Indian Journal of Plant Sciences ISSN: 2319–3824(Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jps.htm
2014 Vol. 3 (3) July-September, pp.37-43/Sharma and Agrawal.
Research Article

IMPACT OF ORGANIC FERTILIZERS ON GROWTH, YIELD AND QUALITY OF SPINACH

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ABSTRACT
'Green revolution' boosted food productivity at the cost of environment & society. It dramatically increased the 'quantity' of the food produced but decreased its 'nutritional quality' and also destroyed the 'physical, chemical & the biological properties' of soil over the years of use. Earthworms and its cast can produce better crops completely organically in terms of quantity and quality. It will provide several environmental benefits to the society by way of producing 'chemical-free' safe, 'nutritive and health protective' organic foods along with protecting flora and fauna.
Considering the aforesaid issue, a pot experiment was conducted to assess the performance of organic fertilizers on growth, yield and quality of Spinach (Spinacea oleracea Linn) with treatments FYM (T1), vermicompost (T2), chemical fertilizer (T3), Vermiculture + cattle dung (as feed) (T4) and control (T5) were organized in kitchen garden. The experiment was a completely randomized design, repeated three times, with four replications. Nutrient analysis of the spinach grown in kitchen garden was also done to ascertain the impact of organic fertilizers on its quality. The selected methods for nutritive analysis were β carotene- calorimetrically, Vitamin C- Titration method and Calcium- Titration method. After repeated use of vermiculture in the same soil, β carotene, Vitamin C and Calcium were observed better in organically grown spinach. In vermicompost cultivated tomato β carotene was recorded g. The organic crops produced with earthworms and its casts really supply more nutrients so used sustainably in food.

Keywords: *Vermiculture, Spinach, β Carotene, Vitamin C*

INTRODUCTION
Spinach (*Spinacea oleracea Linn*) a member of the chenopodiaceae family, is also known as "Palak". Spinach is an annual plant. It is a nutritive leafy vegetable. It is rich in vitamins especially vitamin A and other vitamins like ascorbic acid, riboflavin, and thiamine. There are also appreciable quantities of minerals like iron and calcium. Spinach is an important vegetable in our daily food intake. Food should fulfill the daily requirements without creating health problems. Adverse effects of agro-chemicals (like cancer, offspring's with neural tube defects and limb anomalies, harm nervous system and Blue baby syndrome) on the health of farmers using them and the society consuming the chemically grown food have now started to become more evident all over the world. Provision of a sustainable environment in the soil by amending with organic inputs can improve the quality and acceptability of crop. Earthworms serve as "nature's plowman" and form nature's gift to produce good humus, which is the most precious material to fulfill the nutritional needs of crops. The objectives of this research are to determine the growth, yield and quality of spinach as affected by organic manures and chemical fertilizer and vermiculture.

MATRIALS AND METHODS
Methodology
An experiment was laid in Completely Randomized Design to determine the growth, yield and quality of spinach as affected by organic manures and chemical fertilizer and vermiculture. Spinach was grown in kitchen garden with various fertilizer inputs in kitchen garden at Jaipur city.

To Assess the Quality, the Present Study was Conducted in the Following Phases:

1. Spinach cultivation;
2. Growth and Yield analysis

3. Nutrient analysis
4. Statistical analysis

Treatments Employed were:

T1: FYM
T2: Vermicompost
T3: Chemical fertilizer
T4: Vermiculture (*Eisenia fetida*)
T5: Control

Conical earthen pots of 30.48 cm heights and 30.48 cm diameters were taken to grow the plants. The pots were filled with 10 kg sun dried sieved soil. Five seeds of "Jobner green" variety were sown in each pot. The experiment was repeated three times i.e. December, July and December in the same soil. Various growth parameters studied were germination percentage, plant height etc. The yield parameters studied were leaf area, number of leaves and average leaf weight. Spinach grown in each treatment was harvested for qualitative analysis.

Qualitative Analysis: Representative samples of spinach were collected from each treatment to analyze β Carotene (Colorimetrically), Calcium (Titration method) and Vitamin C (Titration method).

Statistical Analysis: Data for each fertilizer and each replication were analyzed by Analysis of Variance (ANOVA), F- test to assess the significant difference at 5% level between various organic manures,

Chemical Fertilizer and Vermiculture

For each organic to chemical comparison a mean percent difference was calculated using the formula:

$$\frac{\text{Organic value - Chemical value}}{\text{Chemical value}} \times 100$$

(Worthington, 2004)

RESULTS AND DISCUSSION

Results

The results of various growth and yield parameters are as follows.

Germination Percentage

Table 1: Impact of Organic Manures, Chemical Fertilizer and Vermiculture on Germination in spinach (*Spinacea oleracea Linn*)

Treatment	Expt	Germination	Mean Germination
	1	51	
	2	44	
T1	3	52	49
	1	54	
	2	51	
T2	3	56	53.66
	1	48	
	2	42	
T3	3	42	44
	1	61	
	2	54	
T4	3	58	57.66
	1	39	
	2	33	
T5	3	31	34.33
S Em ±			2.09
CD at 5%			6.58

Total number of seedling germinated was the maximum with T4 (vermiculture) (61 % and 58 %) in the first and third experiment respectively. Treatments T4 and T2 (vermicompost) were found significantly superior over T3 (chemical fertilizer) and T5 (control) at 5% level of significance. Vermiculture and vermicompost were found significantly superior at 5% level over chemical fertilizer. If earthworms were physically present in the soil, soil aeration via channels, burrows and galleries, would have been held responsible for the improvement in germination via improved oxygen contents of the soil, and thereby seed metabolism. In their physical absence, the improvement in germination with the different levels of (initial) exposure to earthworms must be due largely to the chemical products of the earthworms (Owa *et al.*, 2008).

Plant Height

Table 2 indicates that the maximum plant height of 11.00 cm was recorded at 15th day with T4 treated plants during the second experiment. The maximum plant height was recorded in T4 (vermiculture) treated plants (25.25 cm) in the first experiment at 30th day. Both T2 and T4 were found significantly superior over T1, T3 and T5 at 5% level of significance in all the three experiments for plant height at 45th day. The plants treated with T2 recorded the maximum height (38.63 cm) in the second experiment.

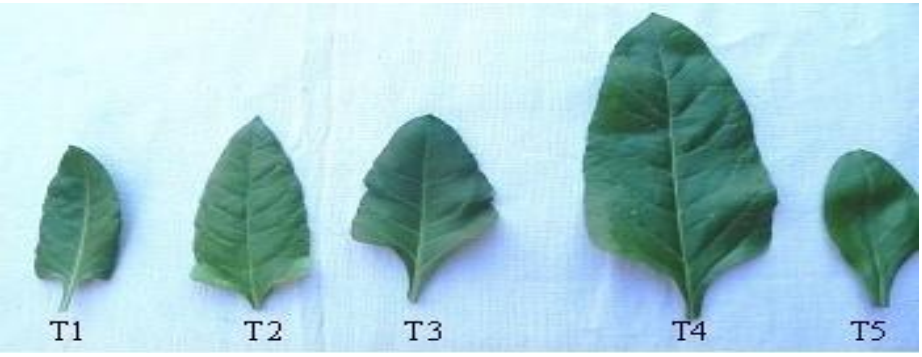
Table 2: Impact of Organic Manures, Chemical Fertilizer and Vermiculture on Plant Height on 15th, 30th and 45th day in spinach (*Spinacea oleracea Linn*)

Treat-ment	Plant Height in three Experiments (in cm)														
	15th day			30th day			45th day			60th day			90th day		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
T1	7.13	7	8.75	14.25	11.5	16.31	20	15	21.75	25.38	32.25	33	36.88	35.5	39
T2	7.5	8.2	9.88	18.56	11.75	19.06	22.75	21.88	25	32.88	34.63	38.63	40.75	38.25	40.31
T3	6.56	7.5	7.38	15.13	12.5	20.55	18	18.25	19.75	19.88	32.5	28.96	35.5	35	34.81
T4	9.88	11	10.88	25.25	21	24.63	31.25	26.25	30	35.75	36.06	34.31	41.25	40.31	40.81
T5	5	5.88	5.94	14	10	13.44	16.63	17.5	17.5	21.13	29.75	25.63	32.63	33.5	31.88
S Em±	0.37	0.37	0.36	0.67	0.78	1.15	0.38	0.41	0.67	1.5	0.41	0.54	0.42	0.46	0.53
CD at 5%	1.13	1.11	1.07	2.01	2.36	3.46	1.15	1.24	2.02	4.53	1.23	1.62	1.25	1.4	1.59

Treatments T1 (FYM), T4 (vermiculture) and T2 (vermicompost) established their significant superiority over T3 (chemical fertilizer) and T5 (control) during the first and third experiments at 60th day. The maximum plant height of 41.25 cm was recorded at 90th day in T4 (vermiculture) treated plants followed by T2 (vermicompost) treated plants (40.75 cm) in the first experiment. It was noticed that the performance of organic fertilizers was much better and showing significant superiority over chemical fertilizer. The findings of Yaseen *et al.*, (2009) are also in line that organic fertilizers i.e. mixture of farmyard and chicken manure, improved the vegetative growth characters of spinach plants.

Leaf Area

Treatment T4 (vermiculture) was found to be significantly superior over (FYM), T2 (vermicompost) and T3 (chemical fertilizer) and T5 (control) consistently in all the three experiments with 30.97, 31.77 and 33.25 cm2 average leaf area (Picture 1). It was found that organic fertilizers performed better in comparison to chemical fertilizer. Roy *et al.*, (2014) also found that organic manure additions to soil increased all the vegetative growth parameters expressed as fresh weight, leaf number, shoot and root length.



Picture 1: Impact of Organic Manure, Chemical Fertilizer and Vermiculture on Leaf Area in Spinach (*Spinacea oleracea Linn*)

Average Number of Leaves

An examination of data indicates that T4 (vermiculture) had significantly better number of leaves in all the experiments with 38, 28 and 42.25 being average number of leaves. It is evident from the data that use of T4 significantly increased number of leaves of spinach over all other treatments in all the three experiments (Figure 1). Sinha *et al.*, (2009) also reported that worm worked waste and their excretory products (vermicast) can induce excellent plant growth. It has been found to influence on all yield parameters such as-improved seed germination, enhanced rate of seedling growth, flowering and fruiting of major crops like wheat, paddy, corn, sugarcane, tomato, potato, brinjal, okra, spinach, grape and strawberry as well as of flowering plants like petunias, marigolds, sunflowers, chrysanthemums and poinsettias.

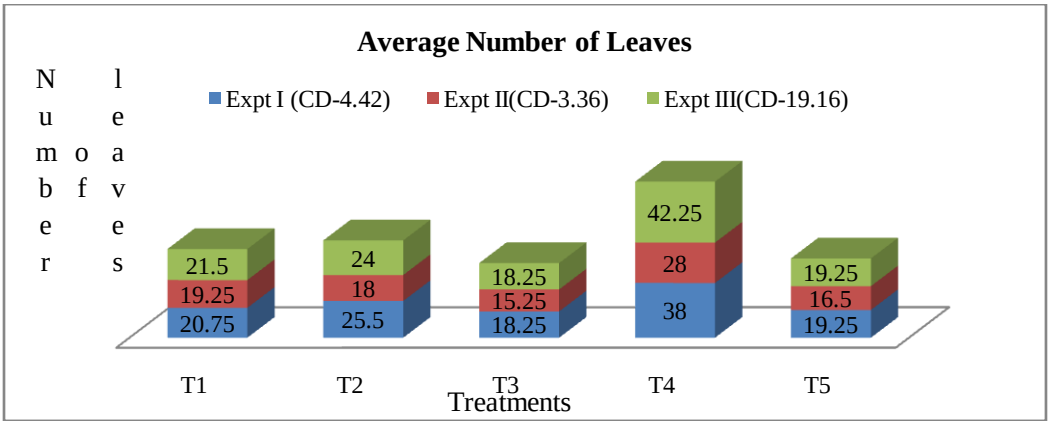


Figure 1: Impact of Organic Manure, Chemical Fertilizer and Vermiculture on Average Number of Leaves in Spinach (*Spinacea oleracea Linn*)

Average Harvested Leaves Weight

T4 (vermiculture) fertilized plants produced maximum average harvested leaves weight of 315.9 g in the third experiment during the whole experiment. In plants fertilized with T2 (vermicompost), maximum average leaf weight recorded was 241.65 g in the third experiment. Treatment T4 (vermiculture) was

found to be significantly superior over T3 (chemical fertilizer) and T5 (control) consistently in the three experiments.

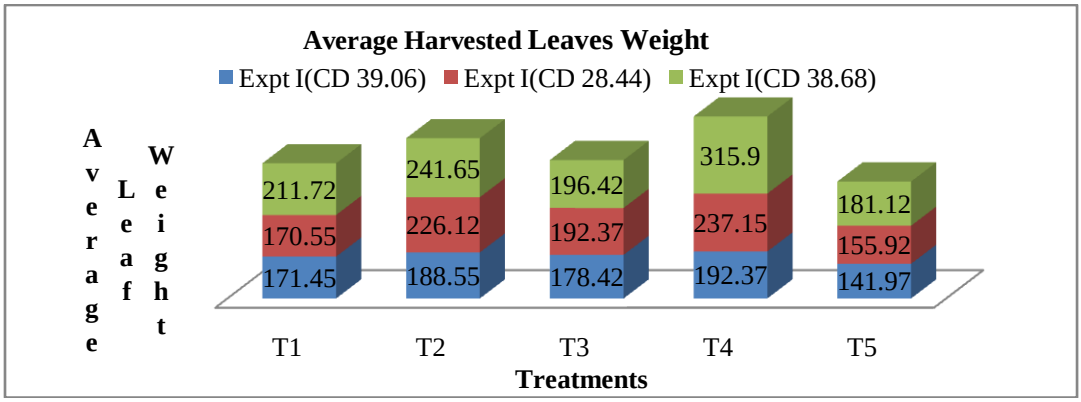


Figure 2: Impact of Organic Manure, Chemical Fertilizer and Vermiculture on Average Harvested Leaves Weight in Spinach (*Spinacea oleracea Linn*)

β Carotene

Treatment T4 (vermiculture) was found consistently superior to T3 (chemical fertilizer) in all the experiments whereas T2 (vermicompost) registered significant superiority over T3 in the second and third experiment at 5 % level of significance. β carotene content was recorded with T4 (vermiculture) (2778.5 µg 100^{-1} g) under the second experiment. It was comparable to the standard given by NIN i.e. 2740 µg100^{-1}g.

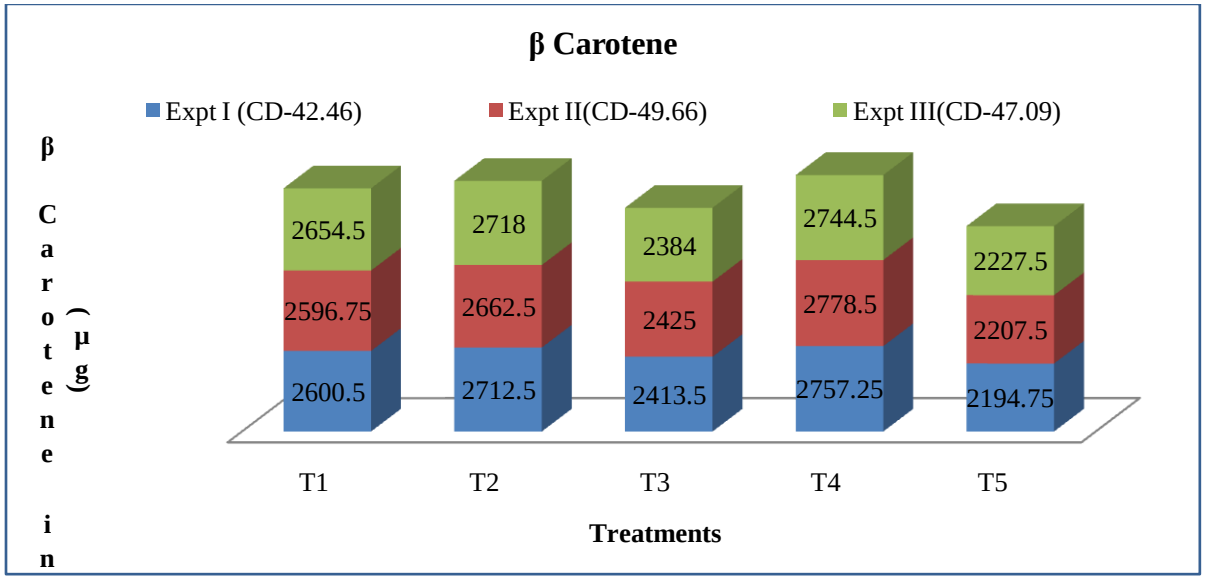


Figure 3: Impact of Organic Manure, Chemical Fertilizer and Vermiculture on β Carotene content in Spinach (*Spinacea oleracea Linn*)

The β carotene content of spinach grown in vermiculture was 14.65 percent more than chemically grown spinach. Similarly, in vermicompost grown spinach the β carotene content was found 12.06 percent more than chemically grown spinach. Levels in the body tend to spike within a few hours of consuming a meal high in total antioxidants, returning to baseline levels after a few more hours. 58.5 percent higher antioxidant levels were observed in sustainably grown corn than conventionally grown corn, while

organically and sustainably grown marionberries had approximately 50 percent more antioxidants than conventionally grown berries (Lester *et al.*, 2007; Reganold *et al.*, 2010).

Calcium

Calcium content was found maximum (72.99 mg 100^{-1} g) with T4 (vermiculture). Calcium content was found maximum (72.99 mg 100^{-1} g) with T4 (vermiculture). It was comparable to the standard given by NIN i.e. 73 mg100^{-1}g. In vermicompost grown spinach the calcium content was recorded 3.86 percent more than chemically grown spinach whereas in vermiculture grown spinach the calcium content was recorded 4.45 percent more over chemical fertilizer.

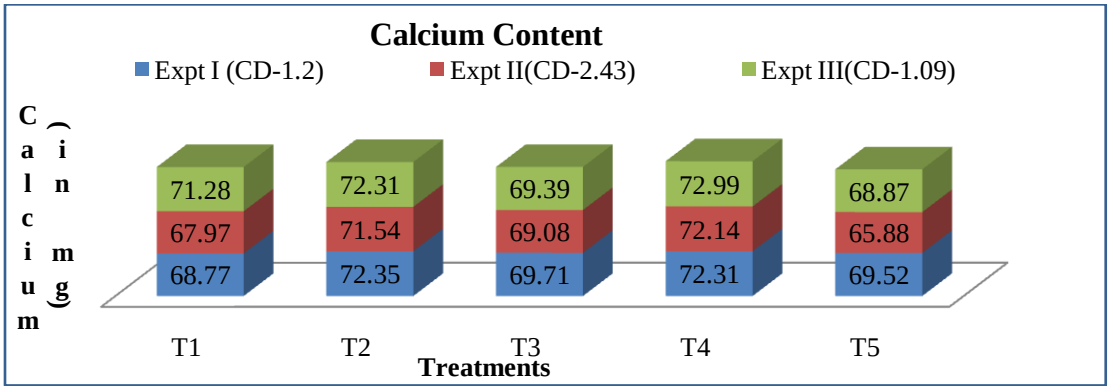


Figure 4: Impact of Organic Manure, Chemical Fertilizer and Vermiculture on Calcium content in Spinach (*Spinacea oleracea Linn*)

Both vermicompost and vermiculture were found significantly superior over chemical fertilizer. Organic plant products have more dry matter and minerals Fe and Mg and far less nitrates similarly more poly unsaturated fatty acids were found in organic animal products organic vegetables (Lairon, 2009).

Vitamin C

The maximum vitamin C content was recorded under T4 (vermiculture) 27.9 mg 100^{-1} g in the third experiment. Vermicompost and vermiculture were found significantly superior over T3 (chemical fertilizer) and T5 (control) for vitamin C content.

In vermicompost grown spinach the vitamin C content was recorded 14.42 percent more than chemically grown spinach whereas in vermiculture grown spinach the vitamin C content was recorded 17.38 percent more over chemical fertilizer. Theunissen *et al.*, (2010) also concluded that organically fertilized plants yielded in higher vitamin C content (6.7- 16.6 mg/100 g) with respect to the conventional ones (4.1 - 9.1 mg/100 g); higher flavonoids content (0.5 - 5.2 mg rutin/g) and, when cooked, the pulp of organic beet maintained a higher polyamine content and higher amount of total carotenoids.

Conclusion

'Organic fertilizer' produced with earthworm digested organic waste are rich in NKP, micronutrients, beneficial soil microbes- 'nitrogen fixing and phosphate solubilizing bacteria' and 'actinomycets'. They are proving as excellent growth promoter and protector. The results clearly indicate that organic fertilizers as well as vermiculture can be used in sustainable horticultural practices; their widespread use can be beneficial for improving health status by using the organic vegetables. The changes in physical and biological properties of the parent soil could also be responsible for observed differences which are brought by earthworms. Consistent application of organic fertilizer inputs satisfy the plants demands for growth and yield by enriching the soil.

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