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Productivity enhancement of organic lettuce through use of organic manures, biofertilizers and bio-stimulants

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Abstract

Production of reasonable head yield is a challenge for the organic lettuce growers. An attempt had been made to increase lettuce head yield and quality by intervening biofertilizer's seedling root dipping and foliar spray of bio-stimulants along with basal organic manure. Field investigations were conducted at UBKV, Pundibari, Cooch Behar,West Bengal, India during November to February of 2014-2015 and 2015-2016 by evaluating thirteen treatment combinations replicated thrice in randomized block design. Results revealed that significantly higher plant height (20.25 cm), number of non-wrapper leaves (11.60), ascorbic acid content (6.24 mg/100g) were recorded by the application of vermicompost (6 t/ha) as basal along with seedling root dipping with *Azophos* biofertilizer and foliar spray of seaweed extract. However, the maximum head weight (436.98 g/plant) and yield (30.59 t/ha) as well as vitamin A content (370.63 IU/100g) were observed in the treatment containing basal application of vermicompost (6 t/ha) along with seedling root dipping with *Azophos* biofertilizer and foliar spray of humic acid.

Key words: Lettuce, yield and quality, biofertilizer and bio-stimulants

Introduction

Lettuce (family-Compositae) is a high value salad vegetable loaded with several minerals, vitamins and dietary antioxidants (Nicolle et al. 2004). Regular inclusion of lettuce in salad is known to facilitate digestion of food, promote weight loss, fight insomnia as well as prevent osteoporosis, iron-deficiency anaemia, age-related macular degeneration (ARMD), Alzheimer's disease etc (Annonymous 2016). The booming demand of international cuisine like burger, pizza, sandwiches, tacos, spring roll etc. has accelerated the production and consumption of lettuce in India. Being a short duration crop, lettuce demands large amount of nutrients for potential growth and yield, however excess use of nitrogenous fertilizer increased the chance of nitrate toxicity within the plant (Rattler et al. 2005). Organically grown lettuce plots showed accumulation of macronutrients and organic matter content in the soil as well as an increase in microbial population in the field (Castro et al. 2009). Pavlou et al. (2007) in their experiment with lettuce established that increased inorganic fertilizer doses would lead to significant rise in nitrate accumulation in leaves but marginal yield increases with no residual availability of N, P and K in the soil whereas use of higher amount of organic manures will contributed to the built up of soil fertility at the end. Reduced nitrate accumulation under farmyard manure fertilized lettuce crop has been reported earlier by Gianquinto et al. (1992). The growing awareness on ill effect of conventional faming on human health and environment, the demand of organic lettuce for salad and other preparation is increasing sharply with perception of being safe, healthy and hazard free besides having superior organoleptic quality (Chatterjee, 2015). As market for organic lettuce is flourishing very fast, farmers are gradually adopting organic cultivation. Although the demand for organic products is high, however the rate of farm conversion to organic production systems is relatively slow as lower productivity hindering large scale adoption of organic lettuce cultivation. Traditionally farmyard manure is used as source of nutrients for organic lettuce cultivation but low nutrient content, slow mineralization rate fails to fulfil the nutrient demand of the crop (Saha 2016). Several research findings suggested that inclusion of biofetilizers along with organic manure will enhance the growth and yield of organic crops. Again, use of bio-stimulants like sea weed extract, humic acid and vermiwash also

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showing positive impact on the productivity of the organic vegetables. Tremendous scope is there to enhance the productivity level of organic lettuce by adopting better crop management through inclusion of biofetilizers and bio-stimulants along with bulky organic manures as a strategy for crop production. Hence an attempt has been made to assess the performance of organically grown lettuce in combination with biofertilizer seedling root dipping and foliar spray of bio-stimulants.

Materials and Methods

The field experiment was conducted during winter season of 2014-2015 and 2015-2016 at Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India. (89°232 532 2 E longitude and 26°192 862 2 N latitude). The area is characterized by high rainfall (2100 to 3300 mm/annum), high relative humidity, moderate temperature (minimum of 7-8°C to maximum of 24-33.2°C), prolonged winter with high residual soil moisture. The soil was sandy loam (61%, 20% and 18% sand, silt and clay respectively) in texture and slight acidic in reaction (pH 5.71). The initial soil organic carbon was 0.83% and available N, P and K contents were 154.28, 21.17 and 124.48 kg/ha respectively. Thirteen treatments were laid out in randomized block design (RBD) and replicated thrice. The treatments were T_1- Farmyard manure (10 t/ha) + 100% RDF(80:50:50 kg N P K/ha) as control; T_2- Farmyard manure (20 t/ha) + *Azophos* biofertilizer; T_3- Farmyard manure (20 t/ha) + *Azophos* biofertilizer + humic acid; T_4- Farmyard manure (20 t/ha) + *Azophos* biofertilizer + vermiwash; T_5- Farmyard manure (20 t/ha) + *Azophos* biofertilizer + seaweed extract; T_6- Vermicompost (6 t/ha) + *Azophos* biofertilizer; T_7- Vermicompost (6 t/ha) + *Azophos* biofertilizer + humic acid; T_8- Vermicompost (6 t/ha) + *Azophos* biofertilizer + vermiwash; T_9- Vermicompost (6 t/ha) + *Azophos* biofertilizer + seaweed extract; T_{10}- Farmyard manure (10 t/ha) + vermicompost (3 t/ha) + *Azophos* biofertilizer; T_{11}- Farmyard manure (10 t/ha) + vermicompost (3 t/ha) + *Azophos* biofertilizer + humic acid; T_{12}- Farmyard manure (10 t/ha) + vermicompost (3 t/ha) + *Azophos* biofertilizer + vermiwash; T_{13}- Farmyard manure (10 t/ha) + vermicompost (3 t/ha) + *Azophos* biofertilizer + seaweed extract. Lettuce seedlings of the heading type cultivar Iceberg were transplanted on 15th November for both the years by ridge and furrow method with a spacing of 45 cm x 25 cm. Vermicompost and farmyard manure were applied to the respective plots two weeks before transplanting of seedlings. *Azophos*, a commercial biofertilizer preparation containing *Azotobacter chroococcum* and Phosphate Solubilizing Bacteria (*Pantoea agglomerans*) with standard microbial population (5×10^8) was applied as seedling root dipping (250 g/litre water) just before transplanting using rice gruel as adhesive. Bio-stimulants namely seaweed extract (*Ascophyllum nodosum*-2ml/litre), humic acid (2ml/litre) and vermiwash (10 ml/litre) were applied through foliar spray for 3 times on standing crop at 30, 45 and 60 days after transplanting. The crop was raised adopting standard cultural practices. Ten plants from each plot were selected randomly for recording the observations on different growth, yield and quality characters. The vitamin A was estimated by analyzing the beta-carotene content of the head and then dividing the value with 0.6 to obtain the vitamin A content of the head (Srivastava and Kumar, 2002). The ascorbic acid content of lettuce head was determined titrimetrically, using 2, 6 dichlorophenol indophenol dye as per method suggested by Ranganna (1986). Two years data collected on various parameters were pooled and statistically analyzed using INDOSTAT statistical package (version 7.00, Hyderabad, India).

Results and Discussion

The results of the present experiment showed that most of the growth, yield and quality attributes (Tables 1, 2 and 3) were significantly influenced by the combined application of different sources of nutrients. Application of vermicompost (6 t/ha) along with seedling root dipping of *Azophos* biofertilizer and foliar spray of seaweed extract (2 ml/litre) three times at standing crop significantly increased the growth attributes in terms of maximum plant height (20.25 cm) and highest number of non-wrapper leaves (11.60). Plants raised with this treatment recorded 19% higher plant height as well as 10% more number of non-wrapper leaves/plant compared to control plots. Addition of microbial inoculants might have favoured the growth of soil micro flora and improved the efficacy of the applied manures of the soil (Kaushal et al. 2011). The treatment comprised of farmyard manure (20 t/ha) and seedling root dipping of *Azophos* biofertilizer was found earlier to head maturity (70.67 days) compare to other treatments. As a culmination of favourable growth attributes, the head weight of lettuce was markedly influence by the foliar application of bio-stimulants like humic acid, seaweed extract and vermiwash in presence of basal organic manure and biofertilizer. The treatment comprised of vermicompost (6 t/ha) along with seedling root dipping of *Azophos* biofertilizer and foliar application of humic acid (2 ml/litre) in standing crop recorded the highest head weight (436.98 g) in pooled analysis that subsequently led to maximum head yield (10.92 kg/plot and 30.59 t/ha) with 19% increase in head weight and

Table 1: Effect of different nutrient sources on growth and development attributes of lettuce crop

Treatments*	Plant height (cm)			No of non-wrapper leaves			Days to head maturity		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
T_1	16.46	16.41	16.43	10.59	10.48	10.40	71.33	71.33	71.33
T_2	14.32	15.28	14.80	10.30	10.17	10.10	70.27	71.07	70.67
T_3	15.63	17.73	16.68	10.80	10.62	10.60	72.23	74.20	73.71
T_4	17.14	19.38	18.26	10.60	10.87	10.80	71.33	71.67	71.50
T_5	17.49	17.11	17.30	10.97	11.19	11.20	72.02	72.35	72.18
T_6	16.83	15.54	16.19	10.29	10.30	10.30	71.33	70.67	71.00
T_7	21.09	18.09	19.59	10.77	10.77	10.70	74.41	73.83	74.11
T_8	17.63	19.26	18.45	10.77	10.84	10.90	72.30	75.05	73.67
T_9	19.41	22.21	20.25	11.36	11.69	11.60	72.12	75.26	73.69
T_{10}	15.77	16.06	15.91	10.50	10.30	10.20	70.21	72.08	71.14
T_{11}	16.81	16.33	16.57	10.57	10.60	10.50	74.32	74.07	74.19
T_{12}	16.91	17.85	17.38	11.07	10.89	10.70	71.33	75.00	73.17
T_{13}	18.99	19.31	19.20	10.93	11.19	11.20	72.07	75.09	73.58
SEm±	0.19	0.15	0.21	0.13	0.15	0.13	0.29	0.41	0.43
CD (P=0.05)	0.55	0.45	0.59	0.39	0.44	0.42	0.84	1.21	1.24

*Treatment details are discussed in materials and methods.

Table 2: Effect of different nutrient sources on yield attributes of lettuce crop

Treatments*	Head weight (g)			Head yield (kg/plot)			Head yield (ton/ha)		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
T_1	291.74	307.89	299.81	7.29	7.70	7.50	20.42	21.55	20.99
T_2	266.36	281.16	273.76	6.66	7.03	6.84	18.65	19.68	19.16
T_3	364.69	360.70	362.70	9.12	9.02	9.07	25.53	25.25	25.39
T_4	306.57	305.84	306.20	7.66	7.65	7.66	21.46	21.41	21.43
T_5	329.00	336.15	332.57	8.22	8.40	8.31	23.03	23.53	23.28
T_6	262.92	291.80	277.36	6.57	7.29	6.93	18.40	20.43	19.42
T_7	453.16	420.80	436.98	11.33	10.52	10.92	31.72	29.46	30.59
T_8	424.27	396.44	410.36	10.61	9.91	10.26	29.70	27.75	28.72
T_9	419.95	441.15	430.87	10.50	11.03	10.77	29.40	30.88	30.16
T_{10}	291.03	299.96	295.49	7.28	7.50	7.39	20.37	21.00	20.68
T_{11}	444.59	417.16	430.56	11.11	10.43	10.76	31.12	29.20	30.14
T_{12}	383.40	400.71	392.05	9.58	10.02	9.80	26.84	28.05	27.44
T_{13}	425.61	412.29	418.95	10.64	10.31	10.47	29.79	28.86	29.33
SEm±	5.29	8.21	11.42	0.13	0.21	0.17	0.37	0.57	0.48
CD (P=0.05)	15.44	23.97	32.32	0.39	0.60	0.50	1.08	1.68	1.39

*Treatment details are discussed in materials and methods.

31% increase in head yield over the control. The bio-stimulant humic acid in presence of vermicompost also proved its superiority and recorded more head weight as well as higher head yield over seaweed extract and vermiwash respectively. Humic acid affects the membranes resulting in improved transport of nutritional elements, encouraged better photosynthesis and respiration, enhanced protein synthesis, enzymatic activities and plant hormonal activities (Vaughn et al. 1985). The results further revealed that performance of the bio-stimulants was also influenced by the form of organic manures. Humic acid in presence of vermicompost as organic manure resulted in 17% more head yield over the farmyard manure. Several research findings suggested that vermicompost is a reservoir of essential plant nutrients and growth promoting substances and the content of humic acid, plant growth regulators and/or symbiotic microbes population were enhanced during the process of vermicomposting (Edwards et al. 2006; Ali et al. 2007). The increase in

Table 3: Effect of different nutrient sources on quality attributes of lettuce head

Treatments*	Chlorophyll content (SPAD value)			Ascorbic acid content (mg/100 g)			Vitamin A content (IU/100 g)		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
T_1	25.42	26.94	26.23	2.94	3.39	3.16	363.27	363.20	363.23
T_2	21.11	24.66	22.93	3.10	2.98	3.04	360.43	361.60	361.02
T_3	27.11	27.70	27.45	4.56	4.29	4.42	364.13	366.40	365.27
T_4	27.98	26.67	27.32	5.12	5.15	5.13	363.43	363.37	363.40
T_5	28.10	26.68	27.44	6.39	5.94	6.16	364.80	363.70	364.25
T_6	26.11	23.41	24.81	3.70	3.68	3.69	362.43	362.40	362.42
T_7	29.11	29.38	29.24	4.48	4.82	4.64	371.60	369.67	370.63
T_8	25.36	29.39	27.47	4.88	5.41	5.14	365.87	366.27	366.07
T_9	26.30	29.02	27.76	6.30	6.18	6.24	368.80	369.60	369.20
T_{10}	23.43	26.70	25.12	3.14	3.15	3.14	362.53	363.63	363.08
T_{11}	30.00	28.30	29.20	4.27	4.36	4.31	371.50	369.53	370.52
T_{12}	26.21	28.66	27.43	4.99	4.99	4.99	366.43	364.80	365.62
T_{13}	25.46	29.88	27.77	6.31	5.72	6.01	366.47	368.30	367.38
SEm±	0.55	0.69	0.76	0.07	0.07	0.09	4.38	5.33	3.41
CD (P=0.05)	1.60	2.01	2.17	0.21	0.22	0.25	12.91	15.72	9.65

*Treatment details are discussed in materials and methods.

head yield in presence of vermicompost along with biofertilizers and bio-stimulant may be attributed to greater movement and availability of essential nutrients resulted in better head development and subsequently higher head weight compared to control plot. Chatterjee (2015) also recorded higher head weight of lettuce through combined use of organic manures and biofertilizers to the plants.

The quality attributes of lettuce head were significantly influenced by different nutrient combination. The data indicated that lettuce head received vermicompost (6 t/ ha) along with seedling root dipping of *Azophos* biofertilizer and foliar spray of humic acid recorded the maximum chlorophyll content of head (29.24 SPAD value in pooled analysis). This may be due to the favourable effect of vermicompost in combination with biofertilizer and bio-stimulant humic acid. Vitamin A content of lettuce head also showed marked influenced with changes in nutrient sources. The treatment, comprised of vermicompost (6 t/ha) along with seedling root dipping of *Azophos* biofertilizer and foliar spray of humic acid surpassed the vitamin A content (370.63 IU/100g) over the other nutrint sources. The increase in vitamin A content in the combined organic and biological sources of nutrients may be attributed to accelerated mobility of photosynthates from source to sink which might have mobilized the biosynthesis of vitamin A in lettuce head. The maximum ascorbic acid content (6.24 mg/100g) was recorded with the application of vermicompost (6 t/ha) along with seedling root dipping of *Azophos* biofertilizer and foliar spray of seaweed extract. The increase in ascorbic acid content with the addition of vermicompost and bio-stimulant may be attributed to increased availability of nutrients and better conversion of source to sink led to biosynthesis of ascorbic acid of the lettuce head.

Conclusion

The results of the study showed that sole application of basal organic manure is not enough to compete the conventional practices for higher yield and better quality of organic lettuce. In addition of basal organic manure, interventions like seedling root dipping with *Azophos* biofertilizer and foliar application of bio-stimulants hold greater promise to enhance the productivity of organic lettuce. The findings established that basal application of vermicompost (6 t/ha) along with seedling root dipping of *Azophos* biofertilizer and foliar spray of humic acid (2 ml/litre at 30, 45 and 60 days after transplanting) on standing lettuce crop was the most productive nutrient combination for large scale organic lettuce cultivation. However foliar spray of seaweed extracts also emerged as potential bio-stimulant for organic lettuce production.

सारांश

कार्बनिक लेट्यूस उत्पादकों को यथोचित शीर्ष उपज प्राप्त करना एक बड़ी चुनौती है। लेट्यूस के शीर्ष उपज एवं गुणवत्ता वृद्धि हेतु नर्सरी नवोद्भिद जड़ों को जैव उर्वरक में डूबोने तथा जैव–उत्तेजक पदार्थों के छिड़काव के साथ आधारीय कार्बनिक खाद का प्रयोग किया गया। कुल तेरह उपचार संयोजनों को यादृक्षिक प्रखण्ड अभिकल्पना के माध्यम से वर्ष 2014–15 व 2015–16 (नवम्बर से

फरवरी) के दौरान प्रक्षेत्र परीक्षण उत्कल बंगा कृषि विश्वविद्यालय (पश्चिम बंगाल) में किया गया। परिणामों से स्पष्ट हुआ कि अधिकतम पौध ऊँचाई (20.25 सेमी.), अ– आवरण पत्तियों की संख्या (11.06) से स्पष्ट हुआ कि एस्कार्बिक एसीड की मात्रा (6.24 मिग्रा./100 ग्राम) वर्मीकम्पोस्ट के 6 टन/हे. आधारीय प्रयोग के साथ नवोद्भिद जड़ों को एजोफास जैव–उर्वरक एवं समुद्री सिवार के तत्व का पर्णीय छिड़काव से प्राप्त हुआ जबकि, अधिकतम शीर्ष भार (436.98 ग्रा./पौध) एवं उपज (30.53 टन/हे.) के साथ विटामिन 'ए' की मात्रा (370.63 आईयू/100 ग्राम) की प्राप्ति उपचार वर्मीकम्पोस्ट (6.0 टन/हे.) के साथ एजोफास जैव–उर्वरक में नवोद्भिद जड़ों के डूबोने व हय्मिक एसीड के पर्णीय छिड़काव से प्राप्त हुआ।

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