Nat. Volatiles & Essent. Oils, 2021; 8(4): 2374-2390

Effect of Organic and Biofertilizers on Seed Yield and Yield Related Attributes of *Perilla frutescens* (L.) Britton

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Abstract

Perilla frutescens (L.) Britton is one of the potential oil seed crop of North Eastern Himalayas region which belongs to family Lamiaceae. It is used since ancient times in herbal medicine, as a garnish and as a natural colorant in Asian countries. It is also regarded as a common annual weed in some areas and is generally ignored by grazing livestock because of the toxic compound *Perilla* ketone presented in the plant. Despite so much potential of the *Perilla* no concerted efforts have made for its diversification and improvement in growth and yield globally as well as in our country. The present study has been done to evaluate the effect of application of vermicompost and biofertilizers on seed yield and yield related attributes on *Perilla* plant in different combination. The maximum growth and yield was reported in T8 treatment where biofertilizers have been applied in consortium form followed by organic fertilizer applied in the form vermicompost (T3) as compare to single application of microbial strains. This may be due to sustained release of nutrients to supply the required elements in a readily available form for plant use. The biofertilizers exhibited beneficial effects on plant growth and development either through producing growth hormones like IAA, kinetin, and gibberellins, synthesizing atmospheric nitrogen and its increased availability to greater protein synthesis as well as increasing phosphorus availability to plant communities. Thus, it was concluded that the enhanced expression of yield and its related attributes will have beneficial impact in production of nutraceutical as well as pharmaceutical products of commercial importance.

Keywords: *Perilla frutescens*, Biofertilizers, Vermicompost, Growth Parameters, Seed Yield, Nutraceutical

1. Introduction

Decreasing availability of land for agriculture, due to diversion of land for industrial use, urbanization, etc. has led to more dependence on degraded lands to meet the increasing requirements of food, fodder, fiber, firewood and timber in the present climate resilient regime and changing food habits. Increased reliance on major food crops has been accompanied by shrinkage of the food basket which mankind has been relying upon for generations. The number of plant species used by human around the world is only one-third of the number of species which generations of diverse cultures around the world have drawn upon to develop crops that would meet specific needs. About 70 species of underutilized crops have been identified to have promise in this regard in Asia pacific region (Eyzaguirre et al. 1999; Arora 2002), particularly in tribal areas of India. These underutilized or future crops now termed as potential crops are adapted to stressed environments and provide food and nutritional cover to population inhabiting remote, tribal and backward areas, offer scope for diversification of agriculture and are source of nutritional security.

The potential crops have many merits, these are easier to grow and hardy in nature, producing a crop even under adverse soil and climatic conditions. Most of *Perilla* species are very rich sources of vitamins, minerals, and other nutrients such as carbohydrates, proteins and fats. Since, the underutilized crops have a long history of consumption, the local people are aware about their nutritional and medicinal properties.

Perilla frutescens (L.) Britton considered one of the potential oil seed crop of North eastern Himalayas region which belongs to family Lamiaceae. The species is distributed in the humid tropical, sub-temperate and temperate climates of the Himalayan region of India, Nepal, Southeast Asia, China, Korea, Japan and Taiwan within the altitudes of 300m to 3500m. Recently, it was introduced to Europe, Russia and USA as an oil seed crop or as a garden plant (Nitta et al., 2003). In India, it is cultivated to a very limited scale in the northeastern hill region, Kumaon, Garhwal and Himachal Pradesh in an unorganized manner. In the northeastern region of India, *Perilla* is grown in all states except Tripura and some plain areas of Assam. The local hilly people of this region grow this crop in certain pockets under Jhoom (shifting) cultivation or in kitchen garden in a limited scale. Improvement of existing crop germplasm is necessary under local condition. *P. frutescens* var. *frutescens* plants are generally taller, larger in seed size and has soft seeds, green leaves and stems, and non-wrinkled leaves which are usually grown in northeastern region of India (Palmer, 1989; Nitta et al., 2003; Lee et al., 2002).

Perilla is used in herbal medicine, as a garnish and as a natural colorant in Asian countries. It is also regarded as a common annual weed in some areas and is generally ignored by grazing livestock because of the toxic compound *Perilla* ketone presented in the plant. Besides culinary and industrial uses, *Perilla* is also reported to have medicinal properties. *P. frutescens* var. *acuta* has been used as an edible biologic medicine in Eastern Asia for more than a thousand years. In the early 1990s, some publications reported that *Perilla* leaf extract and seed oil had the ability to regulate the immune system and could be used as a health food in the treatment of some allergic reactions. The diluted juice extracted by pressing the whole plant is also reported to control insect (*Aphis gossypii*) and pathogens like *Glomerella gossypii* and *Phytophthora infestans* (Yang and Tang, 1988). According to Bachheti et al. in 2014, the plants have been used as an important traditional herbal medicine for treating various disease including depression, anxiety, tumor, cough, antioxidant, allergy, intoxication, and some intestinal disorders the seeds are contain considerably high levels (approx. 60%) of α-linolenic acid, which can be expected to possess various biological activities. The oil is extensively used as a flavoring agent, in which *Perilla* aldehyde is the desirable flavoring compound (Guenther, 1949). The oil is a rich source of protein and fat (Longvah and Deosthale, 1991). The major fatty acids of *Perilla* oil are linolenic, linoleic and oleic acids. The seed has saturated acids 6.7-7.6%, oleic acid 14-23%, linoleic acid 11-16% and linolenic acid 50-70% (FAO, 1992).

Despite so much potential of the *Perilla*, no concerted efforts have made for its diversification and improvement in growth and yield globally as well as in our country. Fertilization is a major factor affecting growth, yield of plant and quality of seed. One of the major problem of excessive use of chemical fertilization is nitrate accumulation in the plant which can directly inhibit oxygen transport by blood leading to methemoglobinemia in human being. Because chemical fertilization strategies might cause this problem. Therefore, it is an urgency to develop some alternative strategies to supply nutrients to the growing plant also to provide the high quality and safety product which will be environmentally friendly. In this regard, use of organic and bio fertilizer is essential (Schütz, 2018). Organic fertilizers i.e. Cattle, chicken manure and compost enhances the physical and chemical properties of soil, supply nutrients to growing plants, microbial activity, root distribution and crop production. Bio fertilizer mainly comprises nitrogen fixer, phosphate dissolvers, silicate bacteria and others. These organism may affect their host plant interaction by enhancing nutrients uptake and protection against pathogens. Besides this, application of organic and bio fertilizer is cost effective and renewable source of plant nutrients to supplement chemical fertilizers.

Thus, *Perilla frutescens* var. *frutescens* belonging to Lamiaceae family which are commonly found in diverse habitats of Uttarakhand, India are selected for the present study to evaluate effect of application of vermicompost and biofertilizers on seed yield and yield related attributes.

2. Materials and Methods

Experimental Site

The field experiment was conducted during Kharif season of 2020-21 in the agricultural field of School of Agricultural Sciences, SGRRU, Dehradun, Uttarakhand. It is located in the north western region of Uttarakhand at an altitude of 450 m above mean sea level (MSL) and 3088 square kilometer in size. Geographically, the location of Dehradun is in between 29°58’ and 31°2’30” North latitude and 77° 34’45” and 78°18’30” east longitudes.

Climate and Weather Conditions

The climate of Dehradun is humid subtropical. Summer temperatures can reach up to 44°C for a few days and a hot wind called Loo blows over North India. Winter temperatures are usually between 1°C - 20°C and fog is quite common in winters like plains. Although the temperature in Dehradun can reach below freezing during severe cold snaps, this is not common. During the monsoon season, there is often heavy and protracted rainfall. Average Rainfall is 2074 mm. Dehradun and other plain areas of Uttarakhand see almost as much rainfall as coastal Maharashtra and more than Assam. Agriculture benefits from fertile alluvial soil, adequate drainage and plentiful rain. It was recorded that Dehradun received 1734mm. rainfall from the month of July to October in 2020. The maximum and minimum temperature was recorded during the growing season of crop (i.e. July-November 2020) was 25° C and 3°C, respectively.

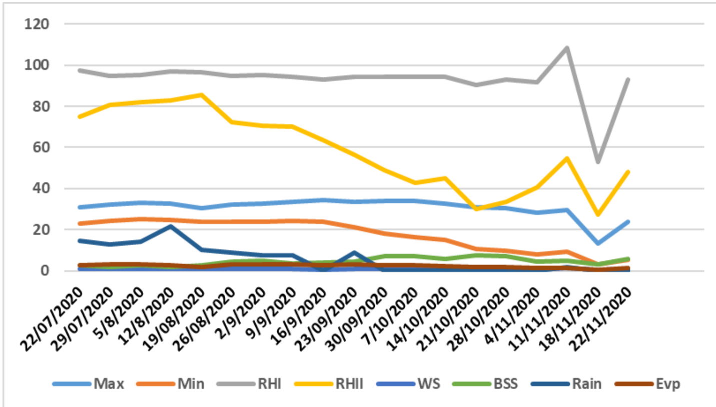

Figure 1. Weekly Weather Data during the Experimental Period (22 July- 22 November 2020)

Soil Characteristics

Soil of experimental site is classified as sandy loam with characteristics as deep, well drained, coarse loamy cover over fragmental soils and of medium fertility. Total five soil samples were taken from upper (0 - 15 cm) layer of the soil and mixed properly from different sites of the field. Soil pH (1:25) soil water suspension value is 7.12 %, Organic Carbon (%) 0.42, Available Nitrogen220.04, Available Phosphorus (kg/ha) is 9.1 and Available Potassium (kg/ha) is 18.1.

Cropping History of Experimental Field

Crops grown in the experimental field during Kharif and Rabi season in 2018, 2019 are as follows:

Table 1: Cropping History of Experimental Field

Year	**Season**	
	Kharif	**Rabi**
2018	Maize	Mustard
2019	Rice	Lentil

Experimental Details

The experiment consist of 8 treatment, was planted in Randomized Block Design (RBD) and each set of treatment was replication for three times.

Table 2: Different Combination of Treatments used for Experiments

T1	Control
T2	Farm Yard Manure (FYM) @100gm/bed
T3	vermicompost @100gm/bed
T4	FYM + vermicompost @100gm/bed
T5	Azotobacter @100gm/bed
T6	Potash @100gm/bed
T7	Phosphorus @100gm/bed
T8	Azotobacter + potash+ phosphorus @100gm/bed

Cultural Operations

Field Preparation

The field was deep ploughing with tractor drawn M.B plough and pulverized followed by two cross harrowing with the tractor mounted disc harrow and leveling the field.

Sowing and transplanting

Seeds are broadcast on raised beds worked up to a fine tilth. Seeds are then just covered with sieved soil or sand and the bed watered and covered with straw. The cover is removed as soon as the sprouts emerge seed rate. Normally one month old healthy seedlings (5-6cm tall, 4-5 leaf stage) were used for transplanting purposes. In the present study30 day's old seedling were used because of heavy rains and unavoidable circumstances. The seedlings were uprooted, washed and treated with biofertilizers as per treatments and were transplanted in to main experimental plot with 15 cm row to row and 15 cm plant to plant distance. The plots were irrigated immediately after transplanting. The seedlings established well by the time of second irrigation. At the stage, gap filling and replacement of poor plants was done so that a uniform stand was achieved.

Irrigation and weeding

The irrigation was given immediately after planting and subsequent irrigation were provided as per requirement of crop and total 4 irrigations were applied during crop growth period.

Weeding operation were performed manually. The weeding was done at 28, 40, 80 days after transplanting to make crop weed free during crop season.

Harvesting

Harvesting of the crop was done when crop attained full maturity. Before harvesting the representative sample plant from each plot were taken out from the postharvest studies. Harvest plants from the border area are excluded and the crop from net plot was left as such on the plot for sun drying for 5 days. The crop was harvested from the net plot area (1m x 1 m) and plants were cut from 65 cm above the ground level with the help of hand sickle. After harvesting, the crop was weighed immediately to record net plot herbage yield.

Observation recorded at different stages

The observation on growth and development of crop parameters like plant height, spreading, fresh weight of leaves, stem and total herbage and dry matter accumulation in leaves, stem and total herbage were recorded at 30, 60days after transplanting and at the time of harvesting.

The total fresh herbage yield was obtained by the harvested plants from net plot area ($1x1m^2$) excluding border plant to avoid the border effect. The total fresh herbage was weighed and weight was recorded in kg/plot and later it was expressed in the q ha $^{-1}$ by using the following formula:

$$\text{Total herbage (q ha}^{-1}\text{)} = \frac{\text{weight of plants harvested from net plot area (kg) x10000}}{\text{Net plot area x 100}}$$

Economics

Gross Return

The yield of *Perilla* crop (seed) was converted into gross return per hectare (Rs/ ha) on the basis of prevalent price of product in the market.

Net Return

Net return was obtained by subtracting the cost of cultivation from gross return of the individual treatments and is expressed in rupee per hectare (Rs/ha).

Benefit: Cost Ratio (BCR)

The benefit: cost ratio was calculated on the basis of net return (Rs/ha) and cost of cultivation (Rs/ha) by the following formula:

$$\text{Benefit: Cost ratio (BCR)} = \frac{\text{Net profit (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

3. Results and Discussion

Perilla frutescens (L.) Britton belongs to family Lamiaceae considered as one of the potential oil seed crop of North eastern Himalayas region. *Perilla* plant is reported to have several biological activities such as culinary, industrial and medicinal properties. In the early 1990s, some publications reported that *Perilla* leaf extract and seed oil had the ability to regulate the immune system and could be used as a health food in the treatment of some allergic reactions. *Perilla* seeds contain 35-54% of a drying oil which is similar to linseed oil. The oil is a rich source of protein and fat (Longvah and Deosthale, 1991). The major fatty acids of *Perilla* oil are linolenic, linoleic and oleic acids. The seed has saturated acids 6.7-7.6%, oleic acid 14-23%, linoleic acid 11-16% and linolenic acid 50-70% (FAO, 1992).

Seed oil has got some industrial uses in the manufacture of paints, varnishes, linoleum, printing ink, lacquers and protective water proof coatings on cloth, artificial leather, enamels, etc. Despite so much potential of the *Perilla* very less efforts have made for its diversification and improvement in growth and yield globally as well as in our country. In view of above studies, *Perilla* plant was selected for the present study to evaluate effect of application of organic and bio fertilizers on seed yield and yield related attributes under tarai condition of Uttarakhand. The significant experimental finding obtained during the present investigation are discussed below with possible evidence wherever necessary in order to find out the cause and effect relationship among different treatments with respect to various characters studied and to sort out information of practical value.

Effect of Organic and Bio Fertilizers on Growth Parameter

The plant height was observed at the interval of 30 days *i.e*. 30, 60 and at the time of harvesting. Maximum vegetative growth was observed between 30 to 60 days in all the treatments. The comparison of treatment mean of plant height with different organic and bio fertilizers indicated that there were significant differences in the height of *Perilla* plants till the end of crop growth period. The maximum plant height (13.2 cm, 40.3 cm and 83.8 cm at 30, 60 and at the time of harvesting, respectively) was observed in case of treatment T8 (Azotobacter+ potash + phosphorus) during all the growth stages. This is followed by treatment T3 (vermicompost). Minimum plant height was observed in treatment T7 (phosphorus). Increased plant height may be due to the application of recommended dose of organic fertilizers and microbial consortia of nitrogen fixer, potash and phosphate solubilizer bacterium with nutrient rich organic source like enriched compost. Similar findings were observed in case of maize where many research studies have showed that the composted organic materials release nutrients slowly and may reduce the leaching losses, particularly Nitrogen (Nevens and Reheul, 2003 and Naveed *et al*., 2008).

The maximum leaf length was observed under treatment T8 (11.8 cm) where Azotobacter+ potash + phosphorus was applied followed by T3 (11.6 cm) and lowest leaf length was observed with T7 (6.7cm). This increase in leaf length may be due to slow and sustain release of nutrients. This will result in increase in metabolic activities like photosynthesis and growth of plants.

Number of branches per plant increased with advancement in crop age up to harvesting of the crop. Differences in number of branches due to different treatments were significant at all the stages of crop growth. Treatment T8 (14.6) recorded the maximum number of branches per plant followed by T3 (14) and T5 (13.6) and had significantly more number of branches over rest of the treatments.T6 (11.3), T7 (11) recorded the minimum number of branches per plant.

Table 3: Effect of fertilizers on growth parameters of *Perilla frutescens* (L.) Britton

Plant height (cm)				**Mean ±SE**				
Days	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**
30days 60 days At harvest	9.7±0.15 32.3±1.45 57.0±2.08	8.6±0.44 23.0±0.58 38.4±1.70	12.1±0.26 38.4±1.70 78.3±2.03	10.2±0.15 36.3±1.08 75.2±0.60	12.0±0.28 29.7±0.50 74.1±1.09	7.03±0.32 22.6±1.59 58.6±0.93	5.7±0.14 19.5±0.76 47.9±1.31	13.2±0.60 40.3±0.18 83.8±1.97
Leaf length (cm)								
30days 60 days At harvest	3.23±0.39 6.8±0.14 10.9±0.27	2.58±0.22 6.6±0.26 9.7±0.07	6.8±0.47 9.7±0.14 11.6±0.1	3.16±0.44 7.6±0.26 10.8±0.07	2.92±0.54 6.1±0.21 10.6±0.17	2.73±0.14 6.0±0.23 7.8±0.07	2.33±0.17 5.7±0.17 6.7±0.17	7.1±0.21 10.7±0.15 11.8±0.13
Number of branches								
30days 60 days At harvest	5.66±0.33 10.7±0.67 12.6±0.67	5.33±0.33 10.3±0.33 12.3±0.33	7.0±0.58 12.0±0.58 14.0±0.58	6.0±0.58 10.0±0.58 12.0±0.58	6.66±0.88 11.0±0.58 13.6±0.33	6.0±0.58 9.33±0.88 11.3±0.88	5.33±0.33 9.0±0.58 11.0±0.58	7.66±0.33 13.0±0.58 14.6±0.33

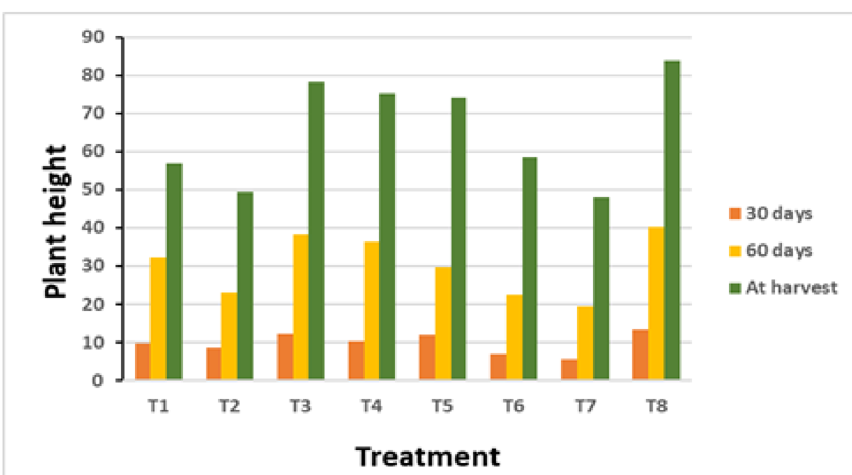

Figure 2. Effect of different treatments on plant height (cm) of *Perilla frutescens*

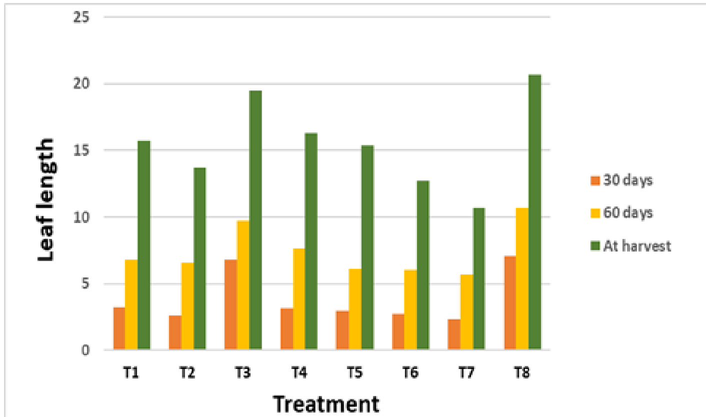

Figure 3: Effect of different treatments on leaf length (cm) of *Perilla frutescens*

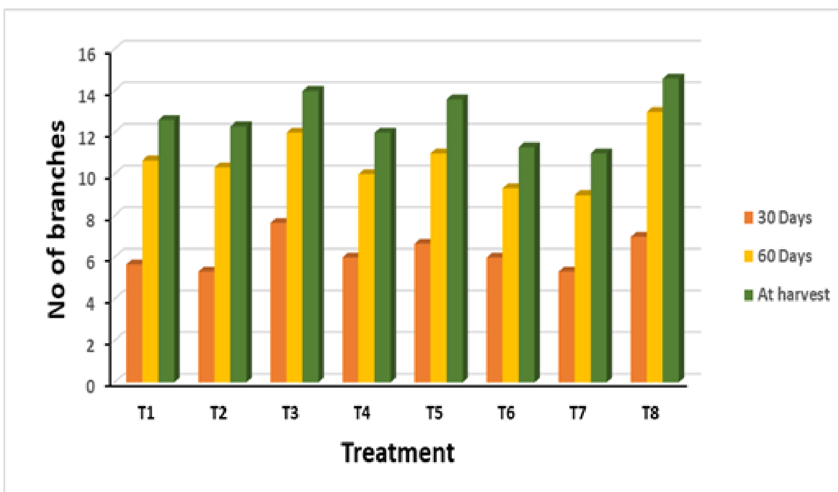

Figure 4: Effect of different treatments on number of branches of *Perilla frutescens*(L.) Britton

Effect of Organic and Bio Fertilizers on Yield Parameter (g/Plant)

Highest leaf fresh weight was observed at T8 (97.3 g/plant) *i.e.* Azotobacter + potash + phosphorus during all the crop growth stages. However leaf fresh weight (50.4 and 50.3 g/plant) of *Perilla* plant was reported to be same at 30 days maturity. At the time of harvesting minimum leaf fresh weight was reported in T7 (50.4g) treatment. The increase in growth attributes along with increase in yield was due to microorganisms that are present in biofertilizers, which stimulates the plant growth by supplying nutrients by their colonization at the rhizosphere or, by their symbiotic association. The association also regulates the physiological process in the ecosystem, by the involvement of organic matter decomposition and atmospheric nitrogen fixation (Rajasekaran *et al*., 2015; Rachel & Sirisha, 2015).

The stem fresh weight was recorded significantly maximum with application of Bio fertilizers T8 *i.e.* Azotobacter+ potash + phosphorus (152.2g) treatment .The lowest stem fresh weight was recorded in T7 *i.e*. phosphorus (108.5g) treatment during all the crop growth stages at the harvest time.

Significantly higher total fresh weight per plant was recorded under T8 *i.e*. Azotobacter + potash + phosphorus (209.4 g) followed by T3 *i.e.* Vermicompost (208.8 g).The lowest total fresh weight was observed under T7 *i.e*. phosphorus (191.2 g) T6 *i.e.* potash (193.4 g) treatment at all the crop growth stages. The leaf- stem ratio ranges from 0.46 to 0.64. The leaf- stem ratio of *Perilla* was recorded significantly maximum (0.64) at T8 treatment. The lowest leaf – stem ratio of *Perilla* was recorded in T7 treatment at the harvest time. Minimum leaf stem ratio was reported to be 0.46 at T7 treatment.

Table 4: Effect of fertilizers on yield parameters of *Perilla frutescens* (L.) Britton

Leaf fresh weight (g)			**Mean ±SE**					
Days	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**
30days	36.0±1.1	33.6±0.9	44.6±0.9	42.3±1.4	43.0±0.6	42.8±1.4	50.4±1.3	50.3±1.1
60 days	113.6±0.9	112.3±1.4	120.0±1.1	114.3±1.2	111.6±1.2	106.3±0.9	90.0±1.1	122.0±1.1
At harvest	76.3±0.9	74.0±1.1	86.3±0.9	83.6±0.9	82.0±0.9	70.0±0.9	50.4±1.1	97.3±1.2
Stem fresh weight (g plant^{-1})								
At harvest	142.3±0.7	140.3±0.6	149.1±0.6	147.3±0.5	132.3±0.6	129.3±0.6	108.5±0.5	152.2±0.6
Total fresh weight (gm)								
At harvest	202.4±0.5	204.3±0.7	208.8±0.2	200.4±0.3	207.4±0.6	193.4±0.6	191.2±0.7	209.4±0.5
Leaf-stem ratio								
At harvest	0.54±0.01	0.53±0.01	0.58±0.01	0.57±0.03	0.62±0.01	0.54±0.01	0.46±0.01	0.64±0.01
Total seed yield (q/ha)								
At harvest	26.8±1.4	25.8±2.04	36.2±2.7	28.6±0.9	25.4±1.5	23.1±1.9	19.6±1.9	37.6±1.6

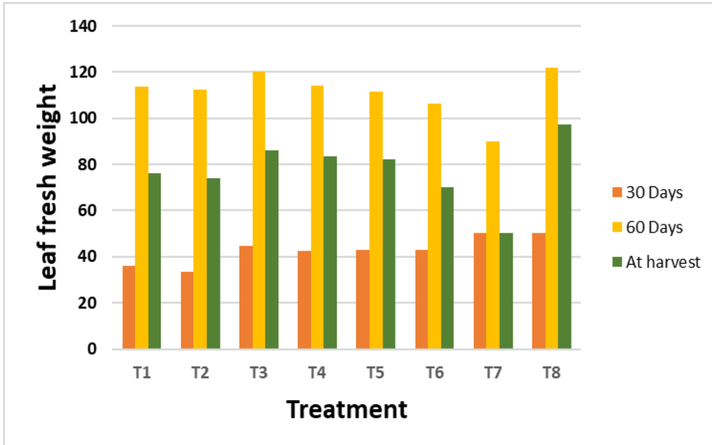

Figure 5: Effect of different treatments on leaf fresh weight of *Perilla* Plant

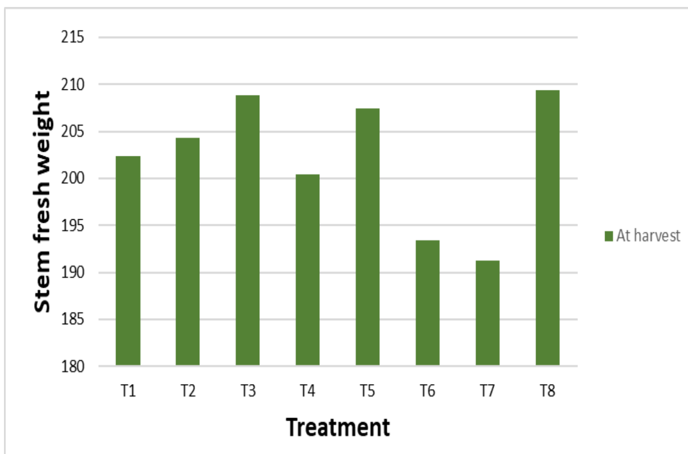

Figure 6: Effect of different treatments on Stem fresh weight of *Perilla* Plant

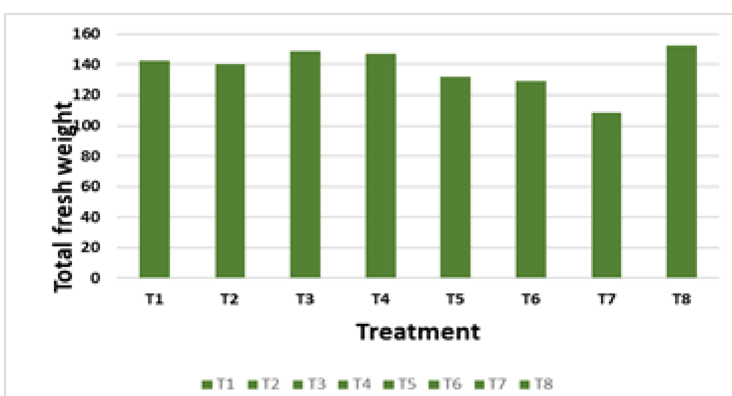

Figure 7: Effect of different treatments on total fresh weight of *Perilla* Plant

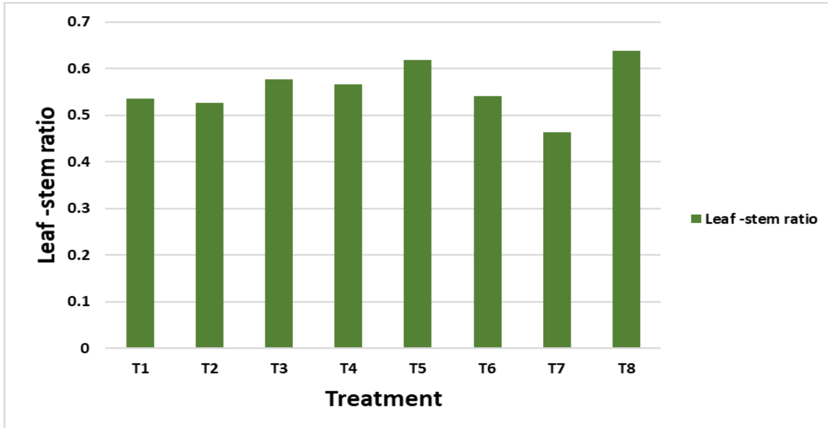

Figure 8: Effect of different treatments on leaf-stem ratio of *Perilla* Plant

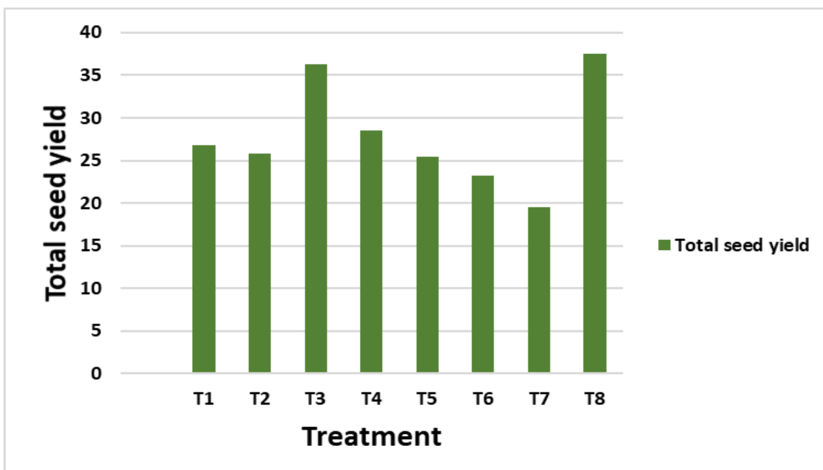

Figure 9: Effect of different treatments on total seed yield at harvest time of *Perilla* plant

Total seed yield of *Perilla* was affected significantly with different combination of organic fertilizers and biofertilizers at harvest. The maximum seed yield was recorded with combine application of Azotobacter, potash and phosphorus (T8) treatment. The lowest value was recorded under T7 (Phosphorus) treatment. The bio fertilizers had shown greater importance in enhancing the seed yield of *Perilla* with its application combination of Azotobacter, potash and phosphorus. As the results indicated that the application of biofertilizers combined to Azotobacter, Potash and Phosphorus (T8) increased maximum yield that was 40.35 % all the growth stages. Treatment T2 (3.58%) minimum yield all the growth stages treatments. Similar studies on effect of chemical and bio fertilizer has been conducted on *Perilla* plant by Qian et al., 2019. Rachel et al., 2016 and Young et al., 2004 showed that there was a remarkable influence of bio-fertilizers on physical and chemical characteristics of plants such as seedling quality, germination percentage, number of leaflets, root, shoot length, total leaf area and biochemical constituents. Whereas the study conducted by Nadjafi et al. (2012) on the effect of bio-fertilizers on growth, yield and essential oil constitutes of thyme (*Thymus vulgaris* L.) and Sage (*Salvia officinalis* L.) showed that there was not any positive change in both the cases at the research farm of Medicinal Plants and Drugs Research Institute of Shahid Beheshti University of Tehran, Iran.

The higher yield was attributed to the higher plant growth development including greater plant height, number of branches, and total fresh weight per plant. The beneficial effect of organic manures on plant growth and development is well established (Vadiraj et al., 1998). The biofertilizers including phosphorus improved the soil fertility by resulting into higher accumulation of humic substances and microbial population in the soil that improved the availability of macro as well as micro nutrients and finally higher photosynthesis. Hanamashetti et al. (2003) also recorded that higher value of growth parameters and yield to safed musli with application of Farm Yard Manure (FYM) and Vermicompost. Similarly, Singh and Ramesh (2002) noticed that significantly higher plant height and seed yield of *Ocimum basilicum* with application of vermicompost @ 2.5 t ha-1. Chand et al. (1996) also found similar findings in Jamrosa, Slawinski and Songin (2001) in Pea, Paturde et al. (2002) in *Chlorophytum borivallianum* and in Davana (*Artemisia pallens*) by Chalapathi et al. (2004).Kumaran et al. (1998) recorded significantly highest growth and yield of *Ocimum grattisimum* with combined application of inorganic fertilizers and biofertilizers. Maheshwari et al. (1991) reported that Azotobacter gave alone significantly higher herbage of palmarosa compared to control under rainfed condition. Kumar et al. (2002) also supported the above findings. According to him, the combined inoculation of coriander seed with Azotobacter and Azospirillum increased the seed, Stover yield and harvest index significantly.

The biofertilizers exhibited beneficial effects on plant growth and development either through producing growth hormones like IAA, kinetin, and Gibberellins, synthesizing atmospheric nitrogen and it increased availability to greater protein synthesis (Pandey and Kumar, 1989) as well as increasing P availability to plant communities (Bolan, 1991).

Economics of Production

Data pertaining to gross return (q/ha), net return (q/ha) and benefit- cost ratio as affected by organic fertilizers and biofertilizers treatment.

Gross Return

The influence of different organic fertilizers and bio fertilizers treatments on gross return (Rs /ha) was well marked. All the treatments registered significantly higher gross return over the treatment. The maximum gross return (1,502,400/- ha) was obtained under treatment T8 though was statistically at per with T3 (1,449,600/- ha) and the minimum gross return (782,400/- ha) was obtained under T7 treatment.

Table 5. Effect of different treatments on gross return (Rs/Ha), net return (Rs/Ha) and benefit – cost ratio of *Perilla* plant

Treatment		Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
T1	Control	1070400	1030400	25.76
T2	Farm Yard Manure (FYM)	1032000	992000	24.8
T3	Vermicompost	1449600	1409600	35.24
T4	Vermicompost + FYM	1142400	1102400	27.56
T5	Azotobacter	1017600	977600	24.44
T6	Potash	926400	886400	22.16
T7	Phosphorus	782400	742400	18.56
T8	Azotobacter + potash+ phosphorus	1502400	1462400	36.56

Net Return

Different treatment showed marked effect on the net return (Rs /ha). All the treatments recorded significantly higher net return over control plot. Treatment T8 although generate the highest net return (1,462,400 Rs/ha). The minimum net return (742,400 Rs/ha) T7 treatments.

Benefit: Cost Ratio

Maximum benefit – cost ratio was obtained with the treatment T8 (36.56) and the minimum benefit – cost ratio was observed the treatment T7 (18.56).

4. Conclusion

The present has revealed that there is a huge potential for the use of bio-fertilizers in a wide variety of crop plants. Application of bio-fertilizers promoted healthy growth and yield of plants while enhancing sustainability of soil. The findings were reported on important growth and yield attributed parameters such as plant height leaf length, number of branches, leaf fresh weight, stem fresh weight, total fresh weight, and leaf -stem ratio in plant organs. The maximum growth and yield was reported in T8 treatment where biofertilizers have been applied in consortium form followed by vermicompost.

Thus, it was concluded that the enhanced expression of yield and its related attributes will have beneficial impact in production of nutraceutical as well as pharmaceutical products of commercial importance. Environmental stewardship and proper use of fertilizer products plays a critical role in meeting global food demand and ensuring increased food production in a responsible and sustainable manner.

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