International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2017): 7.296

To Evaluate the Efficacy of Vermicompost on Green Gram– *(Vigna radiata.L)*

Dr. D. Amish Abragam[1], S. Jeyaseelan[2], Paul David Selson[3]

[1]PG & Research Department of Botany, St. John's College, Palayamkottai, Affiliated by Mononmaniam Sundaranar University, Abishekapatti, Tirunelveli, Tamil Nadu, India

[2]Research Scholar, Department of Botany, St. John's College, Palayamkottai, Affiliated by Mononmaniam Sundaranar University, Abishekapatti, Tirunelveli, Tamil Nadu, India

Abstract: ***Sustainable agriculture is one in which the goal is permanence, achived through the utilization of renewable resources. This leads to development of concept of organic natural farming. There is an increasing awareness about organic farming in view of the energy shortage, food safety and environmental concerns arising out of conventional farming. Organic farming involves harnessing of soil organism to process to animal and plant residues and to produce slow release of nutrients as needed by the crops. Earthworms can be called as biological indicators of soil fertility for millions of years before the green revolution; these silent machines have been performing a marvellous function of ploughing and fertilizing soils. The present investigation deals with effects of vermicompost on germination effiency, growth, yield and quality of Vigna radiata L.(Mung bean) were observed in the 15 days regular intervals. The growth and yield performance of Vigna radiata.L in vermicompost are significantly higher than the control.***

Keywords: Earth worms, Organic farming, Vermicompost, *Vigna radiata L.*

1. Introduction

India generates 25 million tonnes of municipal solid wastes, 320 million tonnes of agricultural wastes, 210 million tonnes of cattle manure and 3.3 million tonnes of poultry manure. Such varied types of solid wastes can be converted into useful resources by subjecting them to any type of bioconversion option such as biogas production, mushroom cultivation, vermicomposting technology, etc, of all these types, incorporation of earthworms for recycling organic wastes offers a most viable rural appropriate technology because the earthworm consumes almost 100% of their weight as wet organic wastes. Earthworms are called friend of formers or natural plough by Darwin (1981).Earthworms can be called as biological indicators of soil fertility for millions of years before the green revolution; these silent machines have been performing a marvellous function of ploughing and fertilizing soils. Darwin (1981) stated that earthworms prepare the ground in an excellent manner for the growth of fibrous rooted plants and for seedlings of all kinds. Among the soil organisms which contribute to soil fertility earthworms are the most important. When earth worms are available in soils they alter soil porosity, increase in soil air volume from 8% to 30%. and always promote plant growth,. (Wollny, 1890).

By adopting vermiculture biotechnology, we can convert any type of organic wastes into useful manure. Composting is one of the biological treatments of solid waste which is an aerobic process that converts organic wastes into humus. Vermicomposting is one of the eco-friendly technology for waste management. Vermicomposting cleans the environment and provides remunerative organic manure. Vermicompost is 100% organic safe non-toxic and odour free. It helps plants to grow faster and stronger. Earthworm can have a significant effect on soil fertility parameters, because of their ability to modify their environment (Hauster et al 1994). The Worms feed on organic material, break it down and then excrete it an worm castings or vermicomost. The castings are in the form of tiny pellets which are coated with a gel. This crumb-like structure helps improve soil drainage and aeration. The organic matter also undergoes chemical changes in the process. This makes the nutrients more readily accessible to plant roots but in a form that is slowly released when required by the plants. Studies also significant pathogen reduction in organic matter that has been through the vermicomposting process. The vermicomposting acts like a buffer for plants where soil pH levels are too high or low making soil nutrients available again to the plant. The castings are much higher in bacteria, organic material and available nitrogen, calcium, magnesium, phosphorus and potassium than soil itself. Vermicompost is biologically active and will continue to condition soils up to 4 years.

The present investigation deals with effect of vermicompost on Vigna radiata L. (Green gram). Pulses play a vital role in providing balanced protein component in the diet of the people in developing countries. Green gram is the third most important pulse crop in India. Mung bean cover an area of 3 million hectares which is about 12% of the total area under pulses in India with a production of 1.31 million tones and productivity of 425 kg/ha. Nutritionalists believe that even non-vegetarians stand to benefits by including in their diet, a reasonable quantity of pulses substitute. The role of pulses in the supply of high quality dietary protein especially by complementing the stable cereals has been legendary. They also grow in a very short period. So pulses are chosen for this present study. Some growth parameters such as shoot length, root length, intermodal length, leaf area index, length of pod, number of seeds, weight of pod and weight of seeds and some biochemical parameters like chlorophyll content, protein and sugar content were analysed.

2. Review of Literature

Kale and Bano (1986) stated that vermiculture can considerably reduce the use of other fertilizers besides improving soil fertility. Bhawalkar (1989) reported that vermiculture a promising source of biofertilizer. Sultan Ismail (1993) and Guna Thilagaraj (1994) stated that vermiculture biotechnology is a man aspect of biotechnology for clearing up environment with cost effective management technology contribution in the field of vermicompost. Edwards and Burrows (1988) Albanell et al., (1988) stated that Vermicompost contain nutrients in forms that are readily taken up by plants such as nitrates, exchangeable phosphorous, soluble potassium, calcium and magnesium, and have less soluble salts, greater cation exchange capacity and increased humic acid contents respectively. Vinceslas-Akpa and Loquet (1997) reported that the Vermicompost product had a lower organic carbon and higher nitrogen ratio, which indicates that the Vermicompost products were most suitable for soil amendment use.

Atlavinyte and Daciulyte (1969) reported the Vermi compost promote the accumulation of vitaim B_{12} in the soil. Jadhav (1996) reported a reduction of 50% of the recommended dose of nitrogen was supplemented by the use of Vermicompost.

Hopkins (1995) reported that Vermicompost increase the plant growth and development as well as crop quality significantly.Krisnamoorthy and Vijrabhiah (1986) reported that Vermicompost contain biologically active substances such as plant growth regulators. Shi-Wei and Fuzhen (1991) stated that the Vermicompost contain large surface area for retention of nutrients. Orozco et.al., (1996) reported the forms are readily taken by the plants.

Vermicompost helps the plant to fight soil – borne plant disease. Choui et al., (2002) pointed out the applications of Vermicomposts have been reported to suppress plant fungi such as Phytophthora, Fusarium and Plasmodiophora in tomatoes and cabbage, Pythium,Rhizootonia in cucumber and radish, Verticilli in strawberries. Addabdo (1995) stated that the various forms of organic matter amendments could often suppress plant parasitic nematode populations. Edward and Bohlen (1996) stated that the nursery plants grown in the biologically enhanced Vermicompost may have increased resistance to pests and pathogen.

Basker et. al., (1993) pointed out the studies carried out under field conditions indicated that the castings of earthworms contained 2-3 times more available potassium than the surrounding soil. Ellio et. al. (1990) found that earthworm castings generally have a higher ammonium concentration and water – holding capacity than bulk soil samples and they constitute sites of high denitrification potential.

Many authors have reported that Vermicompost enchance the plant growth in field soils and green house media has been attributed to a variety of factors including physicochemical properties. Chan and Griffiths (1998); Edwards and Burrows (1988); Wilson and Carlile (1989); Mba (1998); Buckerfield and Webster (1998) reported the use of Vermicompost to soil or green house container media. Edwards and Neuhauser (1988) reported increased plant growth in potting – media enhanced with Vermicompost derived from animal manures. Subler et. al., (1998) pointed out the potential use of Vermicompost in the agricultural and horticultural industries.

3. Materials and Methods

Plant Materials

Vigna radiate Linn. was taken for investigation, the details of which is given below.

Systematic position

Vigna radiata Linn.

Family	-	Fabaceae
Sub – family	-	Papilionaceae
Genus	-	Vigna(or) Phaseolus
Species	-	radiata
Popular name	-	Green gram
Tamil name	-	Patchai Payaru

Collection of seeds

Seeds of *Vigna radiata* Linn. was purchased from agricultural extension centre, Alangulam, Tirunelveli, Tamilnadu.

Collection of Vermicompost

Vermicompost is a balanced plant nutrient. It was purchased from Sri Paramakalyanki center for Environmental Sciences, Manonmanium Sundaranar University, Alwarkurichi, Tirunelveli, Tamilnadu.

Experimental set up

The experiment was carried out the pots in the medium designed with the following permutations.

C - Control (sand without any treatment)

R1 V- Vermi compost (5kg sand+ 2kg vermicompost)

R2 FYD- Farm Yard Manure (5kg sand+2kg Farmyard manure)

R3 CF -Chemical Fertilizer (5kg sand+ 2kg chemical fertilizer)

Selection and Treatment of seeds

The certified seeds of the pulse crop Vigna radiata Linn. selected for the study were purchased from the Agricultural Extension Center, Alangulam. The selected seeds were washed with deionised water and surface sterilized with 0.1% mercuric chloride solution to keep off from spores of fungi and was sown in pots.

Analysing the morphological and biochemical parameters of the plants

Plants cultivated in the pots were watered regularly. The following morphological characteristic of the plant were observed in every fifteen days interval. For biochemical analysis the samples were collected in fully matured healthy experimental plants.

The following morphological characters are studied

1) Germination Percentage (No. of seeds germinated/ Total No. Of seeds sowed)

2) Shoot length (cm)
3) Root length (cm)
4) Inter nodal length (cm)
5) Leaf area index (sq.cm) (By using leaf area meter)
6) Length of pod (cm)
7) Number of seeds / per pod
8) Weight of pod (gm) / per pot
9) Weight of seeds (gm) /per pot

The following biochemical parameters are analysed

1) Protein (Lowry's method,1951)
2) Starch (Lugols Iodine method)

4. Results and Discussion

In the present investigation, the effect of Vermicompost on Green gram (*Vigna radiate* Linn.) and several growth and yield parameters were analysed in control, vermicompost treated soil, as well as other experimental samples. Some chemical parameters were analysed in all experimental samples.

I. Growth Parameters

1. Germination Percentage

The germination percentage of the Green gram was observed on 15th day from sowing of seeds and presented in Table – 1.& Fig. -1. In this present study the germination percentage was observed in Green gram in the control, Vermicompost treated soil (R1) Farm Yard treated soil (FYM) and chemical fertilizer treated soil.On the 15th day the germination percentage of Green gram in the control was 58%, R1 sample -87%, R2 sample – 84% and R3 sample – 81%. Mc Coll et.al.,(1982) have observed the similar results of seed germination and plant nutrient absorption capacity of wheat in the application of earthwarm humic matter on loamy soil.

2. Shoot Length:

The shoot length of the Green gram grown in pots with different samples are given in Table 2 and Fig 2.The shoot length was observed in every 15th day interval. The shoot length of green gram was higher in vermicompost treated soil (R1 sample) than the other experimental samples. Applications of casts showed significant increase in the length and weight of the shoot and root systems of the Sorghum plant (Reddy et al., 1994).

3. Root Length

The root length of the Green gram was recorded and presented in Table – 3 and Fig.3. The length of the shoot and root has increased steadily during the growth of plants. The maximum shoot length and root length was recorded in R1 sample over control and other experimental samples. Nijawan and kanwar (1952) have observed similar results of increased root length than the control in the application of earthworm compost to wheat and many other crop plants. A similar effect in Salvia and Aster grown in the plots was observed by Grappelli et al: (1985). Increase in crop growth due to transport of minerals and other compounds from deep down to the surface soil by the earthworms were found by Sharma (1986). Grappelli et al; (1985) concluded the enhancement of root initiation, root elongation, root biomass and rooting percentage by vermicompost.

4. Internodal Length

The Internodal length of Green gram in each treatment is listed in Table -4 and Fig.-4. In this work, the intermodal length was observed in Green gram in the control, R1, R2 and R3sample in every 15th, 30th and 45th day intervals. The Internodal length was higher in vermicompost treated soil plant (R1 sample) than the control, R2, and R3 sample on the 15th, 30th and 45th day intervals.

The analysis shows that the intermodal length was more in the R1 sample than the control, R2, and R3 sample. Reddy et al; (1994) found that the plant height and biomass of sorghum were significantly higher when applied with earthworm casts and soil mixture than soil alone.

5. Leaf area index

The leaf area index of the Green gram grown in pots with different samples is given in Table -5 and Fig.5 Among the experimental samples the vermin compost treated sample (R1 sample) had higher leaf area index. Leaf being the major site of photosynthesis, the increased surface area of photosynthesis, the increased surface area of leaves and its longevity might be attributed to the enhancement of plant growth and development during its ontogeny by endogenous growth hormonal systems (Parvatham, 1990).

6. Pod Length

The pod length of the Green gram in all the treatments are given in Table.6 and Fig.6. In this present study, the pod length of Green gram in the control, R1, R2 and R3 were measured on the 60th day. The pod length was 3.8cm, 8.2cm, 6.3cm, and 7.1cm, respectively. The pod length was higher in the plants grown in vermicompost treated soil (R1 sample). Hoppkins (1949) stated that the increase in yield of crop plants was attributed to the release of beneficial chemicals from the bodies of earthworms.

7. Number of seeds (Per Pod)

The number of seeds per pod in each treatment is listed in Table.7 and Fig.7. In this work, the number of seeds (per pod) found in the control, R1, R2 and R3 was 3, 8, 4 and 4 respectively. The vermicompost treated soil (R1 sample) plant has more number of seeds than the other experimental samples. Edwards and Bates (1992) found that earthworms significantly increases the number, growth rate and yield of green gram.

8. Weight of Pod (Per Pot) :

The weight of pod per pot in all the treatments are given in Table.8 and Fig.8. In the present study, the weight of pod (per pot) was observed in Green gram in the control, R1, R2and R3. The values are found to be 15gm, 39gm, 25gm and 29gm, respectively. The vermicompost treated soil plants (R1 sample) have increased weight of pod. Kale (1998) recommended the optimum amount of vermicompost without chemical fertilizers for some crops for optimum yield as 15 tonnes for tomato, 10 tonnes for bringal and carrot, 8 tonnes for radish and coriander, 12 tonnes for bhendi and 3 tonnes for cowpea per acre. The increased yield found by Neilson (1965) may be due to the presence of plant growth promoting compounds elaborated by earthworms and their castings.

9. Weight of seeds (per pot)

The weight of seeds per plot in each treatment is given in Table -9 and Fig.9. In this work, the weight of seeds per pot was observed in the control, R1, R2 and R3. The values obtained are 10gm, 29gm, 20gm, 14gm respectively. The weight of seeds was more in the vermicompost treated soil plant (R1 sample). Increase in yield upto 36% to 48% due to the application of verimicompost over control has been reported by Gunjal and Nikam (1992).

II. Biochemical Parameters

1. Protein Content

The protein content of the Greem gram in each treatment is listed in table 11 and Fig.11. In R1 sample, the protein content had increased gradually and reached a maximum of 72.5. µg/ml on the 60th day. On 60th day the control plants had minimum protein content (28.8 µg/ml). The vermicompost treated soil (R1 sample) plants had maximum protein content than the other experimental samples. Bapat et.al., (1986) pointed out increased amount of **S** and **P** application in green gram leads to increased protein content while **S** alone increase the amount of methionine, cysteine contents in green gram grain. Very rich source of S and P present in vermicompost.

2. Starch Content

The starch content of the Green gram in all the treatments is given in Table 12 and Fig.12. In R1 sample, the maximum starch content (89.1 µg/ml) was recorded on 75th day. The control plants had minimum starch content (62.0 µg/ml) on the same day. Bhagat et. al., (1995) studied the effect of vermicompost and their growth regulators on yield and quality attributes mainly the sugar content of green gram.Vermicompost contain more amount of nutrients such as nitrogen, sulphur, potassium, phosphorous, calcium, magnesium etc.

Table 1: Germination Percentage of Green gram

Sl.No	Sample	Germination Percentage of Green gram
1.	Control	58
2.	R1	87
3.	R2	84
4.	R3	81

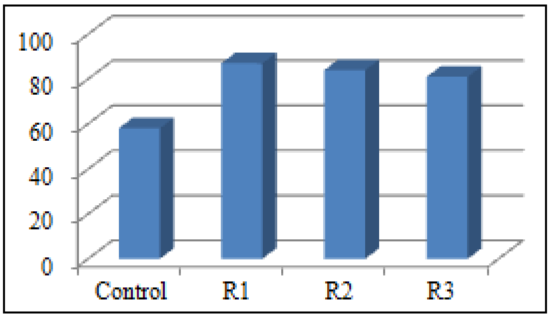


Figure 1: Germination Percentage of Green gram

Table 2: Shoot Length of Green gram

Table 4: Internodal Length of Green gram (cm)

S. No	Sample	Internodal Length of Green gram (cm)		
		15th day	30th day	45th day
1.	Control	2.1	5.9	9.7
2.	Vermi Compost	4.1	9.1	12.6
3.	Farm Yard Manure	3.8	7.0	11.6
4.	Chemical Fertilizer	3.5	6.6	10.7

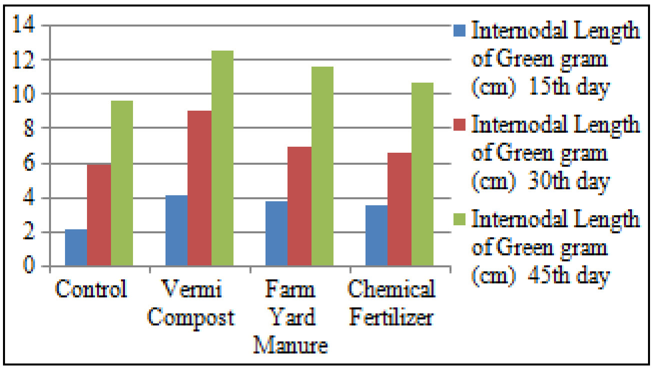


Figure 4: Internodal Length of Green gram (cm)

Table 5: Leaf Area Index of Green Gram

S.No	Sample	Germination Percentage of Green gram				
		15th day	30th day	45th day	60th day	75th day
1.	Control	3.63	9.06	15.37	17.8	19.2
2.	R1	15.86	21.81	45.11	49	59
3.	R2	9.43	17.96	31.39	38.5	57.32
4.	R3	5.38	12.13	20.68	37.3	56.85

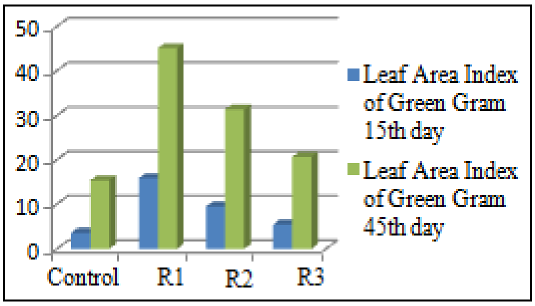


Figure 5: Leaf Area Index of Green Gram

Table 6: Pod Length of Green Gram

S. No	Sample	Pod Length of Green Gram
1.	Control	3.8
2.	R1	8.2
3.	R2	6.3
4.	R3	7.1

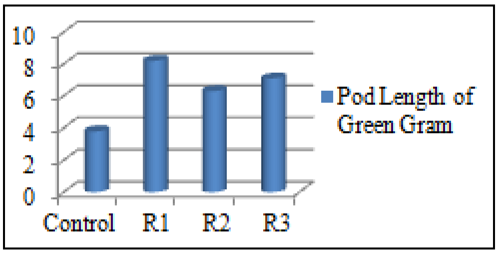


Figure 6: Pod Length of Green Gram

Table 7: Number of Seeds (Per Pod)

Sl.No	Sample	Number of Seeds (Per Pod)
1.	Control	3
2.	R1	8
3.	R2	4
4.	R3	4

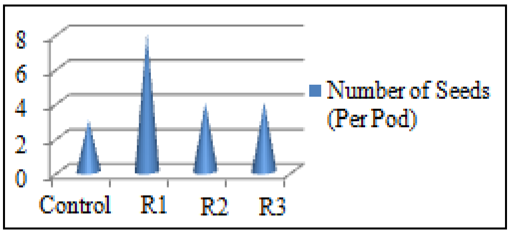
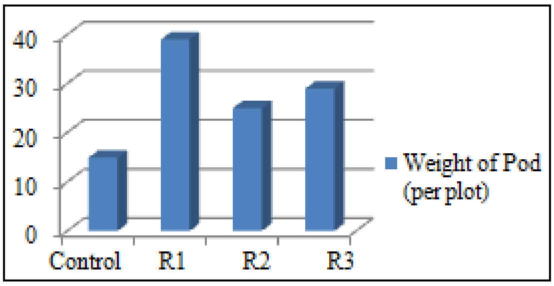


Figure 7: Number of Seeds (Per Pod)

Table 8: Weight of Pod (per pot)

S. No	Sample	Weight of Pod (per pot) gm
1.	Control	15
2.	R1	39
3.	R2	25
4.	R3	29



Weight of Pod (per pot)

Table 9: Weight of Green gram (per pot in gm)

S. No	Sample	Weight of Green gram (per plot in gm)
1.	Control	10
2.	R1	29
3.	R2	20
4.	R3	14

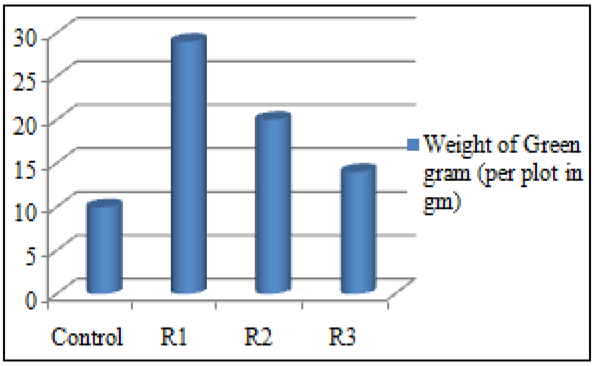


Figure 9: Weight of Green gram (per pot in gm)

Table 10: Protein Content of Green Gram

S. No	Sample	Protein Content of Green Gram			
		15th day	30th day	45th day	60th day
1.	Control	6.9	14.6	19.3	28.8
2.	R1	45.6	52.6	60.3	72.5
3.	R2	34.5	44.3	49.7	69.8
4.	R3	20.6	27.3	35.3	70.3

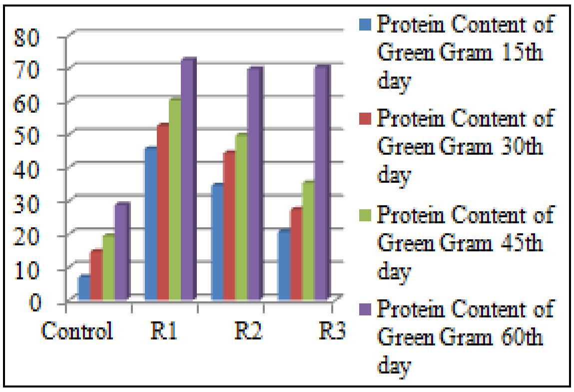
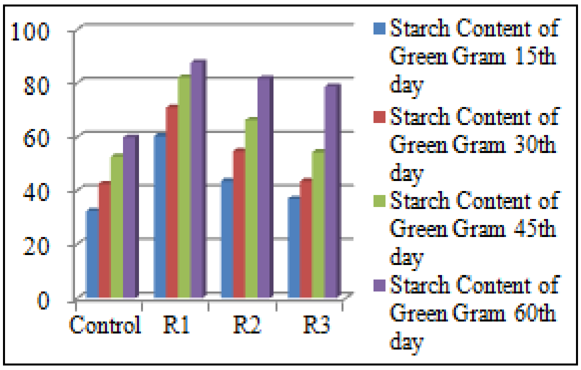


Figure 10: Protein Content of Green Gram

Table 11: Starch Content of Green Gram

S. No	Sample	Starch Content of Green Gram				
		15th day	30th day	45th day	60th day	75th day
1.	Control	32.4	42.5	52.7	59.8	62.0
2.	R1	60.3	71.02	82.02	87.6	89.1
3.	R2	43.5	54.7	66.4	81.6	82.0
4.	R3	36.9	43.5	54.3	78.7	81.0



Starch Content of Green Gram

5. Conclusion

The present investigation reveal that pulses grow much faster in vermicompost treated soil than the control and other experimental samples. Seed germination percentages, shoot, root, intermodal and pod length, leaf area, number of seeds, weight of pod and seeds seem to be promoted in Green gram during the growth period in vermicompost. Control plants had minimum growth in all experiments during all the stages of growth. Then the above results suggest that the vermicompost treated plants (R1 sample) had higher chlorophyll, protein and starch content when compared to the control and other experimental samples.

6. Future Scope

The yield of green gram is limited chiefly due to plant nutritional problem, which is the ubiquitous shortage of total and available nitrogen to the plants especially during seedling establishment. Growth, yield and quality of Mung bean could be improved by application of organing manures to encourage the farmers.

Extension and demonstration programme need toprovide encouragement to utilize material with lower C:N ratios as added organic manures especially vermicompost to derive the maximam benefits. Increased Mung bean production in the country can serve a very useful purpose in this direction.

References

[1] Addabdo, T.D. 1995 The nematicideal effect of Organic amendments: a review of literature 1982-1994 Nemendments : a review of the literature 1982-1994 Nematologia Mediterranea 23:299-305
[2] Albanel, E.Plaixat, J and Cebrero, T. 1988, Chemical changes during vermicompostiong (Eisenia foetida) of sheep manure mixed with cotton industrial wastes, Biology and Fertility of Soils .PP 266-269
[3] Atlavtive O and Daciulyte, J.1969 the effect of earthworms on the accumulation of vitamin B12 in soil. Pedobiologia 9 : 165-170
[4] Bapat , P.N.Sinha, S.B and shinde D.P.1986 Effect of S and P on yeled and mutrient content of black gra. J. Indian Soc soil Sci.34:82-85
[5] Basker, A and Macgregor, a.N 1993 Exchangeable potassium and other cations in non – ingested soil and casts of 2 species of pasture earthworms, Soil. Biol. Biochem 25: 1673-1677
[6] Bhagat, D.V, Yadava H.S and Dixit, J.P. 1995 Effect of mutrients and growth regulators on yeild and quantity attribute of Black gram. J.Soil and Crops 5(1) : 18-21.
[7] Buckerfield J.C. and webster, K.A 1998 Worm – worked waste boosts grape yeilds : Prospects for vermicompost use in Vineyareds. Australian and New Zealand Wine Industry Journal 13:73-76.
[8] Darwin, C. 1981. The formation of vegetable mould through the action of worms, with observation of their habits, Murray: London . P.326.
[9] Edwards, C.A Burrows, I Fletcher, K.E and Jones, B.A. 1985 The Use of earthworms for composting farm wastes. In Gasser J.K.R (ed) composting Agricultrual and other wastes Elsevier London and New York ; 229-241.
[10] Edwards C.A. and Burrows, 1 (1988. The potential of earthworm composts as plant growth media. In : Edwards, C.A Neuhauser , E. (eds) Earthworms in waste and Environmental Management SPB Acadmic Press The Hague, The Netherlands, PP 21-32.
[11] Edwards, CA and Neuhauser, E.F 1988. Earthworms in waste and Enviromental management 392 PP. SPB Academic publishing, The Hague.
[12] Edwards, C.A and Bates; J.E. 1992. The use of earthworms in enviromental management Soil Biol Biochem 14(12); 1683-1689.
[13] Edwards, C.A and Bohlen, P.J. 1996. " Biology end Ecology of Earthworms". Third Edition 426 PP. Chapman and Hall London.
[14] Ellio. P.W.Knight. D and Anderson, J.M.1990. Denitrifiction of earthworm casts and soil from pastures under different fertilizer and draingeregimes. Soil Biol. Biochem.22(5) : 601-605.
[15] Grappelli.A Tomati, V and Galli, E. 1985. Earthworm casting in plant propagation. Horti Sci . 20:874-876.
[16] Guna thilagaraj 1994. Vermicompost for Substainable agriculture, The Hindu April – 6.
[17] Hopkins, W.G. (E.d.), 1995. Introduction to plant physiology wiley, New York, PP.49.
[18] Jadhav, A.D. 1996 Effect of Farmyard manure and vermicompost on the yeild of rice (Oryza sativa) and physicochemical properties of Laterite soils of Konkand , M.Sc Thesis Submitted to the KKU. Depoli.
[19] Kale, R.D and Bano. K. 1986 Feild trials with vermicompost (Vee Com P.E. 83 VAS) an Organic fertilizer. In : Proc. Nat. sem. Orga. Waste utilization vermicomposting paper II verms and vermicomposting Dash, M.C.Senapathi, B.K and Mishra P.C. (eds) 151-156.
[20] Kale, R.D. 1998b. Earthworm Cinderalla of Organic farming, Primson Books Pvt. Ltd., Bangalore 88.
[21] Krishnamoorthy, R.V and Vajrabhiah, S.N 1986 Biological activity of earthworm casts. Proceedings of the Indian Academy of Sciences (Animal Science) 95: 341-351.
[22] Mc.Coll, H.P. Hark, P.B.S and Cook, F.J 1982. Influence of earth worm on some chemical properties and the growth of eye grass on a top soil stripping. New Zealand. J of Agri. Res. 25:239-343.
[23] Neilson, R. 1965 Presence of plant growth substances in earthworms demostratred by paper chromatiography and the went Pea Test. Nature 208 (5015) : 1113 -1114.
[24] Nijhawan, S.D and Kanwar, J.S 1952. Physicochemical properties of earthworm castings and their effects on the productivity of soil. Indian J.Agri. Sci.22:257 – 373.
[25] Orazco, F.H. Cegarra, J.Trujillo, L.M and Roig, A.1996 Vermicomposing of coffee pulp using the arthworm Eisenia foetida: effect on C and N contents and the availability of nutrients. Biology and fertility of Soil 22: 162-166.
[26] Parvatham, P .1990 Studies on phyto hormonal effect on Azospirillum brasilense on Brailense on Bhendhi (Abelmoschus esculenius L.Moench). M.Sc Thesis. Tamil Nadu Agricultural University coimbatore 42-48.
[27] Sharma, N. 1986. recycling of organic wastes through earthworms for crop growht. Ph.D Thesis submitted to Indian Institute of Technology. New Delhi.
[28] Shi – Wei. Z and Fu – Zhen, H .1991. the nitrogen uptake effciency from 15 N labeled chemical fertilizer in the presence kof earthworm manure (cast) In : Veeresh, G.K Rajagopal, D.Viraktmat C.A. (Eds) Advances in management and conservation of Sill fauna oxford and IBH publishing Co., New Delhi, Bombay P. 539-542.
[29] Sultan Ismail, A1993. Composing through earthworms. Shri A.M.M. Murugappa Chettiar Research Centre. Tharamani Madras MCRC Publicatin.
[30] Vinceslas – Akpa M and Lquet, M. 1997. Organic matter transformations in lignocellulosic waste products composted or vermicomposed (Eisenia foetida anderi) Chemical analysis and ^{13}C CPMAS NMR spectroscopy, Soil Biol and Bichem 29: 751-758.