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Effect of organic manures and bio-fertilizers on growth and 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 find out the effect of organic manures and bio-fertilizers on growth and yield of Lettuce cv. LS-2. 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 plant height (37.84 cm), plant spread (39.91 cm), minimum no. of days to first harvest (40), leaf area (280.42 cm^2), no. of leaves $plant^{-1}$ (48.15), average leaf weight (13.95 g), leaf weight $plant^{-1}$ (518.25 g), leaf yield $plot^{-1}$ (9.81 kg) and leaf yield ha^{-1} (23.83 t).

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

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) [1]. 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) [2].

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 was subjected to statistical analysis as per the standard statistical procedure given by Gomez and Gomez (1984) [4]. Levels of significance used for 'F' and 'T' tests were P = 0.05 as given by Fisher (1970) [3].

Result and discussion

Growth parameters

The influence of different organic manures, inorganic fertilizers and biofertilizers on growth parameters are presented in Table 1. The experimental results revealed that treatment T_9(50% RFD + vermicompost @ 4 t ha^{-1} + biofertilizers)significantly reduced the number of days to first picking (40 days), increased the plant height (27.47 cm), plant spread (38.91cm), average leaf area (260.42 cm^2) and number of leaves per plant (36.58) compared to other treatments. Data clearly indicated that nutrition level has a significant effect on days to first picking in lettuce. Combined application of organic manures, inorganic fertilizers and biofertilizers recorded the minimum number of days to first harvest as compared to other treatments. The reduction in the number of days to first harvest due to combined application of organic manures, inorganic fertilizers and biofertilizers may be attributed due to added supply of nutrients and proliferous root system developed early under balanced nutrient application resulting in better absorption of water and nutrients with improved physical environment. The results are in conformity with Jose *et al.* (1998) [6]. Application of organic manures, inorganic fertilizers and biofertilizers in combination exhibited an increase in growth related attributes of lettuce probably due to balanced C/N ratio, better organic matter build up, efficient microbial activity, better root proliferation, abundant supply and availability of nutrients from soil, more translocation of nutrients to aerial parts for protoplasmic proteins and synthesis of other compounds. Superiority of vermicompost over FYM and sheep manure in improvement of growth related character of lettuce might be attributed to its nutritional richness, quick mineralization, more availability of nitrogen and other plant nutrients. Vermicompost prepared with the help of earthworms. Earthworms consume large quantities of organic matter excrete soil as casts which have several plant growth promoters, enzymes rich in plant nutrients, beneficial bacteria and mycorrhiza. Vermicompost is a rich mixture of major and minor plant nutrients. The non-symbiotic N_2-fixing bacteria of the genera *Azotobacter* produce adequate amounts of IAA and cytokinins which increase the surface area per unit of root length and enhanced root branching with an eventual increase in the uptake of nutrients from the soil and finally accelerated plant growth. In addition to this, effects of the different biofertilizers could be due to the efficiency of the different bacterial strains, on N_2-fixation, dissolving immobilized P and producing appropriate amounts of phytohormones necessary for activating plant growth parameters. It may also be due to role of nitrogen in inducing cell division, cell elongation and cell enlargement. The increase in growth parameters may be attributed to the meristematic activity for producing more tissues and organs, since N plays a major role in protein and nucleic acids synthesis and protoplasm formation. In addition, vermicompost contains growth promoting substances thus, leading to better growth whether applied alone or in combination with inorganic fertilizers. The better efficiency of inorganic fertilizers in combination with vermicom post and biofertilizers is due to reduction in soil compaction and improvement in aeration and supply of macro and micro-nutrients, organic matter and increased nutrient availability of nutrients. These results are in conformity with the findings of Jagnow *et al.* (1991) [5], Stancheva and Mithova (2002) [11], Mahmoud *et al.* (2007) [8], Suge *et al.* (2011) [12] and Kavitha *et al.* (2013) [7].

Table 1: Influence of inorganic fertilizers, organic manures and biofertilizers on growth parameters taken to first harvest of Lettuce cv. LS-2.

Treatment	Days taken to first harvest	Plant height	Plant spread (cm)	Average leaf area (cm^2)	Number of leaves per plant
T_1	45	24.39	34.05	206.89	31.27
T_2	50	17.00	32.02	242.70	30.11
T_3	48	17.37	34.83	220.07	30.72
T_4	50	17.17	33.30	217.57	30.31
T_5	45	22.92	32.91	240.68	33.53
T_6	44	23.11	36.66	249.85	33.86
T_7	45	23.02	35.21	243.69	33.64
T_8	42	26.51	37.61	254.30	35.52
T_9	40	27.47	38.91	260.42	36.58
T_{10}	41	26.60	38.00	256.20	35.80
T_{11}	43	25.68	36.01	246.96	33.29
T_{12}	47	22.03	35.03	236.47	29.40
T_{13}	55	14.88	26.77	160.69	27.21
C D (P=0.05)	2.89	0.87	0.62	3.52	0.93

Yield parameters

Perusal of table 2 revealed significant variation in yield and yield related parameters. Plant nutrition exhibited a significant effect on leaf yield and its attributing characters of lettuce. Maximum values of average leaf weight (13.95 g), leaf weight $plant^{-1}$ (498.02 g), leaf yield $plot^{-1}$ (9.65 kg) and leaf yield ha^{-1} (23.83 t) were recorded with application of 50% RFD + vermicompost @ 4 t ha^{-1} + biofertilizers. Among sole application of organic sources, vermicompost @ 8 t ha^{-1}recorded higher values for average leaf weight, leaf weight $plant^{-1}$, leaf yield $plot^{-1}$ and leaf yield ha^{-1} (10.71 g, 373.28 g, 7.31 kg and 23.83 t) respectively.

Integration of different organic, inorganic sources and biofertilizers exhibited significant increase in yield and its attributing characters 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 yield and its attributes 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 nutrientavailability 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-fixingbacteria 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 an eventual 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 Stancheva and Mithova (2002) [11], Romero (2002) [10] and Xu *et al*. (2005) [14] and Tosic *et al.* (2016) [13].

Table 2: Influence of inorganic fertilizers, organic manures and biofertilizers on yield and yield parameters taken to first harvest of Lettuce cv. LS-2.

Treatment	Average leaf weight(g)	Leaf weight per plant(g)	Leaf yield per plot(kg	Leaf yield per hectare (t)
T_1	12.09	395.21	7.91	19.53
T_2	10.50	356.43	7.04	17.39
T_3	10.71	373.28	7.31	18.06
T_4	10.65	363.51	7.11	17.56
T_5	12.23	432.81	8.71	21.51
T_6	13.16	450.50	8.98	22.17
T_7	12.67	441.48	8.80	21.74
T_8	12.98	480.80	9.29	22.93
T_9	13.95	498.02	9.65	23.83
T_{10}	13.23	485.67	9.39	23.19
T_{11}	12.43	435.43	8.76	20.21
T_{12}	11.04	313.65	7.02	17.33
T_{13}	9.47	209.81	4.11	10.16
C D (P=0.05)	0.31	7.50	0.32	1.22

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