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Effect of different sources of plant nutrients on growth, yield and quality of Chinese cabbage (*Brassica rapa* L.var. pekinensis)

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Abstract
The experiment was laid out in RCBD with seven different treatments. The experiment A field experiment was conducted during Rabi 2014 at Experimental Farm of Division of Vegetable Science, SKUAST-K, Shalimar to find out the effect of different sources of nutrients on growth, yield and quality attributes of Chinese cabbage. comprised of two organic manures (Sheep manure and Vermicompost), three types of bio-fertilizers (*Azotobacter*, PSB and KSB) and inorganic fertilizers in the form of Urea, DAP and MOP. The overall treatments of the experiment were divided into three sets *viz*. (i) Complete nutrients through organic manures plus bio-fertilizers (T_2 – T_3), (ii) Half of the nutrients through inorganic fertilizers and half through organic manures (T_4 – T_5), and (iii) Half of the nutrients through inorganic fertilizers and half through organic manures plus bio-fertilizers (T_6 – T_7). Recommended dose of nutrients (NPK @ 100:50:30 kg/ha) through inorganic fertilizers was taken for comparison (T_1). Observations were recorded on growth, yield and quality parameters. The maximum plant height (30.33 cm), fresh weight of plant (1170 g), dry weight of plant (65.43 g), number of folded leaves (30.32), number of unfolded leaves (13.33), days to head initiation (19.33), head diameter (6.50 cm), head length (21.16 cm), head compactness (1.89 z) head weight (613.33 g), head yield (45.42 t/ha), total leaf chlorophyll (8.73 mg/100g), total soluble solids (6.50 brix) and vitamin C (27.33 mg/100g) were observed for the plants grown with the application of vermicompost along with bio-fertilizers (T_3).

Keywords: Chinese cabbage, vermicompost, bio-fertilizers, yield, quality

Introduction
Chinese cabbage (*Brassica rapa* L.var pekinensis) is an important leafy, herbaceous vegetable crop originated in China and belongs to the family Crucifereae. Being nutritionally rich, the Chinese cabbage is also gaining importance in temperate and sub-tropical regions of the country. It is low in calories, fats and carbohydrates but a good source of minerals, proteins and antioxidants (Singh *et al.*, 2004) [11]. In J&K, Chinese cabbage is not so far grown by commercial farmers; however, it is being cultivated by innovative farmers and by agricultural research stations at small scale. With increase in people's preference towards diversified vegetable consumption, Chinese cabbage is also gaining attention in the Kashmir valley. However, the production package of Chinese cabbage is not much known in the valley. Chinese cabbage thrives well in a fertile clay loam soil because it requires considerable amount of nutrients for rapid growth in a short time. For getting higher production and quality yield in any crop it is necessary to ensure availability of essential nutrient components. The increased use of chemicals under intensive cultivation has not only contaminated the ground and surface water but also disturbed the harmony existing among the soil, plant and microbial population. There has been a growing concern about adverse impacts of pesticides and fertilizers on the environment and on the safety and quality of food. An integrated approach can be used to promote the healthy soil condition and to improve growth and quality of vegetables. Judicious use of organic manures, bio-fertilizers combined with inorganic sources may be effective in sustaining crop productivity and also maintaining soil health. Keeping all these facts under consideration, the present work was contemplated to find out the better combination of plant nutrient sources that are effective in sustaining crop productivity, quality and also maintaining soil health.

Materials and method

The present investigation was carried out at Experimental Farm, Division of Vegetable Science, SKUAST-Kashmir, Shalimar campus, during Rabi season of 2014. The experiment comprised of two organic manures (Sheep manure and Vermicompost), three types of bio-fertilizers (*Azotobacter*, PSB and KSB) and inorganic fertilizers in the form of Urea, DAP and MOP. The overall treatments of the experiment were divided into three sets *viz.* (i*)* Complete nutrients through organic manures plus bio-fertilizers (T_2 – T_3), (ii) Half of the nutrients through inorganic fertilizers and half through organic manures (T_4 – T_5), and (iii) Half of the nutrients through inorganic fertilizers and half through organic manures plus bio-fertilizers (T_6 – T_7). Recommended dose of nutrients (NPK @ 100:50:30 kg/ha) through inorganic fertilizers was taken for comparison (T_1). The experiment was laid in a randomized complete block design with three replications. The data was analyzed by using OP-Stat software. Bio-fertilizers were applied as seedling root dip treatment (@ 2.5%) i.e. 25 ml of each of the bio-fertilizers was added in 1 litre of water and roots of the seedlings were kept for 10 minutes in the solution before transplanting in the experimental field. Organic manures were incorporated in the experimental field at the time of land preparation. Representative soil sample of the experimental site before the start of experiment was analyzed for physico-chemical properties *viz.* available nitrogen, phosphorus and potassium. The initial status of experimental site with respect to above characteristics of N, P and K (kg ha^{-1}) are 230.50, 19.25 and 201.20 respectively. Vigorous and healthy seedling of almost uniform size was

Table 1: Effect of different sources of nutrients on plant height, fresh weight of plant, dry weight of plant, number of folded leaves, number of unfolded leaves, days to head initiation and head diameter of Chinese cabbage var. pekinensis.

Treatments	Growth parameters						
	Plant height (cm)	Fresh weight of plant (g)	Dry weight of plant (g)	Number of folded leaves	Number of unfolded leaves	Days to head initiation	Head diameter (cm)
T1	25.00	615.00	38.27	25.00	09.00	22.33	4.63
T2	29.67	943.33	62.39	29.64	13.00	19.66	5.63
T3	30.33	1170.00	65.43	30.32	13.33	19.33	6.50
T4	26.33	645.00	49.44	26.33	10.33	21.66	5.20
T5	26.00	628.33	43.25	26.00	09.33	21.66	4.66
T6	29.00	851.66	53.49	29.33	12.66	20.00	5.33
T7	27.00	695.00	52.35	27.00	12.00	20.66	5.23
CD ($p \leq 0.05$)	3.58	101.66	0.97	3.58	2.92	1.25	0.96

Treatment details

T_1 = Recommended dose of fertilizers (RDF) i.e. NPK @ 100:50:30 kg/ha

T_2 = Sheep manure (SM) @ 16.6 t/ha + Azotobacter + PSB (Phosphorus solubilizing bacteria) + KSB (Potassium solubilizing bacteria)

T_3 = Vermicompost (VC) @ 6.6 t/ha + Azotobacter + PSB + KSB

T_4 = 50% NPK + 50% Vermicompost (VC)

T_5 = 50% NPK + 50% Sheep manure (SM)

T_6 = 50% NPK + 50% (VC) + Azotobacter + PSB + KSB

T_7 = 50% NPK + 50% (SM) + Azotobacter + PSB + KSB

(Amount of nutrients in the organic manures was calculated on Nitrogen equivalent basis) transplanted in well prepared plots with spacing of 45 cm × 30 cm and plot size 3.78m^2 (180 cm x 210 cm). Transplanting was done 25 days after seed sowing. The transplanting was done on 20th August, 2014. Plant height, fresh weight of plant, dry weight of plant and other parameters were taken on 60 days after transplanting (DAT).

Table 2: Effect of different sources of nutrients on head length, head compactness, head weight, head yield, total leaf chlorophyll, TSS and vitamin C of Chinese Cabbage var. pekinensis.

Treatments	Growth parameters				Quality parameters		
	Head length (cm)	Head compactness (z value)	Head weight (g)	Head yield (t/ha)	Total leaf chlorophyll (mg/100g)	TSS (brix)	Vitamin C (mg/100g)
T1	17.83	0.90	323.33	23.93	4.94	4.60	14.10
T2	19.33	1.53	505.00	37.40	8.06	6.03	21.75
T3	21.16	1.89	613.33	45.42	8.73	6.50	27.33
T4	18.16	1.08	371.66	28.16	5.07	5.20	15.50
T5	18.00	0.94	358.33	26.53	4.95	4.93	14.48
T6	18.16	1.23	440.00	30.59	5.70	5.63	18.53
T7	18.33	1.16	395.00	29.00	5.60	5.30	17.33
CD ($p \leq 0.05$)	1.31	0.11	47.79	2.54	1.17	0.24	0.77

Results and discussion

Perusal of the data from Table 1 and 2 showed that growth, yield and quality attributes solely through organic manures along with bio-fertilizers treatment upshot the superior values of growth, yield and quality parameters at 60 days after transplanting (DAT) in contrast to lowest values of these parameters under prescribed supply of nutrients either exclusively through inorganic fertilizers or 50 per cent through inorganic sources plus 50 per cent through organic sources. However, T_3 (Vermicompost along with bio-fertilizers) was found most suitable organic source of nutrients by upholding maximum values of growth, yield and quality parameters viz. plant height (30.33 cm), fresh weight of plant (1170 g), dry weight of plant (65.43 g), number of

folded leaves (30.32), number of unfolded leaves (13.33), days to head initiation (19.33), head diameter (6.50 cm), head length (21.16 cm), head compactness (1.89 z), head weight (613.33 g), head yield (45.42 t/ha), total leaf chlorophyll (8.73 mg/100g), total soluble solids (6.50 brix) and vitamin C (27.33 mg/100g). Whereas, minimum values of growth, yield and quality parameters viz. plant height (25 cm), fresh weight of plant (615 g), dry weight of plant (38.27 g), number of folded leaves (25), number of unfolded leaves (9), days to head initiation (22.33), head diameter (4.63 cm), head length (17.83 cm), head compactness (0.90 z), head weight (323.33 g), head yield (23.93 t/ha), total leaf chlorophyll (4.94 mg/100g), total soluble solids (4.60 brix) and vitamin C (14.10 mg/100g) were observed in T_1. Hence, vermicompost in combination with bio-fertilizer (T_3) significantly increased growth, yield and quality characters of Chinese cabbage. These results are in conformity with the findings of Singh *et al.* (2014); Gopinathan and Prakash (2014) [10, 6]. The increase in plant growth of Chinese cabbage in terms of plant height, fresh weight and dry weight of plant and other parameters under sole supply of organic fertilizer plus bio-fertilizers may be attributed to increased soil tilth and aeration ability as well as availability of essential macro and micro nutrients. The superiority of vermicompost over other organic manures may also be attributed to its more mineral elements contents and also their available forms (Edwards and Burrows, 1988) [4]. Days to head initiation among treatments varied significantly, however, organic sources of nutrients taken lesser time as compared to other treatments. However, T_3 was earliest (19.33) in hastening the head initiation of Chinese cabbage followed by T_2 (19.66) which is at par with T_1 and latest head initiation (22.33) under T_1. The result corroborates findings of Dey and Shil (2016) [3]. Earlier workers also reported that high fertility levels and organic manure favours an early head initiation and maturity in cabbage (Chaubey *et al.*, 2006; Haque, 2006; Wolde, 2015) [1, 8, 12]. The hastened days to head initiation under organic manures may attributed to the faster physiological activities leading to growth and development of the plant due to higher supply of nutrients. Different Treatments caused significant influence on head yield of Chinese cabbage. Among the treatments, T_3 produced highest (45.42 t/ha) head yield and lowest yield (23.93 t/ha) was recorded in T_1 (Table 2). Observation recorded under the study corroborates the findings of Dalal *et al.* (2010); Dey and Shil (2016) [2, 3]. The increased yield under the influence of T_3 may be due to the improved plant growth with faster rates. Also, it may be explained as the increased number of folded leaves which lead to increased head weight of Chinese cabbage. Total leaf chlorophyll, TSS and Vitamin C are the important quality attribute of Chinese cabbage. Organic sources of nutrients in combination with bio-inoculants produced superior quality of head in terms of these contents. However, maximum content of these quality attributes was found in T_3 and minimum in T_1 (Table 2). Increased TSS might be the result of balanced and improved nutrient uptake as a result of vermicompost and bio-fertilizers. More chlorophyll content in leaves might be due to the major and micronutrients supplied by the vermicompost and bio-fertilizers particularly nitrogen which is an important constituent of chlorophyll. Quality improvement due to organic fertilization has also been accounted in previous reports Ghoname and Shafeeq (2005); Haase *et al.* (2007); Narayan *et al.* (2013) [5, 7, 9].

Conclusion

On the basis of results of present investigation following conclusion may be drawn that combined application of vermicompost @ 6.6 t/ha along with inoculation of Azotobacter plus PSB and KSB provided maximum growth, yield and quality for Chinese cabbage var. pekinensis.

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