

Influence of Organic Manuring on the Post Harvest Soil Quality of Chickpea and Radish Grown After Chickpea

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Abstract	Article Information
<p>The quality of a soil is defined in terms of its physico chemical and biological parameters. These characters depend on the supplement provided to the soil in terms of organic and inorganic amendments. It also reflects the soil fertility status which has a high influence on the production of crops. Applications of organic ingredients like composts, vermicomposts and other organic sources have an influence on the productivity of soil and for further sustainable agricultural productivity. The present study was conducted with an objective to assess the influence of different organic sources like composts and vermicomposts prepared from parthenium and poultry manure on post harvest soil of chickpea (<i>Cicer arietinum</i> var.Co 1) and radish (<i>Raphanus sativus</i> var. pusa chetki) and compared with control red soil and recommended dosage of NPK. The chickpea after harvest was incorporated into soil and radish was then grown in that soil. The post harvest soil characters like macro and micro nutrients were assessed after harvesting chickpea and then radish. The post-harvest soil of chickpea had a higher total nitrogen content in composted poultry droppings at 35.0 g per pot and vermicomposted poultry droppings at 43.75 g per pot, phosphorus in vermicomposted poultry droppings at 43.75 g per pot and N : P : K and potassium in vermicomposted poultry droppings at 43.75 g per pot. The zinc was more in vermicomposted parthenium at 26.25 g per pot, vermicomposted poultry droppings at 43.75 g per pot and N: P: K application, copper was high in red loamy soil (control), iron was also observed to be more in control (Red loamy soil) and N: P: K whereas manganese was high in composted parthenium at 35.0 g per pot and 43.75 g per pot. Radish grown with chickpea as green manure had higher N, P and K in vermicomposted poultry droppings at 43.75 g per pot. The micro nutrients zinc and copper were more in vermicomposted poultry droppings at 35.0 g per pot and 43.75 g per pot. Iron was more in T₁₅, N : P : K whereas manganese was more in composted <i>Parthenium</i>. Summing up the salient findings of the present investigation, it can be stated that the toxic weed <i>Parthenium</i> and organic waste poultry droppings can be converted into valuable manures which can promote crop production by improving the soil fertility.</p>	<p>Article History:</p> <p>Received : 15-12-2014</p> <p>Revised : 27-02-2015</p> <p>Accepted : 05-13-2015</p> <hr/> <p>Keywords:</p> <p>Organic Manures</p> <p>Compost</p> <p>Vermicomposts</p> <p>Poultry Manure</p> <p>Parthenium</p> <p>Soil Quality</p> <hr/> <p>*Corresponding Author:</p> <p>Hiranmai Yadav R</p> <p>E-mail:</p> <p>mavahiranbt@gmail.com</p>
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INTRODUCTION

Composting is a process whereby the organic materials are aerobically transformed into a product that can be applied to soil without any detrimental effects. Vermicomposting is the biotechnological process where earthworms are used to convert the waste materials and produce a quality product. It contains macro and micro nutrients like nitrogen, phosphorus, potassium calcium, magnesium, iron, manganese and zinc. These nutrients have positive effect on the plant growth, yield, soil fertility and soil microbes (Tharmaraj *et al.*, 2011).

The organic amendments like composts and vermicomposts have a positive influence on the quality of soil. Angelova *et al.* (2013) carried out a study to assess the effect of compost and vermicomposts applications on the physico chemical properties of soil and their efficiency to reduce the metal toxicity. They observed that application of these organic manures had a significant

influence on the soil properties. The amendments have shown apparent increases in the organic matter, macro and micro nutrient contents. They also reported that the amendments decreased the heavy metals concentration in the soil which might be caused due to immobilization by the humic substances from compost and vermicomposts application. These findings support the utility of organic amendments for reducing the metal toxicity and phyto remediation ability.

The utilization of composts are efficient in improving soil aggregation, structure and fertility, increasing microbial diversity and populations, improving the moisture holding capacity of soils, increasing cation exchange capacity and leading to better crop yields (Zinc and Allen, 1998). Many researchers have documented the quality of vermicomposts in terms of their efficiency for improving soil quality and thereby the plant growth.

Orozco *et al.* (1996) have reported that vermicomposts contains most nutrients in plant available forms such as nitrates, phosphates and exchangeable calcium and soluble potassium. According to Edwards (1998) they influence the growth and productivity of plants. The experiments conducted with vermicomposts under green house and field have also resulted in improved growth and yield of cereals and legumes, vegetable, ornamental and flowering plants and various field crops (Chan and Griffiths, 1988; Atiyeh *et al.*, 2000; Arancon *et al.*, 2004).

In a bioremediation study using vermitechnology, there was considerable improvement in the soil quality which establishes the importance of vermicomposts application for soil properties. This method of reclamation was found to be sustainable (Ansari, 2008). Vermicomposts and composts are prepared using organic constituents which are piled and moistened and permitted to undergo a thermophilic decomposition resulting in an end product rich in humus and microbial populations. They also contain plant available form of nutrients and growth hormones. The vermicomposts also provides protection against various plant diseases (Moradi *et al.*, 2014).

Jayakumar *et al.* (2011) have reported that the vermicomposted turkey litter applied paddy plots have improved the electrical conductivity, nutrients like total nitrogen, potassium, phosphorus, calcium, manganese, copper, iron and zinc. The paddy growth and yield were observed to be improved and the microbial population was also increased due to the vermicomposts application. The present study was conducted to evaluate the effect of composts and vermicomposts prepared from *Parthenium* and poultry manure on the post harvest soil of chickpea and its residual effect on radish grown after incorporating chickpea into soil.

MATERIALS AND METHODS

A pot culture experiment was carried out to assess the effect of fresh, composted and vermicomposted *Parthenium* and poultry droppings on the post harvest soil

physico chemical parameters of chickpea grown soil and radish grown after incorporating chickpea into the soil. The experiment was set up in a completely randomized design with three replications.

The treatment details were as follows,

- T₀: Control – Red loamy soil (7 kg)
- T₁: Fresh *Parthenium* at 35 g per pot
- T₂: Composted *Parthenium* at 26.25 g per pot
- T₃: Composted *Parthenium* at 35.0 g per pot
- T₄: Composted *Parthenium* at 43.75 g per pot
- T₅: Vermicomposted *Parthenium* at 26.25 g per pot
- T₆: Vermicomposted *Parthenium* at 35.0 g per pot
- T₇: Vermicomposted *Parthenium* at 43.75 g per pot
- T₈: Poultry droppings at 35.0 g per pot
- T₉: Composted poultry droppings at 26.25 g per pot
- T₁₀: Composted poultry droppings at 35.0 g per pot
- T₁₁: Composted poultry droppings at 43.75 g per pot
- T₁₂: Vermicomposted poultry droppings at 26.25 g per pot
- T₁₃: Vermicomposted poultry droppings at 35.0 g per pot
- T₁₄: Vermicomposted poultry droppings at 43.75 g per pot
- T₁₅: N : P : K

Soil Sample Analysis

The soil samples were collected after harvesting the chickpea and radish, then dried in shade and crushed and made to pass through 2mm sieve for soil sample analysis. The nitrogen (Micro kjeldahl method by Humphries, 1956), phosphorus (Jackson, 1973), potassium (Piper, 1966) and micro nutrients namely, iron, zinc, manganese and copper (Jackson, 1973) were analysed for these samples. The data collected from the different analyses were subjected to statistical analysis as per the procedure outlined by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Post-Harvest Soil Analysis

Chickpea (*Cicer arietinum*)

The profiles of the macro and micronutrients in the post-harvest soil were analyzed and depicted in Table 1

Table 1: Macro and micronutrients of post-harvest soil of *Cicer arietinum* as influenced by fresh, composted, vermicomposted *Parthenium hysterophorus* and poultry droppings

Treatments	Available nutrients (g kg ⁻¹)				Micronutrients (ppm)		
	Nitrogen	Phosphorus	Potassium	Zinc	Copper	Iron	Manganese
T ₀	0.44	0.03	0.75	1.11	1.34	4.23	5.97
T ₁	0.48	0.04	0.83	1.19	1.25	3.57	6.20
T ₂	0.48	0.07	0.82	1.17	1.26	3.53	6.20
T ₃	0.48	0.06	0.81	1.19	1.28	3.50	6.80
T ₄	0.51	0.05	0.83	1.17	1.25	3.27	6.80
T ₅	0.49	0.05	0.83	1.24	1.27	3.00	5.97
T ₆	0.50	0.06	0.82	1.19	1.27	3.60	6.13
T ₇	0.49	0.04	0.82	1.16	1.26	3.67	6.07
T ₈	0.50	0.06	0.80	1.17	1.27	3.17	6.20
T ₉	0.51	0.07	0.82	1.19	1.25	3.23	6.23
T ₁₀	0.57	0.05	0.81	1.19	1.26	3.23	6.10
T ₁₁	0.45	0.08	0.81	1.18	1.28	3.07	6.20
T ₁₂	0.47	0.05	0.82	1.16	1.29	3.37	6.13
T ₁₃	0.48	0.06	0.82	1.18	1.28	3.43	6.20
T ₁₄	0.57	0.12	0.88	1.24	1.30	3.47	6.13
T ₁₅	0.47	0.12	0.83	1.24	1.27	4.23	6.33
SEd	0.02	0.01	0.01	0.01	0.02	0.15	0.13
CD (0.05)	0.04	0.02	0.03	0.03	0.03	0.31	0.27

SEd – Standard Error Deviation ; CD – Critical Difference ; DAS – Days After Sowing

Macronutrients

Among the various applications, T₁₀ (Composted poultry droppings at 35 g per pot) and T₁₄ (Vermicomposted poultry droppings at 43.75 g per pot) registered the highest N content (0.57 g kg⁻¹) in the soil after harvest. Highest P content was observed in T₁₄ and T₁₅, N : P : K (0.12 g kg⁻¹) among the treatments. T₁₄ recorded the highest value of 0.88 g kg⁻¹ of K among the different treatments. From the results it could be observed that vermicomposted poultry droppings at 43.75 g per pot application have improved all the macro nutrients of the soil.

Micronutrients

Maximum zinc content was found in T₅, Vermicomposted *Parthenium* at 26.25 g per pot, T₁₄ and

T₁₅ (1.24 ppm). Maximum copper content was in T₀, control soil (1.34 ppm) compared to treated plants. Iron content was higher in T₀ and T₁₅ (4.23 ppm) compared to other treatments. Higher manganese content was recorded in T₃, Composted *Parthenium* at 35.0 g per pot and T₄ Composted *Parthenium* at 43.75 g per pot (6.80 ppm) soils among the applications. The decomposed *Parthenium* have an influence on the micro nutrients content.

Radish (*Raphanus sativus*) Grown after Incorporating Chickpea

The profile of available macronutrients and micronutrients of the soil is given in Table 2.

Table 2: Macro and micronutrients status of post-harvest soil of *Raphanus sativus* as influenced by fresh, composted, vermicomposted *Parthenium hysterophorus* and poultry droppings

Treatments	Available nutrients (g kg ⁻¹)			Micro nutrients (ppm)			
	Nitrogen	Phosphorus	Potassium	Zinc	Copper	Iron	Manganese
T ₀	0.44	0.03	0.77	1.10	1.21	4.17	5.63
T ₁	0.45	0.04	0.81	1.18	1.26	3.70	6.20
T ₂	0.47	0.06	0.83	1.18	1.28	3.77	6.27
T ₃	0.48	0.06	0.83	1.20	1.27	3.77	6.60
T ₄	0.49	0.04	0.83	1.17	1.28	3.77	7.07
T ₅	0.47	0.06	0.82	1.24	1.25	3.60	6.40
T ₆	0.48	0.04	0.84	1.18	1.36	4.17	6.20
T ₇	0.46	0.07	0.84	1.17	1.31	3.73	7.07
T ₈	0.45	0.04	0.82	1.18	1.29	3.20	7.07
T ₉	0.45	0.06	0.83	1.24	1.27	3.40	6.10
T ₁₀	0.46	0.05	0.85	1.20	1.28	3.27	6.33
T ₁₁	0.44	0.05	0.83	1.18	1.28	3.37	6.53
T ₁₂	0.46	0.07	0.82	1.24	1.29	3.13	6.40
T ₁₃	0.45	0.06	0.81	1.18	1.28	3.17	7.07
T ₁₄	0.44	0.06	0.82	1.24	1.28	3.13	6.23
T ₁₅	0.53	0.09	0.89	1.17	1.15	4.17	6.27
SEd	0.02	0.01	0.01	0.01	0.02	0.14	0.18
CD (0.05)	0.04	0.02	0.02	0.03	0.03	0.28	0.36

SEd – Standard Error Deviation ; CD – Critical Difference ; DAS – Days After Sowing

Macronutrients

Among different treatments T₁₄, Vermicomposted poultry droppings at 43.75 g per pot exhibited increase in contents of nitrogen (0.58 g kg⁻¹), phosphorus (0.09 g kg⁻¹) and potassium (1.00 g kg⁻¹).

Micronutrients

T₁₃ Vermicomposted poultry droppings at 35.0 g per pot and T₁₄ Vermicomposted poultry droppings at 43.75 g per pot were found to contain higher contents of zinc (1.26 ppm) and copper (1.40 ppm). Highest iron content of 4.0 ppm was found in T₁₅. The manganese content of soil was more in T₂, T₃ and T₄ (Composted *Parthenium* at 26.25 g per pot, 35.0 g per pot and 43.75 g per pot) as 6.80 ppm.

Any organic waste application aids in moisture conservation which is utilized for better root penetration and crop growth. In general incorporation of organic waste enhances the moisture content of the soil. This enhancement could be attributed to the higher water holding capacity of the soil due to the influence of organic waste application (Son, 1995). Mary and Sivagami (2014) have reported that the vermicomposts is rich in nitrogen, phosphorus, potassium and micro nutrients namely, iron, zinc, magnesium and calcium. And the soil analysis after harvest indicated an increased nitrogen and potassium.

They also suggested that the utilization of locally available organic materials can be used to replenish the physical chemical properties of soil.

Studies by Chattopadhyay *et al.* (1997) revealed that use of vermicompost is beneficial in maintaining higher status of fertility in red and lateritic soils and in reducing the need for application of inorganic nutrients in such soils. Baral *et al.* (1997) stated that vermicompost was effective in maintaining higher fertility status of the soils at residual stages which were considered to be beneficial for cultivation of succeeding crops.

Purakayastha and Bhatnagar (1997) and Senthilkumar *et al.* (2000) have reported that vermicompost influences the biological properties of soil which in turn improves its fertility. Saturated hydraulic conductivity of clay soil and water holding capacity of light textured sandy soil improves with application of vermicompost. Decrease in bulk density, increase in porosity and better water conducting properties of the soil is mainly due to the action of gum compounds, polysaccharides and fulvic acid compounds of organic matter on the soil structure (Manickam, 1993). Zhao and Fuzhen (1992) have also reported that mixing of N fertilizer and vermicompost reduced N loss and increased biological fixation of nitrogen.

Composted pig and horse manure application to soil increased macronutrients as well as trace elements (Wong, 1985). The available soil N after chickpea harvest was increased due to the incorporation of organic manures (Raju *et al.*, 1991). Bachthaler and Wonneberger (1974) have reported that application of poultry manure increased available phosphate in soil. Sistani *et al.* (2004) observed that P, Cu, Zn, Mn and Fe accumulate in soil receiving broiler litter. Available P in the soil was increased in the treatments that received chemical fertilizer. Higher level of P in the soil is accumulated by long-term annual application of compost and chemical fertilizers (Park *et al.*, 2004).

The results of Pandit and Jafri (1986) showed that the soil micronutrient needs of sugarcane (*Saccharum officinarum*) except Zn were met by green manuring. It is because of its power to mobilize micronutrients from hitherto unavailable sources in soil. The post-harvest soil of sugarcane supplemented with green manure had more Fe, Cu and Mn and decreased Zn content. Somasundaram *et al.* (1996) reported that green manuring significantly influenced the available nutrient in the soil. Available N, P and K in the soil tended to increase even after two rice (*Oryza sativa*) crops due to the application of green manure. Available soil N was higher when mung straw was incorporated (Rekhi and Meelu, 1983).

Pandit and Jafri (1986) observed that plots receiving no manure also showed at the end of the experiments, a higher level of Fe, Mn and Cu availability in sugarcane fields and they related this to the possibility of sugarcane root exudates in the process of micronutrients mobilization. Kachot *et al.* (2001) observed that available N and P in soil improved with combined application of organic, inorganic and biofertilizers. Soil available nutrients were higher at higher level of fertilization and organic amendments application to groundnut (*Arachis hypogea*) (Christopher and Rajagopal, 1999).

Green manuring with prickly sesban maintained and improved the available P and K status in soil (Mohapatra and Jee, 1993). Green manuring significantly increased the availability of Fe, Cu and Mn in rice grown soil (Bhattacharya and Mandal, 1996). This may be attributed to the greater nutrient binding capacity of soil enriched with organic matter. Green manuring with sunhemp (*Crotalaria juncea*) in combination with 40 kg N ha⁻¹ applied to rice improved the available N, P and K of the soil (Sharma *et al.*, 2000). Bindhu *et al.* (2013) have also documented the influence of biodynamic compost in improving the crop quality as it improves the soil characters.

The quality and value of organic amendments are measured in terms of their contributions to nutrient supplies and soil fertility (Arancon *et al.*, 2006). The application of vermicomposts to straw berries was found to increase the dehydrogenase activity and microbial biomass-N. Increase in microbial population is a key indication for factors influencing the rate of nutrient cycling, production of plant growth regulating materials and build up plant resistance or tolerance to pathogens. Saritha *et al.* (2013) have reported the significance of organic manures in the farming system. Romina *et al.* (2011) have also documented the positive effect of

vermicomposts application on soils chemical and biological properties.

CONCLUSIONS

The application of composts and vermicomposts improves the organic content and plant available nutrients. The soil organic content in turn enhances the microbial activity and humus content of the soil. Organic manuring using composts and vermicomposts helps to improve the soil structure, water holding capacity and also a sustainable supply of macro and micro nutrients. It supports the growth of beneficial micro organisms which can improve further decomposition of added plant residues, weeds and animal residues and animal excreta. They have a residual effect when used in crop rotation. The legumes and non legumes can be benefitted by the organic farming.

Conflict of Interest

Conflict of interest none declared.

REFERENCES

- Angelova, V.R., Akova, V.I., Artinova, N.S. and Ivanov, K.I. (2013). The effect of organic amendments on soil chemical characteristics. *Bulgarian Journal of Agriculture* 19: 958-971
- Ansari, A.A. (2008). Soil profile studies during bioremediation of sodic soils through the application of organic amendments (vermiwash, tillage, green manure, mulch, earthworms and vermijcompost). *World Journal of Agricultural Sciences* 4: 550-553
- Arancon, N.Q., Edwards, C.A. and Bierman. (2006). Influences of vermicomposts on field strawberries: Part 2. Effects on soil microbiological and chemical properties. *Bioresource Technology* 97: 831-840
- Arancon, N.Q., Edwards, C.I., Bierman, P., Welch, P. and Metzger, T.D. (2004). Influences of vermicomposts on field strawberries: Effect on growth and yields. *Bioresource Technology* 93: 145-153
- Atiyeh, R.M., Dominguez, J. Sulber, S. and Edwards, C.A. (2000). Change in biochemical properties of cow manure during processing by earthworms (*Eisenia andrei*. Bouche) and the effects on seedling growth. *Pedobiologia* 44: 709-724
- Bachthaler, G. and Wonneberger, C. (1974). Long term effect of various forms of poultry manure on the level and quality of plant yield under various site conditions. *Landwirtschaftliche Forschung* 30: 186-200.
- Baral, K., M. Ghosh, P.S. Munsu and Chattopadhyay, G.N. (1997). Use of vermicompost in productivity management of red and lateritic soils. In : 3rd IFOAM – ASIA Scientific Conference and General Assembly on "Food Security in Harmony with Nature", 1st – 4th December, 1997, University of Agric. Sci., Hebbal Campus, Bangalore, Abst., p.63.
- Bhattacharyya, K. and Mandal, S.R. (1996). Effect of green manuring on changes of micronutrients in soil and plant systems of rainfed rice. *Indian Agriculture* 40:199-208.
- Bindhu, S., Vijayakumari, B. and HiranmaiYadav. R. (2013). Utilisation of biodynamic farming to improve quality attributes of soybean (*Glycine max* L. Co.Soy). *Science, Technology and Arts Research Journal* 2:32-35
- Chan, P.L.S. and Griffiths, D.A. (1988). The vermicomposting of pretreated pig manure. *Biological Wastes* 24: 57-69

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- Chattopadhyay, G.N., Manas Ghosh and Baral, K. (1997). Effect of vermicompost on fertility status of red and lateritic soils. In : 3rd IFOAM-ASIA Scientific Conference and General Assembly on "Food Security in Harmony with Nature", 1st – 4th December 1997, University of Agric. Sci., Hebbal Campus, Bangalore, Abst. pp. 61-62.
- Christopher, L.A. and Rajagopal, A. (1999). The effect of irrigation and manuring on N, P, K uptake and soil nutrient status in groundnut. *Madras Agricultural Journal* 86: 61-65.
- Edwards, C.A.(1998). The use of earthworms in the breakdown and management of organic wastes. In: Earthworm Ecology. CTC press LLC, Boca Raton,Fl, pp.327-354
- Humphries, E.C. (1956). Modern methods of plant analysis. *Springer-Verlag* 1: 468-502.
- Jackson, M.L. (1973). Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi, pp. 10-50, 461-464.
- Jayakumar, M., Sivakami, T., Ambika, D. and Karmegam, N. (2011). Effect of turkey litter (*Meleagris gallopavo* L.) vermicomposts on growth and yield characteristics of paddy, *Oryza sativa*(ADT-37). *African Journal of Biotechnology* 10:15295-15304.
- Kachot, N.A., Malavia, D.D., Solanki, R.M. and Sagarka, B.K. (2001). Integrated nutrient management in rainy season groundnut (*Arachis hypogaea*). *Indian Journal of Agronomy* 46: 516-522.
- Mary, D.D. and Sivagami, S. (2014). Effect of individual and combined application of biofertilisers, vermicomposts and inorganic fertilizers on soil enzymes and minerals during the post harvesting stage of chilli(NS 1701). *Research Journal of agriculture and environmental Management* 3: 434-441.
- Manickam, T.S. (1993). Organics in soil health and crop production. P.K. Thampan (ed.). Peekay Tree Crops Develop. Foundation, Cochin, pp. 87-104.
- Mohapatra, A.K. and Jee, R.C. (1993). Response of lowland rice (*Oryza sativa*) to green manuring, levels and sources of phosphatic fertilizer in coastal Orissa. *Indian Journal of Agronomy* 38: 374-377.
- Moradi, H., Fahramand, M., Sobkhizi, A., Adibian, M., Noori, M., Abdollahi, S. and Rigi, K. (2014). Effect of vermicompost on plant growth and its relationship with soil properties. *International Journal of Farming and Allied Sciences* 3: 333-338.
- Orozco, F.H., Cegarra, J., Trujillo, L.M. and Roig, A.(1996). Vermicomposting of coffee pulp using the earthworm *Eisenia fetida*: effects on C and N contents and the availability of nutrients. *Biology and Fertility of Soils* 22:162-166
- Pandit, S.N. and Jafri, S.M.H. (1986). Effect of green manuring on micro nutrient status of plant and soils under monoculture of sugarcane. *Indian Journal of Agricultural Science* 56: 884-888.
- Panse, V.G. and Sukhatme, P.V. (1978). Statistical methods for agricultural workers, ICAR, New Delhi, p. 327.
- Park, M., O. Singvilay, W. Shin, E. Kim, J. Chung and Sa, T. (2004). Effect of long-term compost and fertilizer application on soil phosphorus status under paddy cropping system. *Communications in Soil Science and Plant Analysis* 35: 1635-1644.
- Piper, C.S. (1966). Soil and plant analysis, Hanos Publishers, Bombay, p. 368.
- Purakayastha, T.J. and Bhatnagar, R.K. (1997). Vermicompost: A promising source of plant nutrients. *Indian Farming* 46: 35-37.
- Raju, M.S., Verma, S.C. and Ramaiah, N.V. (1991). Effect of phosphorus in relation to FYM Vs Rhizobium inoculation on nutrient uptake by chickpea cultivars under rainfed condition. *Indian Journal of Agricultural Research* 25: 43-48.
- Rekhi, R.S. and Meelu, O.P. (1983). Effect of complimentary use of mung straw and inorganic fertilizer nitrogen on the nitrogen availability and yield of rice. *Oryza*, 20: 125-129.
- Romina, R., Lidia, G. and Roserio, R. (2011). A soil quality index to evaluate the vermicomposts amendments effects on soil properties. *Journal of Environmental Protection* 2: 502-510.
- Saritha,M., Vijayakumari, B., HiranmaiYadav, R. and Kandari,L.S. (2013). Influence of selected organic manures on the seed germination and seedling growth of cluster bean (*Cyamopsis tetragonoloba* (L.) Taub). *Science, Technology and Arts Research Journal* 2: 16-21.
- Senthilkumar, M., Sivalingam, P.N. and Suganthi, A. (2000). Vermitech. *Kisan World* 27: 57-58.
- Sharma, S., Dev, S.P. and Rameshwar. (2000). Effect of green manuring of sunhemp (*Crotalaria juncea* L.) on rice yield, nitrogen turnover and soil properties. *Crop Research* 19: 418-423.
- Sistani, K.R., Brink, G.E., Adeli, A., Tewolde, H. and Rowe, D.E. (2004). Year- round soil nutrient dynamics from broiler litter application to three Bermuda grass cultivars. *Agronomy Journal* 96: 525-530.
- Somasundaram, E., Srinivasan, G. and Manoharan, M.L. (1996). Effect of green manuring *Sesbania rostrata* and fertilizers application on chemical properties of soil and grain yield in rice – rice crop sequences. *Madras Agricultural Journal* 83: 758-760.
- Son, T.T.N. (1995). Bioconversion of organic wastes for sustainable agriculture. Ph.D. Thesis, TNAU, Coimbatore.
- Tharmaraj, K., Ganesh, P., Suresh Kumar, R., Anandan, A and Kolanjinathan, K. (2011). Vermicompost-A soil conditioner cum nutrient supplier. *International Journal of Pharmaceutical and Biological Archives* 2:1615-1620.
- Wong, M.H. (1985). Effects of animal manure composts on tree (*Acacia confusa*) seedling growth. *Agricultural Wastes* 13: 261-272
- Zhao, S.W. and Fuzhen, H. (1992). The nitrogen uptake efficiency from N-15 labelled chemical fertilizer in the presence of earthworm manure (cast), In: Advances in management and conservation of soil fauna. G.K. Veeresh, D. Rajagopal and C.A. Viraktamath (eds.), Oxford and IBH, New Delhi, pp. 539-542
- Zinc, T.A. and Allen, M.F. (1998). The effect of organic amendments on the restoration of a disturbed coastal sage scrub habitat. *Restoration Ecology* 6: 52-58.