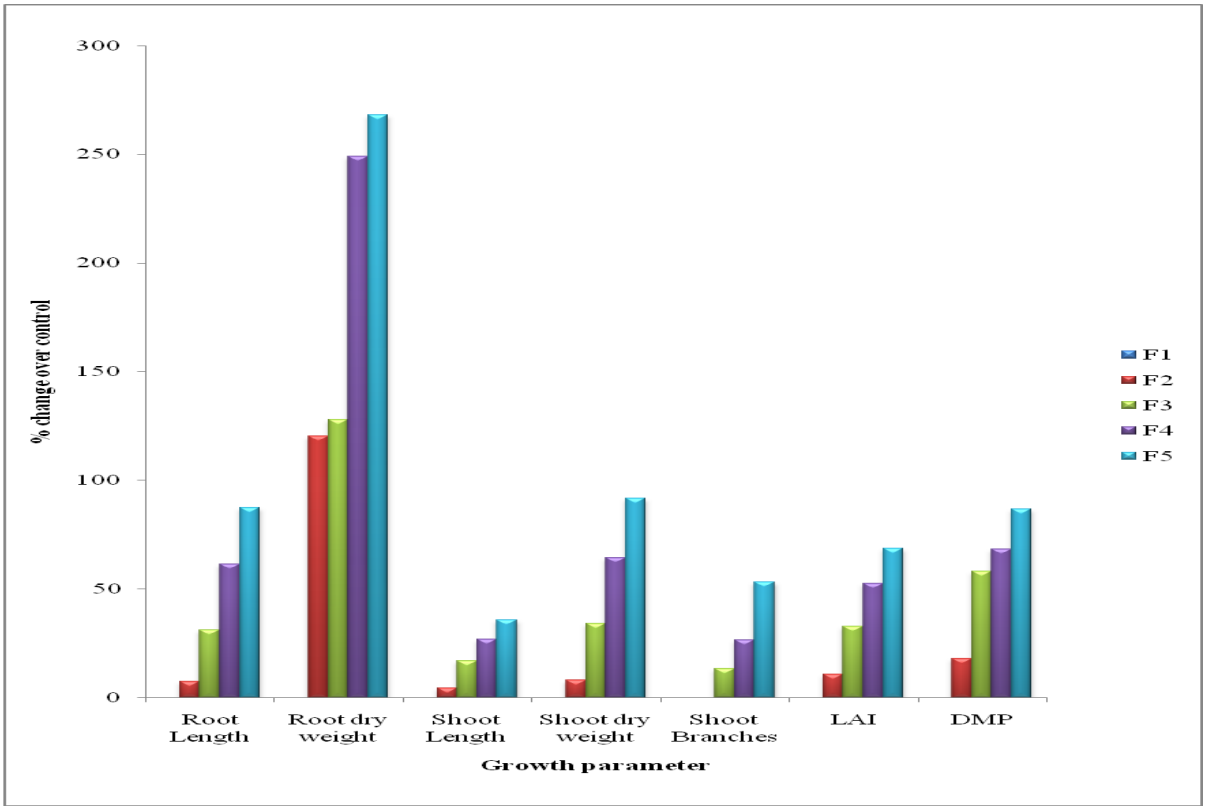

Fig 3: Effect of FYM, NPK, vermicompost and 50% vermicompost supplemented with 50% NPK on Root length, Root dry weight, Shoot length, Shoot branch, Shoot dry weight, LAI, DMP of (*Sesamum indicum.L*) at 80 days

Yield parameters:

The yield components such as number of pods/ plant^{-1}, pod length, pod weight, number of seeds/ pod^{-1}, thousand seed weight and seed yield/ plant were all enhanced in F5 (50% VC + 50% NPK)as well as VC (F4) applied plots (at the rate 5t ha^{-1}) for all the periods of investigation (**Table 6 and Figure 4**). The comparison of percent change over control values indicated that plants grown in vermicompost (F4) and vermicompost supplemented with NPK (F5) applied plots showed roughly 20-90% enhancement in each yield components studies. The percentage of change over control values were presented in **Table 7 to 13**.

The comparison of percent change over control value between F1 to F5 treatment clearly prove that *Sesamum indicum L.* plant cultivated in recommended dose of vermicompost alone (F4) and vermicompost supplemented with 50% NPK(F5) plot showed more number of capsules per plant, maximum number of seeds per capusles and higher capsules weight. For example on 80 days in F5 plots (50% VC + 50% NPK applied plots) the number of seeds / Capsule increased by 50.30%; number of seeds / capsule increased 27.58%; capsule weight / plant increased by 65% over control.

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Table 6: Effect of FYM, NPK, Vermicompost and 50% vermicompost supplemented with 50% NPK on yield components of gingelly (*Sesamum indicum L.)* at 80 (harvest) days

Table 6: Effect of FYM, NPK, Vermicompost and 50% vermicompost supplemented with 50% NPK on yield components of gingelly (*Sesamum indicum L.*) at 80 (harvest) days

Parameters	F1 (Control)	F2 (FYM)	F3 (NPK)	F4 (VC)	F5 (NPK+VC)	F	CD Value
Pod length (% change over control)	2.25±0.023	2.43±0.022 (7.2)	2.54 ± 0.021 (11.6)	2.74±0.012 (19.6)	3.12±0.010 (34.8)	160.5*	0.125
Pod weight (g) (% change over control)	0.497±0.012	0.56±0.06 (12.67)	0.65± 0.021 (30.78)	0.71±0.016 (42.85)	0.82±0.006 (65)	42.4*	0.09
No. seeds/pod (% change over control)	58 ±1.142	62.0±1.752 (6.89)	65.0± 1.541 (12.06)	70.0±0.013 (20.68)	74±0.017 (27.58)	22.1*	5.924
No. pods /plant (% change over control)	51.23±1.631	52.94±2.124 (3.33)	60 ± 2.082 (17.11)	69 ±2.074 (34.68)	77±0.008 (50.30)	21.4*	10.741
Seeds yield / plant (g) (% change over control)	7.45±0.070	8.64±0.034 (15.97)	10.40± 0.014 (39.59)1	12.87±0.012 (68.72)	14.54±0.011 (95.16)	3350.5*	0.225
1000 seeds weight (g) (% change over control)	2.58±0.010	2.63±0.018 (1.93)	2.68± 0.012 (3.87)	2.71±0.021 (5.03)	2.75±0.022 (6.58)	48.2*	0.245

Values are mean of 3 observation ± S.E
Percent increases (+) increases or decreases (-) over control are given parameter
*Indicates the statistical significance at 1 % level (P< 0.01) NS- Not significant

CD- Critical difference
F1- Control (No fertilizer and no manure
F2- Recommended dose (35:23:23) of NPK
F3- Recommended dose (5t ha^{-1})of vermicompost
F4- Recommended dose (12.5t ha^{-1}) of FYM
F5- Application of 50% of vermicompost + 50% NPK

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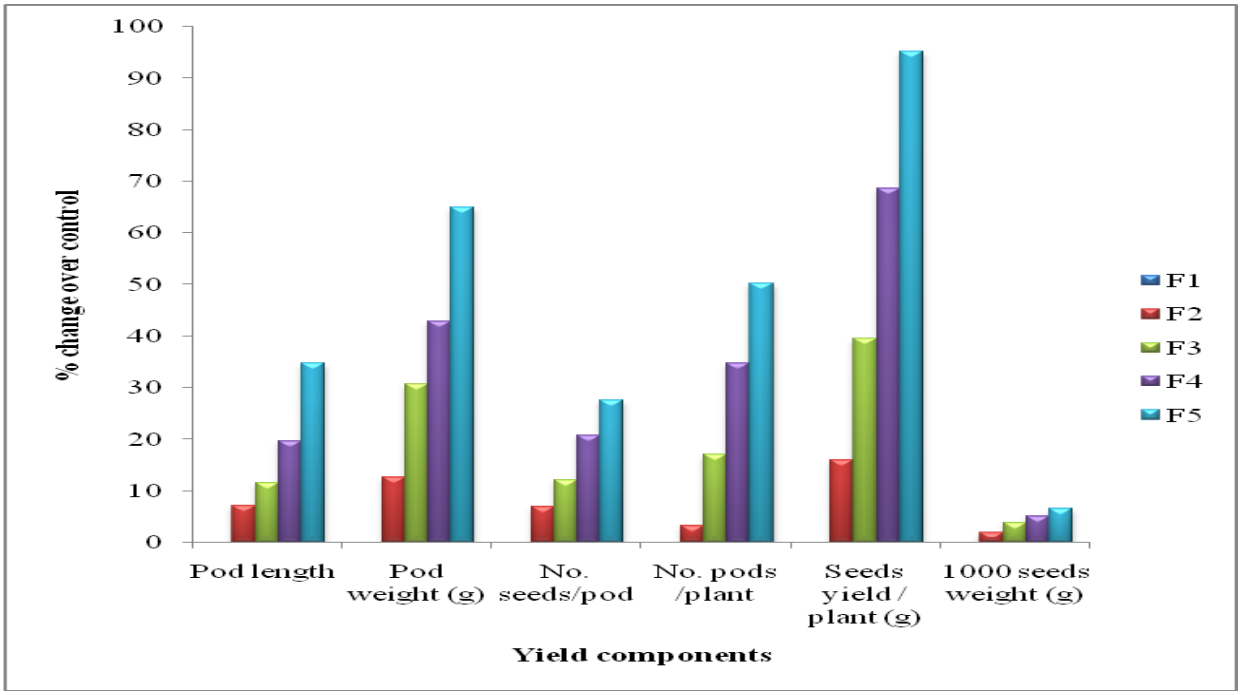

Fig 4: Effect of FYM, NPK, Vermicompost and 50% vermicompost supplemented with 50% NPK on yield components of gingelly (*Sesamum indicum.L*) at 80 days

Table 7: Root length of gingelly (*Sesamum indicum.L*) under different treatments of FYM, NPK, and Vermicompost as observed 30, 60 and 80 days (harvest)

Treatment	30 DAYS		60 DAYS		80 DAYS	
		% change over control		% change over control		% change over control
F1(Control)	6.15	-	10.8	-	11.91	-
F2 (FYM)	6.58	**7.15**	10.95	**1.38**	12.82	**7.64**
F3 (NPK)	7.40	**20.32**	12.42	**15**	15.63	**31.23**
F4 (VC)	8.25	**34.14**	14.27	**32.12**	19.23	**61.46**
F5 (NPK+VC)	10.25	**66.6**	17.46	**61.66**	22.31	**87.32**
F	106.4*		63.12*		109.25*	
CD values	0.814		1.642		5.824	

*Indicates the statistical significance at 1 % level (P< 0.01)

NS- Not significant; CD- Critical difference; F1- Control (No fertilizer and no manure); F2- Recommended dose (35:23:23) of NPK; F3- Recommended dose (5t ha-1) of vermicompost; F4- Recommended dose (12.5t ha-1) of FYM; F5- Application of 50% of vermicompost + 50% NPK

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Table 8: Root dry weight of gingelly (*Sesamum indicum.L*) under different treatments of FYM, NPK, and Vermicompost as observed 30, 60 and 80 days (harvest)

Treatment	30 DAYS		60 DAYS		80 DAYS	
		% change over control		% change over control		% change over control
F1(Control)	0.70	-	0.85	-	1.52	-
F2 (FYM)	0.76	**8.57**	0.97	**14.11**	19.87	**120.2**
F3 (NPK)	1.02	**45.71**	2.43	**185**	3.48	**128**
F4 (VC)	1.45	**107.14**	3.60	**323.5**	5.31	**249**
F5 (NPK+VC)	2.14	**205.71**	3.84	**351**	5.45	**268**
F	2531.7*		249.8*		350.4*	
CD values	0.095		0.420		0.460	

*Indicates the statistical significance at 1 % level (P< 0.01)

NS- Not significant; CD- Critical difference; F1- Control (No fertilizer and no manure); F2- Recommended dose (35:23:23) of NPK; F3- Recommended dose (5t ha^{-1}) of vermicompost; F4- Recommended dose (12.5t ha^{-1}) of FYM; F5- Application of 50% of vermicompost + 50% NPK

Table 9: Shoot lengthof gingelly (*Sesamum indicum.L*) under different treatments of FYM, NPK, and Vermicompost as observed 30, 60 and 80 days (harvest)

Treatment	30 DAYS		60 DAYS		80DAYS	
		% change over control		% change over control		% change over control
F1 (Control)	26.3	-	64.2	-	82.67	-
F2 (FYM)	29.64	**12.69**	66.24	**3.17**	86.35	**4.45**
F3 (NPK)	33.45	**27.18**	75.30	**17.28**	96.63	**16.88**
F4 (VC)	36.17	**37.52**	86.41	**34.59**	105.12	**27**
F5 (NPK+VC)	42.23	**60.52**	93.67	**45.9**	112.23	**35.75**
F	26.45*		81.75*		94.2*	
CD values	6.123		6.645		5.891	

*Indicates the statistical significance at 1 % level (P< 0.01)

NS- Not significant; CD- Critical difference; F1- Control (No fertilizer and no manure); F2- Recommended dose (35:23:23) of NPK; F3- Recommended dose (5t ha^{-1}) of vermicompost; F4- Recommended dose (12.5t ha^{-1}) of FYM; F5- Application of 50% of vermicompost + 50% NPK

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Table 10: Shoot dry weight of gingelly (*Sesamum indicum.L*) under different treatments of FYM, NPK, and Vermicompost as observed 30, 60 and 80 days (harvest)

Treatment	30 DAYS		60 DAYS		80DAYS	
		% change over control		% change over control		% change over control
F1(Control)	5.34	-	20.91	-	12.26	-
F2 (FYM)	6.43	**20.14**	12.45	**7.23**	13.27	**8.23**
F3 (NPK)	8.58	**60.67**	15.37	**32.38**	16.43	**34.01**
F4 (VC)	10.74	**101.12**	18.53	**59.6**	20.14	**64.27**
F5 (NPK+VC)	12.31	**130.52**	11.61	**80.1**	23.51	**91.76**
F	128.80*		1131*		312.3*	
CD values	1.121		0.582		1.180	

*Indicates the statistical significance at 1 % level (P< 0.01)

NS- Not significant; CD- Critical difference; F1- Control (No fertilizer and no manure); F2- Recommended dose (35:23:23) of NPK; F3- Recommended dose (5t ha^{-1}) of vermicompost; F4- Recommended dose (12.5t ha^{-1}) of FYM; F5- Application of 50% of vermicompost + 50% NPK

Table 11: Shoot branches of gingelly (*Sesamum indicum.L*) under different treatments of FYM, NPK, and Vermicompost as observed 30, 60 and 80 days (harvest)

Treatment	30 DAYS		60 DAYS		80 DAYS	
		% change over control		% change over control		% change over control
F1 (Control)	5.0	-	15	-	15	-
F2 (FYM)	5.0	**0**	15	**0**	15	**0**
F3 (NPK)	5.0	**0**	17	**13.33**	17	**13.33**
F4 (VC)	6.0	**20**	19	**26.66**	19	**26.66**
F5 (NPK+VC)	7.0	**40**	22	**46.66**	23	**53.33**
F	1.12 NS		250*		57.2*	
CD values	0.030		0.420		1.976	

*Indicates the statistical significance at 1 % level (P< 0.01)

NS- Not significant; CD- Critical difference; F1- Control (No fertilizer and no manure); F2- Recommended dose (35:23:23) of NPK; F3- Recommended dose (5t ha^{-1}) of vermicompost; F4- Recommended dose (12.5t ha^{-1}) of FYM; F5- Application of 50% of vermicompost + 50% NPK

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Table 12: Leaf area index of gingelly (*Sesamum indicum.L*) under different treatments of FYM, NPK, and Vermicompost as observed 30, 60 and 80 days (harvest)

Treatment	30 DAYS		60 DAYS		80 DAYS	
		% change over control		% change over control		% change over control
F1 (Control)	0.50	-	2.24	-	2.02	-
F2 (FYM)	0.68	**36**	2.54	**13.39**	2..24	**10.89**
F3 (NPK)	0.94	**88**	2.96	**32.14**	2.68	**32.67**
F4 (VC)	1.40	**180**	3.27	**45.98**	3.08	**52.47**
F5 (NPK+VC)	1.80	**260**	3.63	**62.94**	3.41	**68.81**
F	1864.5*		890.2*		1820*	
CD values	0.145		0.090		0.095	

*Indicates the statistical significance at 1 % level (P< 0.01)

NS- Not significant; CD- Critical difference; F1- Control (No fertilizer and no manure); F2- Recommended dose (35:23:23) of NPK; F3- Recommended dose (5t ha^{-1}) of vermicompost; F4- Recommended dose (12.5t ha^{-1}) of FYM; F5- Application of 50% of vermicompost + 50% NPK

Table 13: Dry matter production of gingelly (*Sesamum indicum.L*) under different treatments of FYM, NPK, and Vermicompost as observed 30, 60 and 80 days (harvest)

Treatment	30 DAYS		60 DAYS		80 DAYS	
		% change over control		% change over control		% change over control
F1 (Control)	561	-	2357	-	2524	-
F2 (FYM)	654	**16.57**	2.543	**7.89**	2981	**18.1**
F3 (NPK)	733	**30.65**	2721	**15.44**	3994	**58.24**
F4 (VC)	1024	**82.53**	3982	**62.94**	4251	**68.42**
F5 (NPK+VC)	1253	**123.35**	4427	**87.82**	4712	**86.68**
F	386.0*		4698*		7051*	
CD values	62.14		59.546		49.905	

*Indicates the statistical significance at 1 % level (P< 0.01)

NS- Not significant; CD- Critical difference; F1- Control (No fertilizer and no manure); F2- Recommended dose (35:23:23) of NPK; F3- Recommended dose (5t ha^{-1}) of vermicompost; F4- Recommended dose (12.5t ha^{-1}) of FYM; F5- Application of 50% of vermicompost + 50% NPK

The Figure 5 showed the differential root development in Sesamum indicum L. plants collected from control (F1), FYM (F2), NPK (F3), 100% VC (F4), 50% VC + 50% NPK (F5). It indicates the growth of lengthy primary root with more number of secondary (lateral) roots in VC supplemented with NPK (F5) and VC alone (F4) treated plants compared to plants grown in other plots (F1,F2,F3). The **Figure 6, 7 and 8** showed the visual evidence for the maximum height, more number of branches in vermicompost alone (F4) as well as vermicompost supplemented with NPK (F5) treated plants and minimum growth,

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less number of pods were seen in control (F1) and NPK (F3) treated plants on various harvesting days of 30, 60 and 80.

The efficiency of FYM, NPK, VC and VC+NPK treatments (F1-F5) to support or enhance the growth and yield components of *Sesamum indicum L.* could be ranked in the following order : F5 (50% VC+ 50% NPK) > F4(VC at the rate of 5t ha^{-1})> F3(NPK at the rate of 35:23:23) > F2 (FYM at the rate of 12.5t/ ha^{-1}).

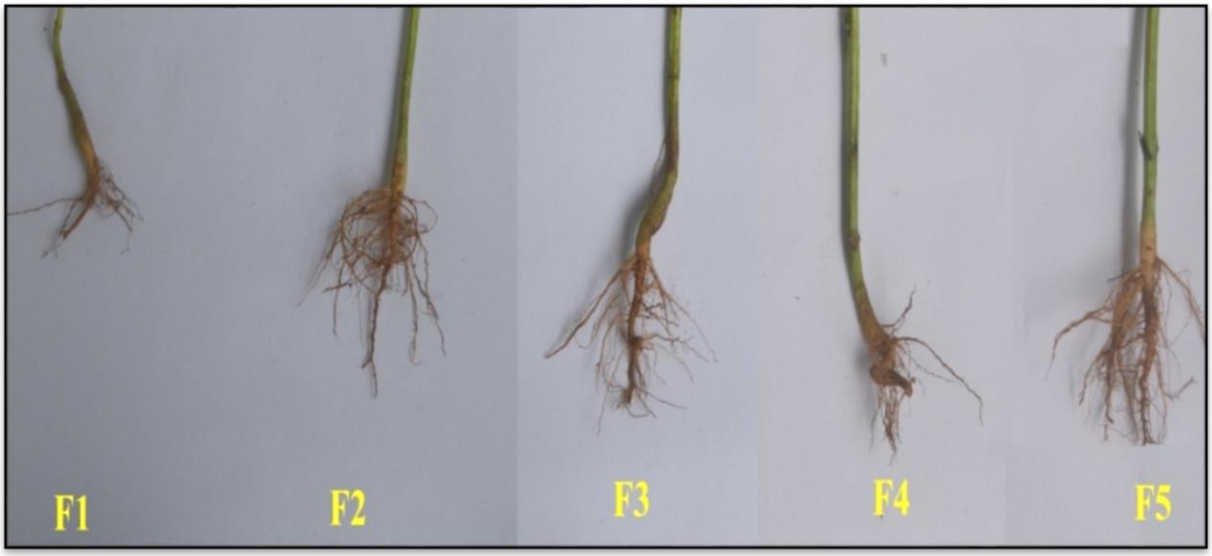

Fig 5: Root development in *Sesamum indicum L.* plant collected from the control (F1), NPK (F2), VC (F3), FYM (F4), VC+NPK (F5) applied experimental plots on 30days.

Fig 6: Growth of *Sesamum indicum L.* plant collected from F1-F5 plots on 30 days

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Fig 7: Growth of *Sesamum indicum L.* plant collected from F1-F5 plots on 60 days

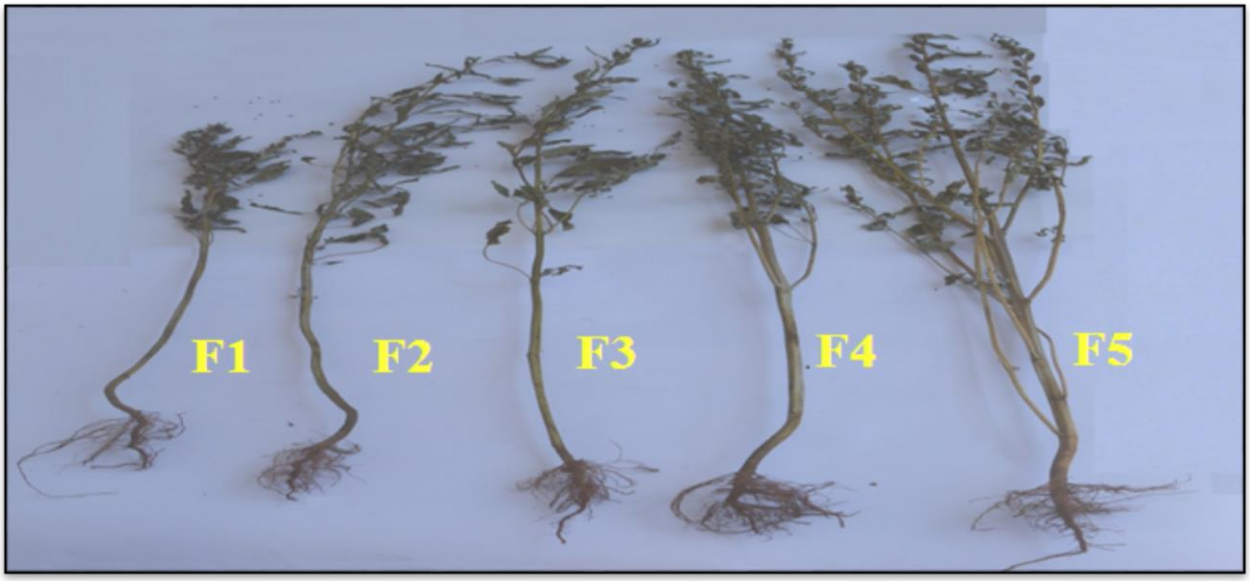

Fig 8: Growth of *Sesamum indicum L.* plant collected from F1-F5 plots on 80 days

In this study the effect of vermicompost with various treatments were tested for the growth of the plant *Seasumum indicum.* The results exposed that the harvested vermicompost increases the soil quality by decreasing pH, particle density and increasing porosity, water holding capacity, cation exchange capacity, and macronutrients, thus significantly enhances the growth and yield components of the plant. There were many similar reports suggesting that the presence of humic substances in the vermicompost might be the reason for reduction of pH (Mahaly et al. 2018).

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The vermicompost was found to be rich in humic acid content which helps in root development by enhancing the effectiveness of the root system and thus increasing the plant growth. This was achieved by stimulating the nutrient uptake by elevating the permeability of cell membrane. The humic acid also had a beneficial role in developing microbial characteristics of soil which results in high production of organic aids and thus the quality of the soil has been raised. The microbes present in the vermicompost may produce various plant growth regulators like auxin, cytokinins, gibberellins etc. and many metabolites which can be utilized by the plants (Gholami et al. 2018). In the current analysis, the plots treated with 50% vermicompost and 50% organic manure showed the significant results on growth of the plants compared to the plots treated with individual fertilizers. The organic manure applying separately may require more time to release N, P, K for utilization by plants. So the microbial characteristics of the vermicompost and the presence of various phytohormones in addition to the organic manure influence high growth and yield components of the plants at less duration of time (Chanda et al. 2011).

CONCLUSION

The quality of the soil is the major factor for promoting the plant growth. Our study demonstrates the effect of vermicompost on the growth and yield components of the plant *Sesamum indicum L.* The results conclude that the proper mixture of vermicompost with other fertilizers enhances the growth and yield parameters of the plant significantly. Also the use of vermicompost improves the soil quality by increasing the porosity, water holding capacity and macronutrients. The diverse microbial population in the vermicompost increases the enzymatic activities and production of various metabolites which contributes to the development and disease resistance of the plants. Therefore the strong correlation was found between vermicompost and the growth of plants which helps in agricultural sustainability. Further the organic waste materials also utilized for beneficiary role which is more economic for industrial purposes.

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