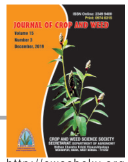
Journal of Crop and Weed, 18(1): 01-06 (2022)

ISSN- O : 2349 9400 ; P : 0974 6315



http://cwssbckv.org
www.cropandweed.com

Effect of organic and inorganic nutrient sources on soil physico-chemical and microbiological properties in cauliflower (*Brassica oleracea* var. *botrytis* L.) under mid hills of Himachal Pradesh

***K. SHARMA, R. KAUSHAL, S. SHARMA AND M. NEGI**

Department of Soil Science and Water Management, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India, 173230

Received: 16.01.2022 ; Revised : 26.03.2022 ; Accepted : 05.04.2022

DOI: https://doi.org/10.22271/09746315.2022.v18.i1.1524

ABSTRACT

An experiment was conducted with seven treatments consisting of different organic and inorganic sources of nutrients to study the changes in soil property and the growth of cauliflower in mid hills of Himachal Pradesh. Results revealed that application of vermicompost along with jeevamrit significantly affected soil physical, chemical and microbiological properties. The application of 100 per cent recommended doses of nutrients through vermicompost + jeevamrit @ 1.5 L/4.32 m^2 was found with highest available NPK (339.20, 65.30, 453.30 Kg ha^{-1}), available Cu, Fe, Zn and Mn (4.43, 19.78, 3.14, 12.90 mg Kg^{-1}), soil dehydrogenase and phosphatase activity (55.73 µg TPF^{-1} g soil^{-1} 24hr^{-1}, 512.67 µ mol l^{-1} g soil^{-1} hr^{-1}) and viable microbial counts (18.53 x 10^5, 4.25 x 10^3, 3.42 x 10^3 cfu g^{-1} for bacteria, fungi and actinomycetes, respectively). Thus, 100 per cent application of vermicompost along with jeevamrit (1.5L/4.32 m^2), a nutrient module may be suggested for the farmers which showed better results on physical, chemical as well as microbiological properties of soil as compared to chemical fertilizers.

***Keywords*:** Farm yard manure, organic and inorganic nutrients, physical and chemical properties, recommended doses of nutrients, soil enzymes activity, vermicompost

Cauliflower is a member of Cruciferae family and curd is the edible part of cauliflower that prevents cancer due to high concentration of glucothiocyanate (Abd El-Rheemkh *et al*., 2019). In India, total area under cauliflower was about 453 thousand ha with a production of 8668 thousand MT and in Himachal Pradesh, total area under cauliflower was about 5.5 thousand ha with a production of 131 thousand MT (Anonymous, 2018). In Himachal Pradesh, it is grown throughout the year in different agro-climatic zones which bring remunerative returns to the small and marginal hill farmers. The farmers of the state are growing cauliflower for fresh vegetable as well as for seed production, which brings lucrative returns to them. Current agriculture trends are focusing on reducing the use of chemical pesticides and inorganic fertilizers, necessitating the search for environmentally friendly alternatives.

The injudicious and imbalanced uses of chemical fertilizer inputs produce precarious effects on soil health and may sometimes enters into the food chain which is injurious to human health (Karmakar *et al*., 2013). Therefore, it is necessary to use different sources of nutrients *viz.* vermicompost (VC), farm yard manure (FYM) and jeevamrit in order to keep the soil fertility and sustain the environment. Organic inputs increase the soil microbial activity which improves the physical as well as chemical properties of the soil. Therefore, application of organic manures is essential for maintaining crop yields, as it contributes to nutrient accumulation in soil (Thirunavukkarasu and Vinoth, 2013). The accretion of pathogens that cause diseases is lowered due to biological reactions taking place during the decomposition of organics (Ramesh *et al*., 2010). So, combining organic inputs with bio-inoculants minimizes the reliance on chemical inputs without compromising yields (Giraddi, 2000).

Various fermented organic inputs such as panchagavya, jeevamrit, beejamrit and vermiwash are made primarily from cow dung, urine, pulse flour, jaggery, live soil and local vegetation extracts *etc* (Kulkarni and Gargelwar, 2019). Application of jeevamrit enhances the microbial activity in soil and also helps to improve soil fertility (Aulakh *et al*., 2018). Application of liquid manures enhances the cycling of the nutrients and is also effective in promoting growth and yields of crops. The application of liquid manures enhances the microbial activity in soil which helps to improve fertility of soil and also provide adequate supply of nutrient requirement of crop as well as pest management (Joshi, 2012). These manures may not directly provide nutrients to the soil where they are applied, but they do accelerate the activity of microorganisms in soil, which supports to maintain the fertility of soil (Yadav and Mowade, 2004). Chemical fertilizers cause soil degradation, poor soil health and leaching of nutrients into the groundwater, all of which pose a health risk to humans and animals. Therefore, current study was carried out to study how different sources of nutrients affect soil physical, chemical and microbiological properties under the mid hills of Himachal Pradesh.

Email: kapiluhf123@gmail.com

MATERIALS AND METHODS

The experiment was accomplished at the experimental farm of Department of Soil Science and Water Management, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) in the year of 2018. Table 1 shows the initial physico-chemical and microbiological properties of experimental soil. Cauliflower variety “Sweta” was planted in a plot size of 2.40m×1.8m with a spacing of 60cm×45cm.

Recommended doses of N: P: K- 125:76:72 kg ha^{-1} and FYM @ 250 q ha^{-1} through VC and FYM were computed on account of N equivalence. Before transplanting full amount of VC and FYM were applied and mixed with soil. After transplanting, concentrated jeevamrit was applied at 15 days interval according to treatment. The experimental plants were given uniform recommended cultural practices during the entire course of investigation.

Preparation of jeevamrit

1) Fresh cow dung (10Kg) and cow urine (10 L) was added in water.

2) Jaggery (2 Kg), pulse flour (1Kg) and live soil (1 Kg) were mixed in 200 L of water.

3) The above mixture was stirred properly (morning and evening) for 4 days for 5-10 minutes.

4) On fifth day the solution was filtered and filtrate was ready for soil drenching per spray.

RESULTS AND DISCUSSION

Effect of different sources of nutrient on pH, EC, OC and available macronutrients

In Table 5, it is noticeable that no treatment had a significant effect on pH, EC and OC during the period of investigation. The values of pH, electrical conductivity and organic carbon ranged from 6.41 to 6.85, 0.32-0.68 dS m^{-1} and 0.73 to 1.22 per cent, respectively.

In Table 5, the maximum available NPK (339.20 Kg ha^{-1}) was noted under T_3 (100% RDN through VC + jeevamrit @ 1.5 L/ 4.32 m^2) which increased to 23.61 per cent in comparison to the initial soil available N status. Increased microbial population may be responsible for this increase in N availability due to application of higher amounts of VC and FYM that cause the mineralization of organically bound N to inorganic form. These results are supported by Azarmi *et al.* (2008) and Yourtchi *et al.* (2013) in tomato and potato.

Maximum available P (65.30 Kg ha^{-1}) was registered in T_3 which increased upto 62.76 per cent from the initial soil available P status and lowest (48.12 Kg ha^{-1}) available P was found under treatment T_2. However, treatment T_5 was found with approximately similar results as that of T_3. Increase in available P by the application of VC may be because of on decomposition of organic matter there was discharge of humic acid by the enhanced microbial activity which transformed unavailable soil phosphate into available form. These results are supported by Arancon *et al*. (2006), Sharma and Banik (2014) in strawberry and maize.

Significantly, highest available K (453.30 Kg ha^{-1}) was noted under treatment T_3 and lowest was found under treatment T_2 (380.66 Kg ha^{-1}). In case of available K 47.79 per cent increase was found as compared to the initial soil available K content. Mineralization and microbial activity in the rhizosphere may have contributed to the increase in available K. The favorable effect of VC and jeevamrit resulted in a higher microbial population as well as enzymatic characterstics, particularly dehydrogenase and phosphatase enzymes, guaranteeing that these nutrients were more readily available in soil. The results are analogus to that have been reported by Demir (2019) who reported that application of VC increases availability of K in lettuce. Zakir *et al*. (2012) also reported that K availability in soil was increased due to presence of higher K content in VC. Organic manure enhances the amount of organic matter in the soil which also provides nutrients such as NPK.

Effect of nutrient sources on DTPA extractable micronutrients

The data analysis on available micronutrients in Table 6 presented that highest available micronutrients *viz.* Cu, Fe, Zn and Mn (4.43, 19.78, 3.14, 12.90 mg Kg^{-1}, respectively) were recorded under T_3 (100% RDN through VC + jeevamrit @ 1.5 l/ 4.32 m^2) and lowest Cu, Fe, Zn and Mn (3.16, 15.10, 2.41, 10.51 mg Kg^{-1}, respectively) was recorded under T_7 (100% RD through chemical fertilizers). However, in case of Cu and Fe treatment T_3 was statistically at par with T_5 (75% RDN through VC + jeevamrit @ 3.0 l/ 4.32 m^2)

The increase in available micronutrients may be attributed due to increased level of VC doses. Higher degradation and oxidation of organic matter by the increased microbial activity results increase in available micronutrients in soil. Jordao *et al*. (2006) suggested that high Mn content was associated with higher level of microbial activity which disintegrated the Mn precipitates (Phosphate, hydroxide and carbonates). Similarly, McGrath *et al.* (2000), SOM has a considerable impact on Zn and Cu mobility in the soil. The inclusion of organic inputs resulted in a considerable increase in available micronutrients was also noticed by Parkash *et al*. (2002). In comparison to solubilization of inherent soil micronutrients, greater accessibility of micronutrients in bulky organic manure plots credibly associated with more organic nutrients and their micronutrients boosted microbial population.

Table 1: Treatment details

Sr. No.	Treatment details
T_1	100 per cent RDN (Recommended Dose of Nutrients) through VC
T_2	100 per cent RDN through FYM
T_3	100 per cent RDN through VC + jeevamrit @ 1.5 L $plot^{-1}$
T_4	100 per cent RDN through FYM + jeevamrit @ 1.5 L $plot^{-1}$
T_5	75 per cent RDN through VC + jeevamrit @ 3.0 L $plot^{-1}$
T_6	75 per cent RDN through FYM + jeevamrit @ 3.0 L $plot^{-1}$
T_7	100 per cent RD through chemical fertilizers

Table 2: Nutrient contents of manures

Manures	N (%)	P (%)	K (%)
Vermicompost	1.35	0.45	0.61
Farm Yard Manure	0.51	0.26	0.51
Jeevamrit	1.39	0.88	0.04

Table 3: Methods for analysis of different soil properties

Particulars	Method employed	Reference(s)
Physico-chemical properties of soil		
pH	1:2 soil water suspension	Jackson (1973)
EC	1:2 soil water suspension	Jackson (1973)
Organic carbon	Rapid titration method	Walkely and Black (1934)
Available N	Alkaline potassium permanganate method	Subbiah and Asija (1956)
Available P	Olsen's method	Olsen *et al*. (1954)
Available K	Ammonium acetate method	Merwin and Peech (1951)
Cu, Zn, Fe, Mn	Atomic absorption spectrophotometer	Sarma *et al*. (1987)
B. Microbiological properties		
Microbial count	Total culturable microbial count by serial dilution pour plate technique	Rao (1999)
Soil enzymes		
Dehydrogenase	Soil incubation	Casida *et al*. (1964)
Phosphatase	Soil incubation	Tabatabai and Bermner (1969)

Table 4: Initial values of experimental soil before the start of experiment

Properties	Values	
	Organic site	Inorganic site
pH (1:2)	6.87	6.84
EC (dS m^{-1})	0.27	0.62
Organic carbon (%)	1.02	1.06
Available N (Kg ha^{-1})	74.4	294.7
Available P (Kg ha^{-1})	40.12	48.5
Available K (Kg ha^{-1})	306.7	350.7
Available Zn (mg Kg^{-1})	2.26	2.40
Available Cu (mg Kg^{-1})	3.10	3.28
Available Fe (mg Kg^{-1})	14.80	16.34
Available Mn (mg Kg^{-1})	10.30	11.24

Table 5: Effect of nutrient sources on soil pH, electrical conductivity, organic carbon and available macronutrients

Treatments	pH (1:2.5)	EC(dS m^{-1})	Organic carbon (%)	N(Kg ha^{-1})	P(Kg ha^{-1})	K(Kg ha^{-1})
T_1	6.85	0.35	0.81	295.14	51.10	385.66
T_2	6.71	0.32	0.73	287.27	48.12	380.66
T_3	6.55	0.38	1.14	339.20	65.30	453.30
T_4	6.80	0.37	0.81	316.23	59.40	403.89
T_5	6.41	0.36	1.10	336.52	63.71	416.00
T_6	6.71	0.36	0.78	311.09	56.22	399.97
T_7	6.85	0.68	1.22	327.67	61.35	409.63
LSD(0.05)	**NS**	**NS**	**NS**	**2.06**	**2.02**	**2.72**

Table 6: Effect of nutrient sources on DTPA extractable micronutrients contents in soil

Treatments	DTPA extractable micronutrients (mg Kg^{-1})			
	Cu	Fe	Zn	Mn
T_1	3.72	16.52	2.79	11.22
T_2	3.36	15.81	2.55	10.76
T_3	4.43	19.78	3.14	12.90
T_4	4.16	18.34	3.04	12.06
T_5	4.42	19.74	3.10	12.80
T_6	3.96	17.27	2.96	11.53
T_7	3.16	15.10	2.41	10.51
LSD(0.05)	**0.03**	**0.17**	**0.03**	**0.04**

Table 7: Effect of nutrient sources on viable microbial counts in soil

Treatments	Dehydrogenase	Phosphatase	Bacteria	Fungi	Actinomycetes
	(µg TPF^{-1} g $soil^{-1}$ $24hr^{-1}$)	(µ mol l^{-1} g $soil^{-1}$ hr^{-1})	(x 10^5 cfu g^{-1})	(x 10^3 cfu g^{-1})	(x 10^3 cfu g^{-1})
T_1	48.38	473.00	14.61	2.95	2.89
T_2	47.32	466.17	14.38	2.76	2.68
T_3	55.73	512.67	18.53	4.25	3.42
T_4	51.11	485.88	15.89	3.52	3.21
T_5	52.85	499.33	17.48	4.13	3.36
T_6	50.30	479.88	17.15	3.65	3.25
T_7	50.99	481.82	15.49	3.30	3.05
LSD (0.05)	**3.63**	**5.95**	**0.71**	**0.15**	**0.12**

Effect of nutrient sources on soil enzymes and viable microbial counts

In Table 7, the maximum (55.73 µg TPF^{-1} g $soil^{-1}$ $24hr^{-1}$) dehydrogenase activity was recorded under T_3 (100% RDN through VC + jeevamrit @ 1.5 L/ 4.32 m^2) which was statistically at par with T_5 (75% RDN through VC + jeevamrit @ 3.0 L/ 4.32 m^2). The minimum (47.32 µg TPF^{-1} g $soil^{-1}$ $24hr^{-1}$) dehydrogenase activity was noted under T_2 *i.e.* 100 per cent RDN through FYM.

Presented data in Table 7 showed that the maximum (512.67 µ mol l^{-1} g $soil^{-1}$ hr^{-1}) phosphatase activity was registered under treatment T_3 (100% RDN through VC + jeevamrit @ 1.5 L/ 4.32 m^2) and minimum (466.17 µ mol l^{-1} g $soil^{-1}$ hr^{-1}) phosphatase activity was noted under T_2 (100% RDN through FYM).

Rise in enzymatic activity caused by implementation of bulky as well as liquid organic inputs boosts soil enzymatic activity. Organic manure application enhances the amount of organic matter which accelerates microbial activity as well as enzyme cell multiplication by creating a favorable environment, resulting in an increase in soil enzymatic activity. Kaur *et al.* (2005) observed increase in enzymatic activity as a result of microbes that utilizes nutrients delivered by organic material, leading in an increase in microbial activity. Singh *et al.* (2012) and Doan *et al.* (2013) discovered enhancing enzymatic activity by applying organic manures in tomato. Similarly, Giuaquiani *et al*. (1994) found that incorporation of organic manure increased the phosphatase activity in soil as compared to chemical fertilizers.

Table 7 revealed that maximum viable bacterial, fungi and actinomycetes (18.53 × 10^5, 4.25 x 10^3, 3.42 x 10^3 cfu g^{-1}, respectively) count was recorded under T_3 (100% RDN through VC + jeevamrit @ 1.5 l/ 4.32 m^2) and minimum (14.38 × 10^5, 2.76 x 10^3, 2.68 x 10^3 cfu g^{-1}, respectively) count was noticed under T_2 (100% RDN through FYM).

Singh *et al*. (2008) found that application of both bulky as well as liquid organic manures increased the viable microbial count. Application of organic wastes provides more surface area for microbial colonization. The increased microbial activity speeds up the decomposition process, resulting in humification, which converts unstable organic matter to a more stable state. Natarajan (2007) reported that liquid organic manure had exixtence of macronutrients, micronutrients, amino acids, growth promoting factors like IAA, GA and it delivered the nutrition to microorganisms present in rhizosphere which helps to increase their population. Similar results were observed by Kanan *et al.* (2005) in tomato and Rana *et al.* (2015). Shwetha (2007) reported combined application of organic and liquid inputs in soyabean. Similarly, Kumar and Singaram (2011) found that treatment of organic manure as well as spray in green chilies increased the soil viable microbial count (bacterial, fungal and actinomycetes).

CONCLUSION

In this experiment, we can conclude that combined application of organic and liquid manures T_3 *i.e.* 100 per cent RDN through VC (77q ha^{-1}) + jeevamrit @ 2800 L ha^{-1} (at 15 days interval) had shown significant effect in enhancing available macro and micro nutrients, soil enzymatic activity and viable microbial count in soil. Application of organic manure has increased soil fertility status. However, combined application of organic as well as liquid manures was more effective to boost physical, chemical and microbiological properties of soil. Hence, combining organic and liquid manures is the best strategy to improve soil health in a long term manner.

REFERENCES

Abd El-RheemKh, M., Entsar, M., Essa Neama, M. M. and El-Tanahy, A.M.M. 2019. Effect of vermicompost and foliar application of methanol on cauliflower plants grown in sandy soil. *J. Hort. Sci. Ornamental Pl.,* **11**: 152-158.

Anonymous. 2018. Indian Horticulture Database. National Horticulture Board, Gurgaon, Haryana. pp. 142-44.

Arancon, N.Q., Edwards, C. A. and Bierman, P. 2006. Influences of vermicomposts on field strawberries: Part 2. Effects on growth and yields. *Bioresource Technol.,* **97**: 831-840.

Aulakh, C. S., Singh, H., Walia, S. S., Phutela, R. P. and Singh, G. 2018. Effect of farmyard manure and jeevamrit in maize-wheat organic production system in Punjab. *Agric. Res. J.,* **55**: 485-89.

Azarmi, R., Giglou, M. T. and Taleshmikail, R. D. 2008. Influence of vermicompost on soil chemical and physical properties in tomato (*Lycopersicum esculentum* L.) field. *African J. Biotechnol.,* **7**: 2397-2401.

Casida, L.E., Klein, D. A. and Santoro, T. 1964. Soil dehydrogenase activity. *Soil Sci.,* **98**: 371-76.

Demir, Z. 2019. Effect of vermicompost on soil physicochemical properties and lettuce (*Lactuca sativa* var. *Crispa*) yield on greenhouse under different soil water regimes. *Communi. Soil Sci. Pl. Anal.,* **1**-18.

Doan, T. T., Jusselme, D. M., Lata, J. C., Nguyen, B. V. and Jouquet, P. 2013. The earthworm species *Metaphire posthuma* modulates the effect of organic amendments (compost vs. vermicompost from buffalo manure) on soil microbial properties. A laboratory experiment. *European J. Soil Biol.,* **59**:15-21

Giraddi, R. S. 2000. Influencing vermicomposting methods on the biodegradation of organic wastes. *Indian J. Agric. Sci.,* **70**: 663-666.

Giuaquiani, P. L., Gigliotti, G., and Businelli, D. 1994. Long-term effects of heavy metal from composted municipal waste on some enzymes activities in a cultivated soil. *Biol. Fertility Soils,* **17**: 257-262.

Jackson, M. L. 1973. Soil Chemical Analysis. Prentice Hall Private Limited, New Delhi. 498p.

Jordao, C. P., Nascentes, C.C., Cecon, P. R., Fontes, R. L. F. and Pereira, J. L. 2006: Heavy metal availability in soil amended with composted urban solid wastes. *Environ. Monitoring and Assessment,* **112**: 309-326.

Joshi, M. 2012. *New Vistas of Organic Farming*. Scientific publishers, New Delhi. pp140.

Kanan, P., Saravanan, A. and Ntrajan, S. K. 2005. Biological properties of soil as influenced by different organic manures in tomato. *Res. J. Agric. Biol. Sci.,* **1**: 181-83.

Karmakar, S., Brahmchari, K. and Gangopadhyay. 2013. Studies on agricultural waste management through preparation and utilization of organic manures for maintaining soil quality. *African J. Agric. Res.,* **8**: 6351-58.

Kaur, K., Kapoor, K. K. and Gupta, A. P. 2005. Impact of organic manures with and without mineral fertilizers on soil chemical and biological properties under tropical conditions. *J. Pl. Nutri. Soil Sci.,* **168**: 117–122.

Kulkarni, S. S. and Gargelwar, A. P. 2019. Production and microbial analysis of Jeevamrutham for Nitrogen fixers and Phosphate solubilizers in the rural area from Maharashtra. *J.Agric. Veterinary,* **12**: 85-92.

Kumar, V. K., and Singaram, P. 2011. Impact of organic manure and organic spray on soil microbial population and enzyme activity in green chillies. *J. Eco-Agric.,* **6**: 10-12.

McGrath, S. P., Zhao, F. J., Dunham, S. J., Crosland, A. T. and Coleman, K. 2000. Long term changes in the extractability and bioavailability of zinc and cadmium after sludge application. *J. Environ. Quality*, **29**: 875-883.

Merwin, H. D. and Peech, M. 1951. Exchangeability of soil potassium in sand, silt and clay fraction influenced by the nature of complementary exchangeablecations. *Soil Science American Proceedings* **15**: 125-128.

Natarajan, K. 2007. Panchgavya for plant. In: Proceedings of the National Conference on Glory of Gomatha, held at Sri Venkateswara Veterinary University, Tirupati, 1-3 December 2007, Tirupati, India. pp.72-75.

Olsen, S. R., Cole, C.V., Watanable, F. S. and Dean L. A. 1954. Estimation of availablr phosphorus in soil by extraction with sodium carbonate. *USDA Circular* 939: 1-19.

Parkash, V. S., Bhandoria, P. B. and Amitava, R. 2002. Comparative efficiency of organic manure on some physical and chemical properties of red loam soil under multiple cropping. *J. Indian Society Soil Sci.,* 31: 601p.

Ramesh, P., Panwar, N. R., Singh, A. B., Ramana, S., Yadav, S. K. and Rao, A. S. 2010. Status of organic farming in India. *Curr. Sci.,* **98**: 1190-94.

Rana, M., Raverkar, K. P., Pareek, N., Chandra, R. and Singh, D.K. 2015. Impact of biodynamic preparations and panchgavya in organically managed cropping systems comprising legumes on soil biological health. *Legume Res.,* **38**: 219-228.

Rao, S. N. S. 1999. Soil Microbiology. Oxford and IBH publishing co-operative. New Delhi. 252p.

Sarma, V. A. K., Krishan, P. and Budihal, S. L. 1987. *Soil Resource Mapping of Different States in India-A Laboratory Manual*. National Bureau of Soil Survey and Land Use Planning, Nagpur. 49p.

Sharma, R. C. and Banik, P. 2014. Vermicompost and fertilizer application: Effect on productivity and profitability of baby corn (Zea Mays L.) and soil health. *Compost Science and Utilization,* **22**:83-92.

Shwetha, B. N. 2007. Studies on nutrient management through organics in soybean-wheat cropping system. M. Sc. Thesis. Department of Agronomy, Dharwad University of Agricultural Sciences, Dharwad, India. 101p.

Singh, A. B., Saha, J. K. and Ghosh, P. K. 2008. Effect of nutrient management practices on soybean – chickpea cropping system for improving seed yield quality and soil biological health under rainfed condition. *Indian J. Agric. Sci.,* **78**, 485-489.

Singh, R. P., Varshney, G. and Srivastava, G. 2012. Effect of carbofuran on enzymatic activities and growth of tomato plants in natural, fertilized and vermicompost-amended soils. *Archives of Agronomy and Soil Sci.,* **58**: 1349-1364.

Subbiah, H. V. and Asija H. L. 1956. A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci.,* **25**: 259-260.

Tabatabai and Bremner. 1969. Use of p-nitrophenyl phosphate for assay of soil phosphatase activity. *Soil Biol. Biochem.,* **1**:301-317.

Thirunavukkarasu, M. and Vinoth, R. 2013. Influence of Vermicompost application alongwith nitrogen on growth, nutrients uptake, yield attributes and economics of rice (*Oryza sativa* L.). *Int. J. Agric. Environ. Biotechnol.,* **6**: 599-604.

Walkely, A. and Black I. A. 1934. Examination of the method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.,* **37**: 29-38.

Yadav, A.K. and Mowade, S. M. 2004. Organic manures and compost. In: Organic Farming- A Ray of Hope for Indian Farmer. National Center of Organic farming, Ghaziabad, Utter Pradesh. India. pp. 14-19.

Yourtchi, M. S., Hadi, M. H. S. and Darzi, M. T. 2013. Effect of nitrogen fertilizer and vermicompost on vegetative growth, yield and NPK uptake by tuber of potato cv. Agria. *Int. J. Agric. Crop Sci.,* **5**: 2033-2040.

Zakir, H.M., Sultana M. N. and Saha K.C. 2012. Influence of commercially available organic vs inorganic fertilizers on growth yield and quality of carrot. *J. Environ. Sci. Nat. Res.,* **5**: 39-45.