

Influence of Inorganic Fertilizer Supplemented Organic Manure (Vermicompost) on the Growth and Yield of an Edible Leguminous Plant in South India

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India.

ABSTRACT: 65 day pot culture studies with a leguminous plant *Vigna unguiculata* (L.) Walp using vermicompost prepared from abundantly available leaf materials of *Cassia auriculata* Linn + *Leucaena leucocephala* (Lam.) De Wit with cow dung (1:1:2) using the earthworm *Eudrilus eugeniae* (Kinberg) either individually (control) or in supplementation with 25,50,75 and 100% of recommended dose of NPK showed the best germination percentage (94%) and growth performance measured as shoot length (47.2cm), root length (25.7cm), leaf area index (71.27cm²), number of root nodules (62.2), fresh weight of the nodules (1.33g) and dry weight of the root nodules (0.13g), chlorophyll a content of the leaves (0.29mg/g of fresh leaf), chlorophyll b content of the leaves (17.21mg/g of fresh leaf), total chlorophyll content of the leaves (17.5mg/g of fresh leaf), fresh weight of the whole plant (34.25g) and dry weight of the whole plant (3.42g), day of first flower appearance (45), number of pods/plant (21.8), pod length (20.2 cm), number of seeds per pod (20) and dry weight of 100 seeds (16.53g) in the 50% supplementation of NPK fertilizer over the control and the 25, 75 and 100% supplementation of the vermicomposts prepared using the earthworm species *E.eugeniae* and *Eisenia fetida*, the vermicompost prepared using the former species showed higher manorial values over the latter.

KEYWORDS: Vermicompost, NPK, *Vigna unguiculata*

I. INTRODUCTION

India is basically an agricultural country and majority of the Indians are engaged directly or indirectly on agriculture and agriculture related activities. Agriculture can be defined as the practice of crop and animal production on organized land units and mankind cannot survive in large numbers without productive agriculture. Ancient records show that man had been using various kinds of organic wastes, animal and vegetable manures, sewage waste, dung and urine of animals, fowl manures, even dead animal matter, green manure crops, wood ashes, lime, salt etc for enriching the soil. However with the exponential rise in human population the necessity has arose for production of greater quantity of food and only in the early 20 century the benefit of fertilizers was fully realized and man has started to develop and use fertilizers. Though some of the developing countries have developed self sufficiency in some of the basic food crops, the over use of chemical fertilizers has caused environmental degradation and soil sickness. After a few decades of intensive agriculture now agriculturists and scientists have come to realize the importance and value of the use of organic manure for improving the fertility of the soil and also for improving the quality and quantity of the produce. Continuous use of organic manure will result in sustainable agriculture, safe food, good nutrition, animal welfare, social justice and sustainable ecosystems. It will also help in increasing income of the farmers. A growing awareness on some of the adverse economic and environmental impacts of agrochemicals in crop production has stimulated greater interest in the utilization of organic amendments such as vermicomposts or composts for crop production (Follet *et al.*, 1981)[1]. Use of such organic manures is associated with improved soil structure, enhanced

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soil fertility, increased soil microbial populations and an improved moisture holding capacity of the soil. The principal goal of agriculture is the production of high quality, safe and affordable food for an ever increasing worldwide population. Furthermore, agricultural growers and producers have the additional constraints of economic profitability and sustainability. With the increasing problems associated with the use of synthetic chemicals in agriculture, there has been an ever increasing interest in the use of native and non-native beneficial microorganisms to improve plant health and productivity while ensuring safety for human consumption and protection of the environment (Autoun and Prevost, 2005)[2].

II. METHODOLOGY

1. Vermicompost Preparation

For the present study epigeic earthworms, *Eudrilus eugeniae* (Kinberg) and *Eisenia fetida* (Savigny) were separately collected from the breeding stock of the Department of Biology, Gandhigram Rural Institute-Deemed University, Gandhigram, Tamilnadu, India and leaf materials of *Gliricidia sepium* Jacq, *Leucaena lucocephala* (Lam.) De Wit and *Cassia auriculata* Linn were collected from Gandhigram campus. The leaf materials were separately subjected to predigestion for 15 days by sprinkling water on the heap and covering it with gunny bag and turning it periodically in order to release out the initial heat produced during decomposition of organic material. The changes in temperature were observed every three days. The vermibeds were prepared by mixing predigested leaf material with cow dung (1:1) in plastic containers and the substrate was moistened to hold 60-80 percent moisture and kept for 24 hours stabilization. 20 numbers of healthy clitellate *E. eugeniae* and 30 numbers of *E. fetida* were separately introduced in the vermibeds per kilogram of the substrate. The vermicomposting trials were carried out in the rearing room with the relative humidity and the temperature of 75-85 percent and 26-28⁰ C respectively. The substrate was turned (mixed) once a week and maintained up to 60 days. The experiment was carried out with three replicates for each substrate with proper control following the experimental design of Daniel and Karmegam (2000)[3]. Based on the manurial value of the vermicomposts prepared, one vermicompost prepared using *C.auriculata* + *L. lucocephala* + Cow dung was selected for use as organic manure for pot culture studies.

2. Pot Culture Studies

Pot culture studies (65d) were conducted in the Department of Biology, Gandhigram Rural Institute-Deemed University, Gandhigram, with a leguminous plant *V. unguiculata* (L.) Walp in earthen pots, with 5 replicates, to evaluate the effect of a selected vermicompost (T5-*C.auriculata* + *L.leucocephala* + Cow dung (1:1:2) + *E.eugeniae*) on the growth performance of this pulse plant. The experimental design followed for pot culture studies is given below.

Table 1.Experimental design for pot culture studies of leguminous plant, *Vigna unguiculata* (L.) Walp

Treatment	Substrate
T0- Control	Sand + Red soil (1:1)
T1-Treatment1	Sand + Red soil (1:1) + 100 % Vermicompost
T2 -Treatment2	Sand + Red soil (1:1) + 75 % Vermicompost + 25 % NPK
T3 -Treatment3	Sand + Red soil (1:1) + 50 % Vermicompost + 50% NPK
T4 -Treatment4	Sand + Red soil (1:1) + 25 % Vermicompost + 75 % NPK
T5 -Treatment5	Sand + Red soil (1:1) + 100 % NPK

3. Seed selection, Processing and Sowing

Certified seeds of cowpea, *V.unguiculata* (Vamban-variety) were procured from Tamil Nadu Agricultural College, Tamil Nadu Agriculture University, Madurai, South India. Healthy hand sorted and undamaged seeds were washed with distilled water and then with 0.1 percent mercuric chloride and sown in pots containing the medium as given in the experimental design. All the pots were regularly watered and observed periodically for growth and yield parameters (Okaleye and Okalana, 1997)[4] i.e. germination percent, shoot length, root length, leaf area index, chlorophyll content of the leaves, number of root nodules, fresh weight of the root nodules, dry weight of the root

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nodules, fresh weight of the whole plant, dry weight of the whole plant, day of first flower appearance, number of pods per plant, length of pods, number of seeds per pod and dry weight of the seeds.

4. Growth Parameters Observed

The following growth parameters such as Germination Percentage, Shoot length, Root length, Leaf area, Chlorophyll content of the leaves, Number of root nodules, Fresh weight of the root nodules, Dry weight of the root nodules, Fresh weight of the whole plant, Dry weight of the whole plant and Appearance of first flower, Pod characteristics: Number of pods and number of seeds, Length of pods, Dry weight of seeds were done using standard procedures.

5. Statistical Analysis

The following statistical tools were used for the analyses and interpretation of the data. The experimental results are presented in the form of tables and graphs using Microsoft Excel (Version 2003 and 2007). Mean and Standard Deviation were also calculated with the help of the same tool. One-way ANOVA methods were used for the analyses using MS-DOS based software DMRT-AGRESS, 1994 (Version 7.01), PASCAL-Intel Software Solutions. The data input was done manually and computed. The output results obtained from the software indicate whether the differences between the treatments are significant (at $P < 0.05$ and $P < 0.01$) or insignificant. The Standard Error Deviation (SED), the percentage of Critical Difference (CD) values at $P < 0.05$ and $P < 0.01$ were also obtained. These values are provided in the respective tables for discussion. The treatments which show insignificant difference are grouped as on par.

III. RESULTS AND DISCUSSION

A. Evaluation of Vermicompost (Pot culture studies)

The results of the plant growth and yield performance of *V. unguiculata* in pot culture studies (65d) supplied with vermicompost supplemented with various percentage of inorganic fertilizer and in the control are given in Fig1 to 9 and in Tables 1 to 9. The germination percentage was high in Treatment 3 i.e. the pot that received 50 % vermicompost + 50 % inorganic fertilizer than in the control and other four treatments (Fig 1).

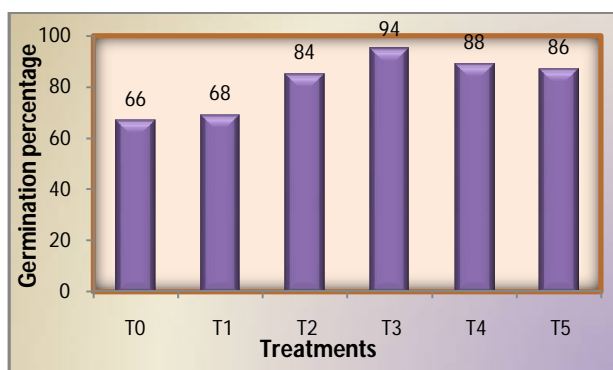


Fig1. Germination percentage of the seeds of *Vigna unguiculata* sown in pots supplied with various percentage of vermicompost supplemented with NPK fertilizer and in the control

The findings of earlier workers also agree with this finding. A germination efficiency of 93.33 percent was observed for *P. aureus* which received vermicompost when compared to the control (Karmegam *et al.*, 1999)[5]. Plant growth parameters such as shoot length, root length and leaf area index of measured on the 15, 30, 45 and 65 day were also significantly ($P < 0.05$) higher in Treatment 3 than in other treatments given in Tables 2, 3 and 4 respectively.

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Table2. Shoot length of *Vigna unguiculata* in pot culture studies supplied with various percentage of vermicompost supplemented with NPK fertilizer on 15, 30, 45 and 65d and in the control

Treatment	Shoot length at different day intervals (cm)			
	15d	30d	45d	65d
T0	7.6	15.6	24.7	31.9
T1	11.7	21.8	32.1	41.7
T2	12	22.3	32.5	42.5
T3	14.5	24.7	34.7	47.2
T4	13.1	23.2	32.9	44.1
T5	12.8	22.7	32.7	43.2
One way ANOVA				
SED	0.2840	0.3647	0.3962	0.5660
CD(.05)	0.5925	0.7607	0.8265	1.1806
CD(.01)	0.8082	1.0377	1.1275	1.6105
CV%	3.76	2.66	1.98	2.14

SED – Standard Error Deviation, CD – Critical Difference, CV – Critical Variance

Table3. Root length of *Vigna unguiculata* in pot culture studies supplied with various percentage of vermicompost supplemented with NPK fertilizer on 15, 30, 45 and 65d and in the control

Treatment	Root length at different day intervals (cm)			
	15d	30d	45d	65d
T0	6.3	10.2	13.2	16
T1	7.7	12.2	15.9	20.5
T2	8.3	12.4	17.2	21
T3	11.6	16.3	21.1	25.7
T4	9.7	13.2	17.9	22.7
T5	9.5	12.8	17.4	22
One way ANOVA				
SED	0.2058	0.3028	0.2714	0.2910
CD(.05)	0.4292	0.6316	0.5662	0.6070
CD(.01)	0.5855	0.8615	0.7723	0.8280
CV%	3.68	3.73	2.51	2.16

Table4. Leaf area index of *Vigna unguiculata* in pot culture studies supplied with various percentage of vermicompost supplemented with NPK fertilizer on 15, 30, 45 and 65d and in the control

Treatment	Leaf area index at different day intervals (cm ²)			
	15d	30d	45d	65d
T0	6.41	15.07	26.52	38.54
T1	11.21	35.13	54.56	68.52
T2	11.35	35.24	57.72	68.71
T3	12.67	36.92	56.85	71.27
T4	11.97	35.85	55.72	69.67
T5	11.92	35.54	55.57	69.54
One way ANOVA				
SED	0.0812	0.0097	0.2298	0.0079
CD(.05)	0.1694	0.0202	0.4793	0.0165
CD(.01)	0.2310	0.0275	0.6538	0.0225
CV%	1.15	0.04	0.66	0.02

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Such influence of vermicompost on the growth of plant may be attributed to better availability of plant growth promoting substances as observed by Arancon *et al.*, (2004)[6]. There is a very substantial evidence demonstrating that microorganisms, including bacteria, fungi, yeasts, actinomycetes and algae, are capable of producing plant growth regulators (PGRs) such as auxins, gibberellins, cytokinins, ethylene and abscisic acid in appreciable quantities (Frankenberger and Arshad, 1995[7] and Tomati *et al.*,1983)[8]. Vermicomposts also stimulate the rooting, and lengthening of internodes (Tomati *et al.*, 1987)[9]. In the present study vermicompost + inorganic fertilizer amended treatment in 1:1 ratio showed consistently better chlorophyll content over pots receiving vermicompost and inorganic fertilizer in four other combinations (Figs 2, 3, 4 and 5).

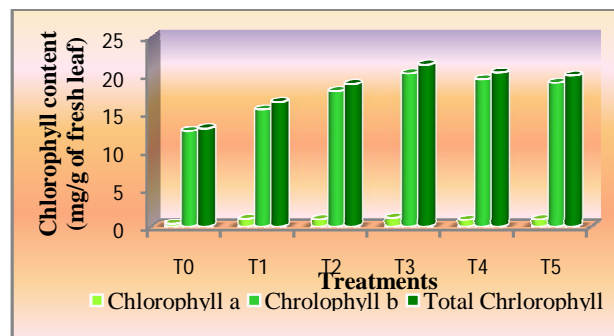


Fig2. Chlorophyll content of leaves of *Vigna unguiculata* in pot culture studies supplied with various percentage of vermicompost supplemented with NPK fertilizer and in the control on 15d

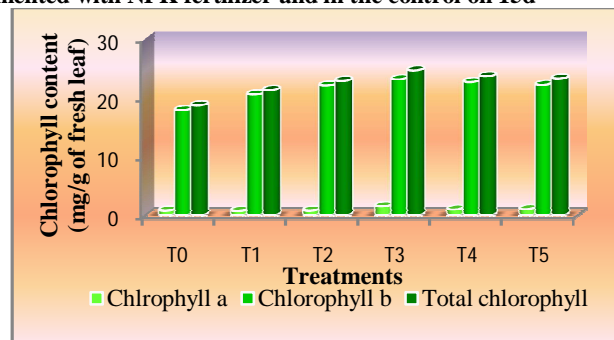


Fig3. Chlorophyll content of leaves of *Vigna unguiculata* in pot culture studies supplied with various percentage of vermicompost supplemented with NPK fertilizer and in the control on 30d

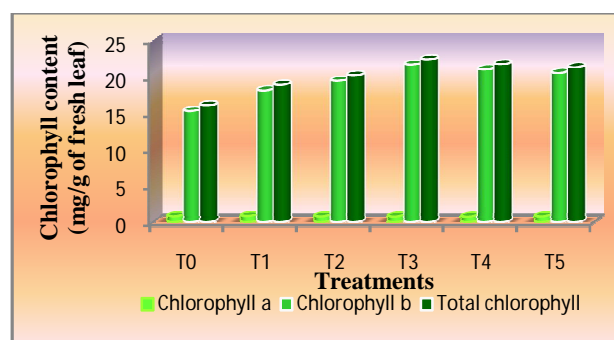


Fig4. Chlorophyll content of leaves of *Vigna unguiculata* in pot culture studies supplied with various percentage of vermicompost supplemented with NPK fertilizer and in the control on 45d

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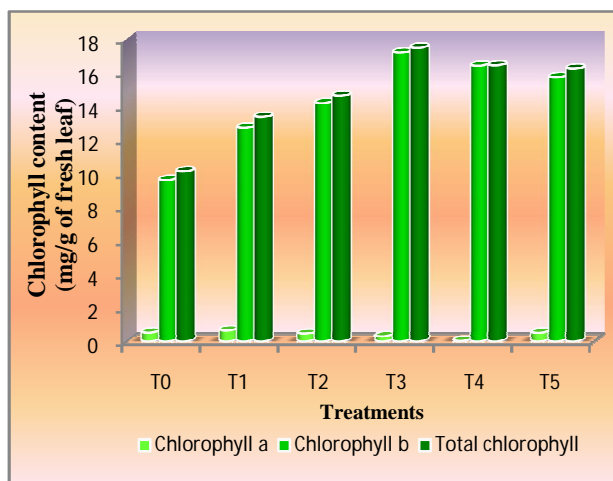


Fig5. Chlorophyll content of leaves of *Vigna unguiculata* in pot culture studies supplied with various percentage of vermicompost supplemented with NPK fertilizer and in the control on 65d

Several other studies had assessed the effect of vermicompost amendments in potting substrates on the growth of a wide range of crops (Arancon *et al.*, [10] 2003-a and Karmegam *et al.*, 1999)[5]. In the present study application of vermicompost had significantly ($P < 0.05$) influenced the number of root nodules, fresh weight of the root nodules, dry weight of the root nodules, fresh weight of the whole plant and dry weight of the whole plant of *V. unguiculata* (Table 5, 6, 7, 8 and 9)

Table 5. Number of root nodules produced by *Vigna unguiculata* in pot culture studies supplied with various percentage of vermicompost supplemented with NPK fertilizer on 15, 30, 45 and 65d and in the control

Treatment	Number of nodules at different day intervals			
	15d	30d	45d	65d
T0	5.4	10.4	17.4	25.4
T1	18.6	28.4	43.4	51.8
T2	18.6	27.4	38.4	50.8
T3	21.4	38	52	62.2
T4	20.4	36.6	50.4	61.2
T5	19.6	29.4	43.6	52.4
One way ANOVA				
SED	0.4033	0.3795	0.5228	0.5329
CD(.05)	0.8413	0.7916	1.0906	1.1116
CD(.01)	1.1476	1.0798	1.4876	1.5164
CV%	3.49	2.00	1.92	1.57

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Table6. Fresh weight of the root nodules produced by *Vigna unguiculata* in pot culture studies supplied with various percentage of vermicompost supplemented with NPK fertilizer on 15, 30, 45 and 65d and in the control

Treatment	Fresh weight of the nodules at different day intervals (g)			
	15d	30d	45d	65d
T0	0.10	0.12	0.21	0.44
T1	0.23	0.34	0.80	1.09
T2	0.22	0.44	0.82	0.94
T3	0.27	0.57	0.93	1.33
T4	0.20	0.32	0.75	1.10
T5	0.26	0.52	0.91	1.30
One way ANOVA				
SED	0.0046	0.0042	0.0068	0.0065
CD(.05)	0.0095	0.0087	0.0142	0.0136
CD(.01)	0.0130	0.0119	0.0194	0.0185
CV%	3.36	1.65	1.34	0.94

Table7. Dry weight of the root nodules produced by *Vigna unguiculata* in pot culture studies supplied with various percentage of vermicompost supplemented with NPK fertilizer on 15, 30, 45 and 65d and in the control

Treatment	Dry weight of the nodules at different day intervals (g)			
	15d	30d	45d	65d
T0	0.01	0.01	0.02	0.04
T1	0.02	0.03	0.08	0.11
T2	0.02	0.04	0.08	0.09
T3	0.03	0.05	0.09	0.13
T4	0.02	0.03	0.07	0.11
T5	0.02	0.05	0.09	0.13
One way ANOVA				
SED	0.0005	0.0007	0.0007	0.0010
CD(.05)	0.0011	0.0014	0.0015	0.0021
CD(.01)	0.0015	0.0020	0.0020	0.0029
CV%	4.05	2.85	1.42	1.48

Table8. Fresh weight of the whole plant of *Vigna unguiculata* in pot culture studies supplied with various percentage of vermicompost supplemented with NPK fertilizer on 15, 30, 45 and 65d and in the control

Treatment	Fresh weight of the whole plant at different day intervals (g)			
	15d	30d	45d	65d
T0	1.15	4.56	8.15	15.43
T1	1.86	11.30	18.42	30.21
T2	2.03	11.89	19.21	31.19
T3	2.95	13.42	22.52	34.25
T4	2.36	12.36	20.56	32.81
T5	2.21	12.19	20.20	32.34
One way ANOVA				
SED	0.0172	0.0141	0.0135	0.2324
CD(.05)	0.0358	0.0294	0.0281	0.4847
CD(.01)	0.0488	0.0401	0.0384	0.6612
CV%	1.27	0.19	0.11	1.18

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Table9. Dry weight of the whole plant of *Vigna unguiculata* in pot culture studies supplied with various percentage of vermicompost supplemented with NPK fertilizer on 15, 30, 45 and 65d and in the control

Treatment	Dry weight of the whole plant at different day intervals (g)			
	15d	30d	45d	65d
T0	0.11	0.46	0.82	0.15
T1	0.19	1.13	1.84	3.22
T2	0.22	1.22	2.20	3.23
T3	0.29	1.34	2.25	3.42
T4	0.23	1.24	2.57	3.28
T5	0.20	1.33	1.92	3.12
One way ANOVA				
SED	0.0017	0.0014	0.0060	0.0040
CD(.05)	0.0035	0.0029	0.0126	0.0084
CD(.01)	0.0048	0.0039	0.0171	0.0115
CV%	1.24	0.19	0.47	0.20

In other studies addition of vermicompost showed higher growth rate of plants, increased uptake of nutrients, increased rate of growth of beneficial microorganisms and increased rate of yield in crops like paddy, tomato, green gram and cow pea (Sivasankari *et al.*, 2010[11]; Kale and Bano, 1986[12]; Karmegam *et al.*, 1999[5]; Karmegam and Daniel, 2008[13]; Buckerfield and Webster, 1998[14] and Kale *et al.*, 1992[15] and Nagarathinam *et al.*, 2000[16]).

These results clearly indicate that plants from pots receiving vermicompost+ inorganic fertilizers had significantly ($p < 0.05$) taken lesser days for appearance of first flower and increase in number of pods produced per plant, average pod length, average number of seeds present in each pod and dry weight of 100 seeds as shown in Figs 6, 7, 8, 9 and 10 respectively.

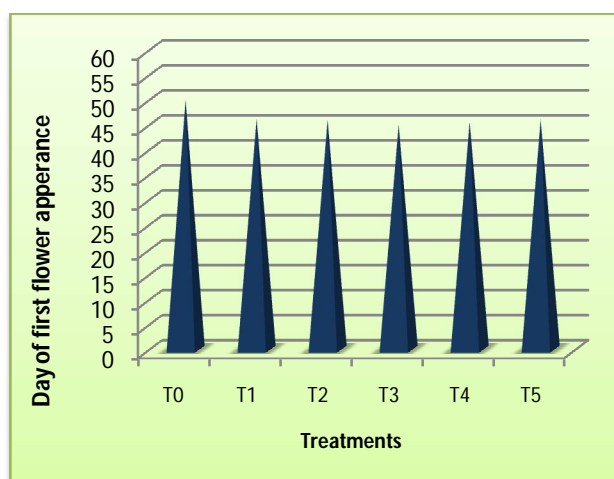


Fig6. Day of first flower appearance of *Vigna unguiculata* in pot culture studies supplied with various percentage of vermicompost supplemented with NPK fertilizer and in the control (65 d study)

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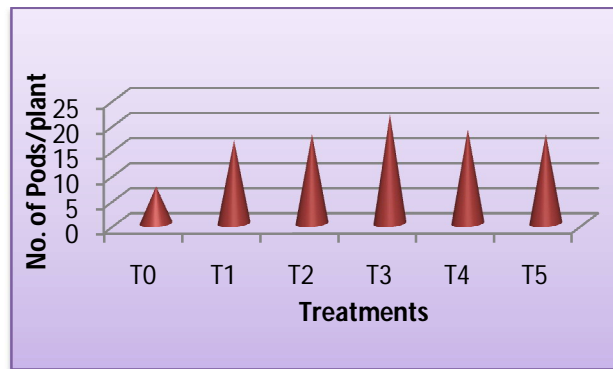


Fig7. Number of pods per plant of *Vigna unguiculata* in pot culture studies supplied with various percentage of vermicompost supplemented with NPK fertilizer and in the control (65 d study)

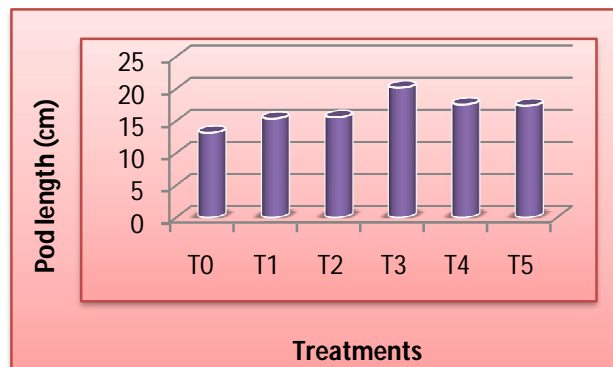


Fig8. Pod length of *Vigna unguiculata* in pot culture studies supplied with various percentage of vermicompost supplemented with NPK fertilizer and in the control (65 d study)

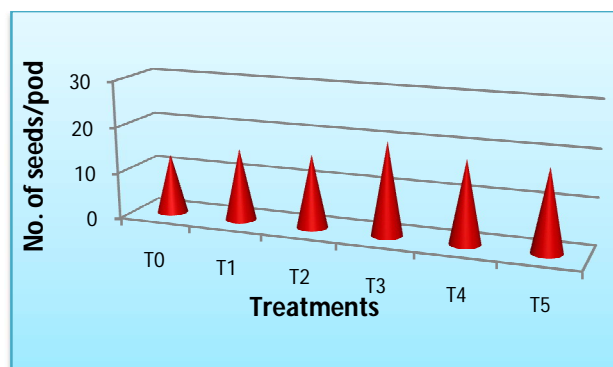


Fig9. Number of seeds per pod of *Vigna unguiculata* in pot culture studies supplied with various percentage of vermicompost supplemented with NPK fertilizer and in the control (65 d study)

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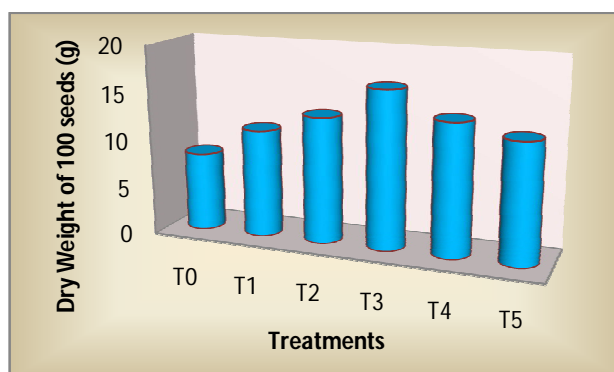


Fig10. Dry weight of 100 seeds of *Vigna unguiculata* in pot culture studies supplied with various percentage of vermicompost supplemented with NPK fertilizer and in the control (65 d study)

Ushakumari *et al* (1999)[17] reported that the yield of Okra (*Abelmoschus esculantus*) in the field applied with vermicompost as an organic source along with full recommended dose of inorganic fertilizers produced the highest yield and it was on par with in situ release of earthworms after basal application of inorganic fertilizers. The same treatments recorded enhanced yield of 105 % and 51% respectively over the cattle manure+inorganic fertilizer (NPK). Field experiment was conducted by Jadhav *et al* (1998)[18] to study the influence of in situ vermiculture and application of vermicompost and NPK fertilizer on growth and yield parameters of S41 mulberry (*Morus alba*). Vermicompost provides large particulate surface area that provides many microsites for microbial activities which helps in strong retention of nutrients (Shi-wei and Fu-Zhen, 1991[19]). As a result, most nutrients are in available forms such as nitrates, phosphates and exchangeable calcium and soluble potassium for ready absorption by plants (Orosco *et al.*, 1996)[20]. Kale and Bano (1986)[12] have shown in their studies that chemical fertilizer application along with vermicomposts increased the nutrient uptake and net production of wheat and sugarcane. The loss of N from the soil was minimized when vermicompost was the source of organic matter. Similar studies on paddy showed the possibilities of reducing the chemical fertilizer application when vermicompost was used as organic fertilizer.

The present study shows that not only the leaf litters but also the leaf materials have the potential to support vermiculture and they can be biodegraded to vermicompost in combination with animal waste, the cow dung. The vermicompost has supported the growth and yield of *V.unguiculata* replacing NPK fertilizers at all four levels of supplementation i.e. 25, 50, 75 and 100 % level. However highest yield was observed at 50 % replacement followed by 25, 75 and 100 % supplementation. No doubt that vermicomposts contained nutrients in the form available for ready absorption by the plants such as NPK and micronutrients but also other valuable microorganisms which are responsible for nitrogen fixation, phosphate solubilization and plant growth promotion. Such microorganisms are available in large numbers, species wise and genera wise. The vermicomposts, vermicasts and earthworm gut all carry valuable microorganisms essential for enhancing crop yield. Together by symbiotic and synergistic effect these microorganisms and their products make vermicompost an attractive substrate for soil health and soil enrichment. By its products while living and by its protein rich body on death, the earthworms contribute the essential nitrogen for fertilizing the soil (Ghosh *et al.*, 1999[21]; Bhattacharjee *et al.*, 2001[22]).

IV. CONCLUSION

The present study revealed that supplementation of vermicompost with chemical fertilizers would immediately benefit the farmers by increasing the yield of *V.unguiculata* and decreasing the expenditure on inorganic fertilizers. Vermicomposts can be used in place of chemical fertilizer to increase the plant growth crop yield and also improve the soil fertility. India is a land rich in diverse type of ecosystems, habitats, flora, fauna, cultivated crops, animal wastes, organic industrial wastes, culture, people, food habits, food choices and food preferences. With increase in population and health awareness of the individuals and also demand for novel healthy food, the necessity for organic food and

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tasty food prepared using the produces grown at least semi-organically will be on high demand in the coming years. The present research will add a solution for such a demand.

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