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EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON THE PERFORMANCE OF *SPINACIA OLERACEA* L.

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The study was conducted to observe the comparative effects of organic and inorganic fertilizers on the morphological and biochemical parameters of spinach (*Spinacia oleracea* L.) var. Savoy under pot trials. Organic fertilizers viz. sesame and mustard oil cake were applied @ (15t/ha) and inorganic fertilizer viz. NPK was applied @ (120 kg/ha) individually as well as in combinations. The application of sesame and mustard oil cakes showed significant enhanced growth over the inorganic fertilizer NPK in terms of root, shoot, total length, fresh and dry weight of the plant. Similarly results of biochemical parameters have shown significant differences between organic fertilizers, inorganic fertilizers and control. The best plant performance was obtained in integrated treatment of organic and inorganic fertilizer that is sesame, mustard oil cake and NPK treatment. Thus the study supports and recommends the use of organic fertilizers like sesame and mustard oil cake with judicial use of inorganic fertilizers by farmers to have better yield.

Keywords: Inorganic fertilizer, Organic fertilizer, Plant performance, *Spinacia oleracea* L.

Introduction

The industrial revolution followed by green revolution caused increase in yield per unit area in agricultural production, but they also caused increase in use of synthetic fertilizers in agriculture. Intensive inorganic fertilizer usage in agriculture cause many health problems and unrecoverable environmental pollution. To reduce and eliminate the adverse effects of Synthetic fertilizers on human health and environment, new agricultural practices have been developed in the organic agriculture[1,2]. The organic fertilizers include peat, animal wastes, plant waste from agriculture, and treated sewage sludge whereas inorganic fertilizers includes synthetic ammonium nitrate, potassium chloride, urea, NPK etc. Although the nutrients in inorganic fertilizers are higher as compare to organic fertilizers, and the release of these nutrients is quick because there is no need for decomposition but inorganic fertilizers are known for their negative impact on environment and high cost[3,4]. Organic farming is growing fast worldwide and

gaining popularity. Work done earlier shows noteworthy effect of organic manures including application of oilcakes. The farmyard manure is another organic nutrient that has proved to be one of the most effective organic sources of nutrients for crop production[5]. Spinach is widely produced leafy vegetable which belongs to the kingdom- Plantae, order- Caryophyllales and family- Amaranthaceae, grown in the temperate regions of the world. Spinach is rich in beta-carotene and an efficient source of both macro and micronutrients such as nitrogen, phosphorus, potassium, calcium, boron, magnesium and manganese etc. To maintain a good crop of high quality the plant requires a constant and uniform supply of water, fertile sandy soil with high organic matter content. Spinach requires optimum soil pH 6 and is sensitive to acidity and saturated soil conditions[6].

The high chlorophyll content, the high percentage of protein and carbohydrate indicates, better physiological and biochemical conditions within the plant. It is usually suggested that the use of organic fertilizers and amendments are eco-friendly and gives compatible results with synthetic fertilizers, which are routinely used by farmers to enhance plant growth. All fertilizers improve the nutritional status of soil. These nutrients are then absorbed by a plant which is reflected in the improved plant growth and yield. Inorganic fertilizers contain salt which require more energy to draw water from the soil and cause them to appear wilted. After application of inorganic fertilizers in the field if there is a rainfall shortly then it can wash away applied salt and can pollute water bodies similarly due to leaching, it may enter to the food chain and they get accumulated and harm us[7]. The best way to reduce pollution is to replace gradually chemical fertilizers with biofertilizers and to add to this, followed study was planned to examine the production of spinach under varying levels of organic and inorganic fertilizers.

The study was carried to compare the effect of organic oil cakes and inorganic fertilizers on the morphological and biochemical performance of spinach. The major parameters which determine the quality of spinach as a vegetable crop were studied with the following objectives:

1. Morphological performance study included analysis of morphological parameters like Root, Shoot and Total plant length, Fresh weight and Dry weight.
2. Biochemical performance study included analysis of physiological parameters like chlorophyll (a, b and total), carotenoids, proteins and Carbohydrates.

Material and Methods

Experimental Design

The present investigation was carried out using two locally available organic oil cakes- sesame and mustard and compared with synthetic chemical fertilizers- NPK. Both were obtained from local market. Savoy (a genetic variety) of *Spinacia oleracea L.* was taken from Rajasthan Agricultural Research Institute, Durgapura, Jaipur. The treatments of organic fertilizer and inorganic fertilizer were calculated according to the application of fertilizer per hectare soil and added to the sterilized soil in 5kg pots with seeds.

The Spinach was propagated by seeds after surface sterilization with alcohol and 0.1% mercury chloride before treatment. The spinach crop was seeded directly, with the planting depth about 20 mm in soil in suitable pots. Three replicates of each treatment were studied 45 days after planting for morphological and biochemical analysis.

The following treatments were given:

1. T1 = Spinach + Mustard oil cake (MOC) @20t/ha.
2. T2 = Spinach + Sesame oil cake (SOC) @20t/ha.
3. T3 = Spinach + NPK @ 120kg/ha.
4. T4 = Spinach + Mustard oil cake (MOC) @10t/ha + NPK @60kg/ha.
5. T5 = Spinach + Sesame oil cake (SOC) @10t/ha + NPK @60kg/ha
6. T6 = Spinach + Mustard oil cake (MOC) @10t/ha +Sesame oil cake (SOC) @10t/ha
7. T7 = Spinach + Mustard oil cake (MOC) @ 5t/ha +Sesame oil cake (SOC) @ 5t/ha + NPK@30kg/ha
8. T8= Control (A control treatment for which no inorganic or organic supply is made)

Physical Parameters

After 45 days, plants were uprooted and major morphological parameters viz. root length, shoot length, total length, fresh weight and dry weight were measured.

Biochemical Parameters

For estimating biochemical parameters, Leaf samples from plant were harvested. Following method[8] was used for chlorophyll estimation. For this, 100 mg fresh leaf was crushed in 20 ml of 80% acetone. The extract centrifuged for 10 min at 1000 rpm and supernatant absorbance was recorded at 645nm and 663nm in a UV-Spectrophotometer (Hitachi). Chlorophyll content was calculated for each sample as follow:

Chlorophyll a = 12.7 (A_{663}) – 2.69 (A_{645}) x VW (mg/g-1)
Chlorophyll b = 22.9 (A_{645}) – 4.86 (A_{663}) x VW (mg/g-1)
Total Chlorophyll = [20.2 (A_{645}) + 8.02 (A_{663}) x VW] /1000 (mg/g-1)
Where, A = Absorbance at respective wave length = Volume of extract (ml), W = weight of fresh leaf sample (g).

The amount of leaf Carotenoid was also calculated by the following mentioned method[9]. To estimate the carotenoid content, the same chlorophyll extract and was measured at 480 nm in UV-spectrophotometer.

Carotenoids = A_{480} + (0.114 × A_{663}) – (0.638 × A_{645}) (mg/g-1)
Where, A = Absorbance at respective wave length

Estimation of total soluble protein was carried by Folin Lowry method[10] using bovine serum albumin as the standard solution. Total Sugars were estimated by Anthrone method[11] and standard solution of D-glucose was used.

Statistical analysis

All the studied parameters of *S. oleracea* L. under different treatments were analyzed using SPSS software. The average values of ± SE are given.

Results and Discussion

The plants were uprooted from the soil without damaging root system, gently rinsed with running water to remove extra adhering debris matters and then all morphological features were measured. Results offered in Table 1 and 2 revealed that, overall increased growth was observed in treated spinach plants as compared to untreated control. Regarding morphological parameters, highest shoot and root length was observed in T7 (17.33 and 7.16cm) treatment followed by T5 (16.90 and 5.76cm), T4 (16.53 and 5.73cm), T6 (16.10 and 5.23cm) and T1 (14.33 and 5.01cm) treatments. In the control the length of the shoot (9.66cm), root (4.46cm) and complete plant (14.13cm) was observed to be the least. Similar trend was observed regarding fresh and dry weight of plants in which T7 (3.44 and 1.40g) treatment showed highest value followed by T6 (2.43 and 0.35g), T4 (2.17 and 0.33g), T5 (2.08 and 0.30g) and T1 (1.76 and 0.15g) respectively. Similar observations were seen with regard to other parameters like total chlorophyll, carotenoids, sugars and proteins. The prime photosynthetic pigments, a, b and total

Treatments	Root length (cm)	Shoot length (cm)	Total length (cm)	Plant fresh Weight (g)	Plant dry Weight (g)
T1	5.01±0.98*	14.33±0.92*	19.34±1.902*	1.76±0.15*	0.15±0.14*
T2	4.63±0.43*	11.50±0.86*	16.13±1.29*	1.22±0.08*	0.18±0.08*
T3	4.53±0.53*	11.43±0.93*	15.96±1.46*	1.19±0.07*	0.07±0.38*
T4	5.73±0.62*	16.53±0.48*	22.26±1.10*	2.17±0.19*	0.33±0.12*
T5	5.76±0.54*	16.90±1.26*	22.66±1.80*	2.08±0.48*	0.30±0.48*
T6	5.23±0.66*	16.10±1.26*	21.33±1.92*	2.43±0.26*	0.35±0.03*
T7	7.16±1.45*	17.33±2.33*	24.49±3.78*	3.44±1.01*	1.40±0.42*
T8	3.46±0.26*	09.66±1.69*	13.12±1.95*	0.34±0.97*	0.02±0.00*

Table 1: Effect of organic and inorganic fertilizers on the morphological parameters of *Spinacia oleracea* L. variety- Savoy**.**

The data shown are the means ± standard error (n = 3). Value within each column marked with different * means values are * = significant and ** = not significant at p<0.05.

Where T1 = Spinach + MOC**;** T2 =Spinach +SOC; T3 = Spinach+ NPK. T4 = Spinach+ MOC + NPK T5 Spinach+ SOC+ NPK; T6 = Spinach+ MOC + SOC; T7 = Spinach+ MOC + SOC + NPK; T8= Control (No synthetic or organic matter supply is made)

Treatments	Chlorophyll a (mg/g-1)	Chlorophyll b (mg/g-1)	Total Chlorophyll (mg/g-1)	Carotenoids (mg/g-1)	Proteins (mg/g-1)	Carbohydrates (mg/g-1)
T1	13.07±1.66*	5.05±0.71*	18.12±0.19*	0.61±0.73**	2.25±0.19*	0.28±0.48*
T2	13.98±1.73*	6.16±1.87*	14.93±0.24*	0.46±0.02**	4.69±0.45*	0.49±0.03*
T3	13.00±1.80*	6.17±1.22*	17.01±2.01*	0.76±0.17**	4.77±0.50*	0.51±0.03*
T4	11.51±3.05*	5.50±1.90*	20.17±2.85*	0.59±0.05**	4.78±0.38*	0.35±0.06*
T5	11.61±0.13*	5.09±0.95*	21.14±1.14*	0.57±0.83**	4.13±0.13*	0.34±0.40*
T6	11.52±2.23*	5.70±0.69*	22.22±3.38*	0.53±0.05**	4.78±0.19*	0.36±0.06*
T7	17.31±0.72*	7.31±1.03*	24.62±0.49*	0.86±0.00**	5.01±0.28*	1.03±0.39*
T8	07.82±0.99*	2.65±0.12*	10.47±0.02*	0.37±0.01**	2.18±0.14*	0.28±0.48*

Table 2: Effect of organic and inorganic fertilizers on the biochemical parameters of *Spinacia oleracea* L. variety- Savoy**.**

The data shown are the means ± standard error (n = 3). Value within each column marked with different * means values are * = significant and ** = not significant at p<0.05.

Where T1 = Spinach + MOC**;** T2 =Spinach +SOC; T3 = Spinach+ NPK. T4 = Spinach+ MOC + NPK T5 Spinach+ SOC+ NPK; T6 = Spinach+ MOC + SOC; T7 = Spinach+ MOC + SOC + NPK; T8= Control (No synthetic or organic matter supply is made)

chlorophyll along with carotenoids were estimated. Chlorophyll a, b and total ranged from 7.82, 2.65 and 10.47 mg/g-1respectively in T8 treatment to 17.31, 7.31 and 24.62 mg/g-1 respectively in T7 treatment. It was observed that a, b and total cholorophyll were high in T6 followed by T5 and T4 as compared to T1, T2 and T3 treatments. Carotenoids ranged from 0.37 in T8 to 0.86 mg/g-1 in T7 treatment. Proteins and carbohydrates varied in different treatment with highest in T7 (5.01, 1.03 mg/g-1) and lowest in T8 (2.18, 0.28 mg/g-1) respectively. Protein and carbohydrate content in T3 and T4 treatments were almost at par with each other (Table 2).

Individual and concomitant effect of sesame, mustard oil cake and NPK was studied to *evaluate* their compatibility in enhancing spinach plant growth vigour and yield. A significant enhancement in plant growth was observed when either one of the two oil cakes, was used individually and in combination as well. In the present study it was found that organic amendments integrated with chemical fertilizers have

given better results than individual treatments. Similarly it was reported by many workers[12] that the use of different combinations of NPK and farmyard manure have given superior results. The sesame oil cake was better in performance than mustard oil cake which was somewhat at par with applied inorganic fertilizer. Similar types of results were observed earlier by workers using field yard manure, mycorrhizae and vermicompost[13, 14].

In present study fresh and dry weight was found to be great in integrated treatment with sesame oil cake, mustard oil cake and NPK followed by individual sesame and mustard oil cake treated plants. These results are in accord with earlier findings[15] where NPK treatments enhanced number of fruits per plant. The higher chlorophyll content was observed in integrated organic and NPK application followed by sesame and mustard and oil cake application. Earlier also it was found the biological applications have enhanced crop yield. The higher yields obtained from plots with treatments may be due to their higher nutritional content particularly Fe, Zn and Mn in organic treatments[16,17]. These elements encourage vegetative growth, total chlorophyll and the photosynthetic rate which enhance flowering and fruiting and leading to an increase in early fruit maturity. It was also reported previously that additions of organic amendments (composts) to agricultural soils can lead to improved soil quality and reduced severity of crop diseases, as well as increased cucumber yield[18].

In present study, all the treatments with organic and inorganic fertilizers recorded high protein and carbohydrate percentage as compared to control samples. Treatment with sesame and mustard oil cakes gave better results than others. Organic amendments have been found to enhance plant growth by earlier workers also[19]. The indication of better photosynthetic and cell metabolic activity are mainly due to chlorophyll a, b and total chlorophyll content. The presence or absence of chlorophyll in plant greatly affects the production of secondary metabolites viz., proteins, glycosides, tannins, carotenoids etc. and other essential plant constituents.

From the above discussion it is very clear that the use of organic fertilizers have produced better results as compared to other forms of traditional synthetic fertilizers in spinach crop. Our approach intends at using organic fertilizers along with judicial use of chemicals fertilizers, thus giving a wealthier, better and economically practicable alternative traditional farming. The use of bio fertilizers such as oil cakes has enhanced not only the quality of the yield but it has also produced spinach without any chemical application. Thus, it is suggested that by using these two natural products the Indian farmer will be benefitted financially and the people will be benefitted by getting organically produced vegetables without any harmful effects.

Conclusion

In can be concluded that, this work has generated satisfactory spinach yield and comparative quality, in fact better to those usually produced by chemical fertilizers. Based on the data and method described earlier, use of fertilizer combinations oil cakes with suggested NPK dose could be recommended for organic spinach production. This approach is eco-friendly, easily available and cost effective also. The conventional growers can obtain good results in organic production systems using adequate combinations and rates of inorganic and organic nutrient sources.

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