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To study role of organic manures and bio-fertilizers on quality and leaf yield of lettuce

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Abstract
A field experiment was conducted during Rabi 2016-17 at Experimental Farm of Division of Vegetable Science SKUAST-K Shalimar Campus, to study role of organic manures and bio-fertilizers on quality and leaf yield of lettuce. The experiment was laid out in RCBD with inorganic fertilizers, three types of both organic manures and bio-fertilizers constituting 13 treatments combinations in all.The investigation revealed that the treatment T_9, (60 kg N ha^{-1} + 45 kg P ha^{-1}+ 30 kg K ha^{-1}+ Vermicompost (4 t ha^{-1}) + Biofertilizers @ 7.5 *l* ha^{-1}) recorded higher values for quality parameters viz., dry matter content (10.17 %), Vitamin C (37.48 mg 100 g^{-1}), total chlorophyll content (18.85 mg 100 g^{-1}) and total carotenoids (4.26 mg 100 g^{-1}) and leaf yield (23.83 t ha^{-1}).

Keywords: Bio-fertilizers, lettuce, organic manures, Vermicompost, quality

Introduction
Lettuce (*Lactuca sativa* L.), is an annual plant of Asteraceae family. It is a self-pollinated annual plant.It is a vital salad crop and is especially valuable in terms of vitamin content, minerals and other properties. It also possess various health benefits. It has anti-inflammatory properties, protects neuronal cells etc. In India, salad crops are not grown on commercial scale as in the United States and other European countries where it is being grown by large number of commercial growers. In Jammu and Kashmir, the crop is grown on a very limited scale. There has been a gradual increase in its cultivation as the temperate conditions of Kashmir are congenial for its cultivation. The quantity and quality of this crop is affected by many factors and the most important factor is fertilizers. For optimum plant growth, nutrients must be available in sufficient and balanced quantities. With the increase in population, the crop production needs to be enhanced manifold. As a result of which, growers are making heavy use of chemicals (fertilizers and pesticides) without any consideration to soil and human health. The increased use of chemicals under intensive cultivation has not only contaminated the ground and surface water but has also disturbed the harmony existing among the soil, plant and microbial population (Bahadur *et al.*, 2006) [2]. Organic farming is appreciated by vegetable consumers as it enhances quality of the produce. Lettuce being a salad crop, organic cultivation of this crop is preferable, which increases its quality with minimum residual effect. Organic manure plays a direct role in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization and improves physical and chemical properties of soils (Chaterjee *et al*., 2005) [3].

Materials and Methods
The present investigation was carried out at Experimental Farm, Division of Vegetable Science, SKUAST-Kashmir, Shalimar campus, during Rabi 2016-17. The experimental material consisted of one cultivar named LS-2 of lettuce crop, chemical fertilizers (Urea, Diammonium Phosphate, and Muriate of Potash), organic manures viz. farm yard manure (FYM), vermicompost (VC), sheep manure (SM) and three types of biofertilizers namely *Azotobacter*, Phosphorus Solubilising Bacteria and Potassium Solubilising Bacteria. All of these Biofertilizers were procured from Biofertilizer Labarotory, Faculty of Agriculture, Wadura, SKUAST-K. The treatment combination T_1 [120 kg N ha^{-1} + 90 kg P ha^{-1}+ 60 kg K ha^{-1} (RFD)], T_2 [Farmyard manure (24 t ha^{-1})], T_3 [Vermicompost (8 t ha^{-1})], T_4 [Sheep Manure (17 t ha^{-1})], T_5 [60 kg N ha^{-1} + 45 kg P ha^{-1}+ 30 kg K ha^{-1}+ Farmyard manure (12 t ha^{-1})], T_6

[60 kg N ha^{-1} + 45 kg P ha^{-1}+ 30 kg K ha^{-1}+ Vermicompost (4 t ha^{-1})], T_7 (60 kg N ha^{-1} + 45 kg P ha^{-1}+ 30 kg K ha^{-1}+ Sheep Manure (8.5 t ha^{-1}) and T_8 (60 kg N ha^{-1} + 45 kg P ha^{-1}+ 30 kg K ha^{-1}+ Farmyard manure (12 t ha^{-1}). Biofertilizers were applied as seedling root dip treatment (@ 7.5 l ha^{-1}) before transplanting of seedlings in the experimental field. All chemical fertilizers and organic manures were incorporated in the experimental field at the time of land preparation. Full dose of P and K along with half dose of N was given as a basal dose and thoroughly mixed with soil. The remaining half dose of N was applied as two splits, first 30 days after transplanting and second 45 days after transplanting. Experimental data of quality parameters was taken by standard methods viz., Vitamin-C content (AOAC, 1980) [1], total Chlorophyll content (Jayaraman, 1981) [8], Total Carotenoids (Mahadevan and Sridhar, 1986) [15] and data was subjected to statistical analysis as per the standard statistical procedure given by Gomez and Gomez (1984) [7]. Levels of significance used for 'F' and 'T' tests were P = 0.05 as given by Fisher (1970) [5].

Result and discussion

The results pertaining to dry matter, vitamin C, carotenoid content and chlorophyll content presented in Table 1 revealed marked variation due to effect of various treatments. Among different treatments, treatment T_9 (50% RFD + vermicompost @ 4 t ha^{-1} + biofertilizers) recorded significantly maximum dry matter content of 10.17%, vitamin C (37.48 mg/100g), total carotenoids content of 4.26 mg/100`g and total chlorophyll content of 11.13 mg/100g than other treatments. Improvement in quality attributes of lettuce due to integration of organic sources with inorganic and biofertilizers could be attributed to better and balanced nutrition and production of growth promoting substances by organics in presence of biofertilizers, which might have led to better quality. Improvement in quality of lettuce can also be attributed to the improvement in soil physical, chemical and biological properties leading to better root proliferation, improved nutrient uptake and better accumulation of photosynthates. The present investigation also reveals that microbial inoculation increases quality parameters as compared to other treatments. The enhancing effects of biofertilizers on the chemical contents of leaves can be related to the hormonal exudates of the non-symbiotic bacteria which modify root growth, morphology and physiology resulting in more acquisition of nutrients by the growing plants. The improving effects of nitrogen fertilizer on chemical contents of leaves might be related to the vital role of nitrogen, for the formation of chlorophyll pigments and stimulation of photosynthesis process. Dry matter content is one of the important attributes that gives an idea about the photosynthetic ability and food accumulation in edible parts. Increase in dry matter content might be attributed to more plant spread, photosynthetic area and availability of micronutrients that resulted in better accumulation of photosynthates in leaves. These results are in conformity with the findings of Magkos *et al.* (2003) [10], Ghoname and Shafeek (2005) [6], Kavitha *et al.* (2013) [9] and Sheikh *et al.* (2017) [16].

The increase in vitamin-C content could be due to ability of *Azotobacter* to fix atmospheric nitrogen and secretion of plant growth promoting hormones by both vermicompost and *Azotobacter* that helped in accelerating the process of carbohydrate synthesis. Therefore, the combined application of organic and inorganic fertilizers promotes vitamin-C synthesis which is a sugar acid. Similar findings were also reported by Ghoname and Shafeek (2005) [6], Vlahora and Popov (2013) [14], Singh *et al*. (2014) [13, 17] and Sheikh *et al.* (2017) [16].

The increase in chlorophyll content might be due the role of nitrogen, which is a constituent of all amino acids and hence proteins that are essential structural component of chloroplasts, secondary nutrients particularly magnesium and micronutrients like boron and zinc that are produced during solubilisation and decomposition of organic manures, which gets enhanced in presence of biofertilizers. These results are in line with the similar findings of Stancheva and Mithova, (2002) [18], Fawzy *et al.* (2012) [4] and Singh *et al.* (2014) [13, 17].

Vermicompost in combination with biofertilizers and inorganic fertilizers have shown positive effect on total carotenoids content in lettuce leaves. Biofertilizers increased the availability and uptake of micronutrients which physiologically influence the activity of number of enzymes that leads to increased cell metabolism which in turn change the biochemical composition of leaves. These results are in line with the similar findings of Kavitha *et al.* (2013) [9] and Singh *et al.* (2014) [13, 17].

Table 1: Influence of inorganic fertilizers, organic manures and biofertilizers on quality parameters and leaf yield of Lettuce cv. LS-2.

Treatment	Dry matter content (%)	Vitamin C(mg/100g)	Total Carotenoid content (mg/100g)	Total Chlorophyll (mg/100g)	Leaf yield per hectare (t)
T_1	8.16	26.96	2.44	16.45	19.53
T_2	9.33	33.34	3.54	13.47	17.39
T_3	9.79	34.64	3.64	15.75	18.06
T_4	9.63	33.81	3.19	14.11	17.56
T_5	8.83	30.18	2.67	14.72	21.51
T_6	9.29	31.49	2.54	17.55	22.17
T_7	8.97	30.74	2.49	16.01	21.74
T_8	9.74	35.65	3.83	17.85	22.93
T_9	10.17	37.48	4.26	18.85	23.83
T_{10}	9.91	36.25	3.72	18.04	23.19
T_{11}	8.35	30.26	2.73	17.76	20.21
T_{12}	7.61	24.20	2.01	14.54	17.33
T_{13}	6.95	20.01	1.86	11.13	10.16
C D (P=0.05)	0.25	0.64	0.34	0.46	1.22

Leaf yield (t ha^{-1})

Perusal of Table 2 revealed significant influence of various treatments on leaf yield ha^{-1}. Among different treatments, treatment T_9 (50% RFD + vermicompost @ 4 t ha^{-1} + biofertilizers) recorded significantly maximum leaf yield ha^{-1} (23.83 t) over to other treatments but was at par with treatment $T_8$and T_{10}. However, a minimum leaf yield of 10.16 t ha^{-1} was noticed by treatment T_{13} (control). Among sole application of organic manures, vermicompost @ 8 t ha^{-1} i.e. treatment T_3 registered maximum leaf yield ha^{-1} (18.06 t) which was at par withT_2 and T_4. Integration of different organic, inorganic sources and biofertilizers exhibited significant increase in leaf yield of lettuce. This could be due to the balanced C/N ratio, more decomposition, more mineralization and more availability of macro and micro nutrients. Vermicompost proved its superiority in enhancing leaf yield of lettuce over FYM and sheep manure whether used as a sole application or in conjunction with inorganic fertilizers and biofertilizers. This superiority could be attributed to nutritional richness, production of growth promoting substances, balanced C/N ratio, efficient microbial activity leading to sustainable nutrient availability and improvement in soil physical conditions. Some of the organic substances released during the mineralization may act as chelates that help in the absorption of iron and other micro-nutrients. The non-symbiotic N_2-fixing bacteria of the genera *Azotobacter* and *Azospirillum* produced adequate amounts of IAA and cytokinins which increase the surface area per unit of root length and enhanced root branching with aneventual increase in the uptake of nutrients from the soil and finally accelerated plant growth. The increased vegetative growth, balanced C/N ratio and role of co-enzymes directly or indirectly in regulating various physiological processes within plant might have ultimately promoted greater yield. All these properties might have led to better root proliferation, better translocation of plant nutrients and accelerated carbohydrate synthesis, finally leading to better leaf yield. Similar results were reported by Nowak and Stancheva and Mithova (2002) [18], Romero (2002) [12] and Tosic *et al.* (2016) [19].

Table 2: Role of inorganic fertilizers, organic manures and biofertilizers on leaf yield of Lettuce cv. LS-2.

Treatment	Treatment combination	Leaf yield per hectare (t)
T_1	120 kg N ha^{-1} + 90 kg P ha^{-1}+ 60 kg K ha^{-1} (RFD)	19.53
T_2	Farmyard manure (@ 24 t/ha.)	17.39
T_3	Vermicompost (@ 8 t/ha.)	18.06
T_4	Sheep manure (@ 17 t/ha.)	17.56
T_5	60 kg N ha^{-1} + 45 kg P ha^{-1}+ 30 kg K ha^{-1}+ FYM(12 t ha^{-1})	21.51
T_6	60 kg N ha^{-1} + 45 kg P ha^{-1}+ 30 kg K ha^{-1}+ Vermicompost (4 t ha^{-1})	22.17
T_7	60 kg N ha^{-1} + 45 kg P ha^{-1}+ 30 kg K ha^{-1}+ Sheep manure(8.5t ha^{-1})	21.74
T_8	60 kg N ha^{-1} + 45 kg P ha^{-1}+ 30 kg K ha^{-1}+ FYM(12 t ha^{-1})+Biofertilizers @ 7.5 l ha^{-1}	22.93
T_9	60 kg N ha^{-1} + 45 kg P ha^{-1}+ 30 kg K ha^{-1}+ Vermicompost (4 t ha^{-1}) + Biofertilizers @ 7.5 l ha^{-1}	23.83
T_{10}	60 kg N ha^{-1} + 45 kg P ha^{-1}+ 30 kg K ha^{-1}+ Sheep manure(8.5t ha^{-1})+Biofertilizers @ 7.5 l ha^{-1}	23.19
T_{11}	120 kg N ha^{-1} + 90 kg P ha^{-1}+ 60 kg K ha^{-1} + Biofertilizers @7.5 l ha^{-1}	20.21
T_{12}	60 kg N ha^{-1} + 45 kg P ha^{-1}+ 30 kg K ha^{-1}+ Biofertilizers @ 7.5 l ha^{-1}	17.33
T_{13}	Control	10.16
C D (P=0.05)		1.22

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