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Integrated nutrient management studies in cabbage (*Brassica oleracea*) under subtropical plains of Jammu

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ABSTRACT

A two year field investigation was conducted to study the effect of integrated nutrient management in cabbage (*Brassica oleracea* var. capitata L.) under subtropical plains of Jammu during *rabi* 2014–2015 and 2015–16 at Vegetable Experimental Farm of SKUAST, Jammu, Jammu and Kashmir. The experiment was laid in RBD and comprised 14 treatments with three levels of nitrogen (50, 75 and 100 %) in combination with two levels of organic manures (FYM @20t/ha and Vermicompost@2t/ha) and seedling dip with two biofertilizers [*Azotobacter* and Phosphate Solubilising Bacteria (PSB)]. The results revealed that for all the morphological (50% head initiation and maturation) and yield parameters (head size, net and gross head weight and marketable yield), the treatment combination comprising 75% inorganic nitrogen + Vermicompost + *Azotobacter* + Phosphate Solubilizing Bacteria recorded significantly high values as compared to other treatment combinations and control. Quality parameters like TSS recorded non significant influence by the application of different organic manures (FYM and Vermicompost) in combination with biofertilizers and reduced quantities of N (50 and 75%),however ascorbic acid content in cabbage recorded statistically higher values (51.16 mg/100g) in the treatment having 50% of inorganic nitrogen + Vermicompost + *Azotobacter* + Phosphate Solubilizing Bacteria (PSB). Economically, the study pointed out that application of vermicompost in the treatment combinations resulted in higher values in cost of cultivation, thereby, lowering down B:C ratios as compared to FYM treatments. Maximum B:C ratio (1:2.55) was recorded in treatment having 75% inorganic nitrogen + Vermicompost + *Azotobacter* + Phosphate Solubilizing Bacteria as compared to 1.96 in control (100% NPK + FYM).

Keywords: Cabbage, Economics, Growth, INM, Quality, Yield

Integrated plant Nutrient Management (INM) is one of the important methods for supplying nutrients to the plants to enhance soil fertility and supply plant nutrients at an optimum level. It helps to sustain the desired productivity and improve the profitability through optimization of the benefits from all possible sources of organic, inorganic and biological components in an integrated manner. Incorporation of organic source of plant nutrients in the form of farmyard manure and biofertilizers is known to enhance the availability and uptake of nitrogen thereby enhancing crop growth and yield (Sharma *et al.* 2012). Use of biofertilizers is needed as an alternative source to bring forth the eco-friendly methods of farming. The concept of sustainable agriculture envisages primary emphasis on manipulation and management of biological systems not only to maximize yield but also to stabilize the agro-systems and to minimize industrial input demands. In recent years, biofertilizers have emerged as an important aspect of Integrated Nutrient Supply System (INSS) and hold a great promise to increase crop yields through better nutrient supplies.

Cabbage (*Brassica oleracea* var. *capitata* L.) is one of the most important cole crops grown extensively in India over an area of 7.3 lakh hectares with a production of 9037 (000)MT (Anonymous 2019). In Jammu region, it is grown in the plains/hilly areas over an area of 1672 ha with production of 46.3 (000) MT (Anonymous 2015). It is a heavy feeder of plant nutrients particularly nitrogen for head production, however, supply of nitrogen through inorganic fertilizers often produces coarse and loose heads that adversely affect the head quality, storage life and increase nitrate content of head (Ojetayo *et al*. 2011). Therefore, it is important to utilize all the nutrient sources in an integrated manner to realize the optimum production potentials (Khan *et al*. 2009). In an endeavour to standardize its production technology based on efficient nutrient management strategy,

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the present investigation was undertaken to find out the influence of integrated nutrient management on growth, yield and economics of its production.

MATERIALS AND METHODS

The present investigation was conducted at Vegetable Experimental Farm of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Main campus, Chatha during *rabi* 2014–15 and 2015–16. Golden Acre-a popular cabbage variety among the farmers, was used for the experiment and the plants were planted at a spacing of 60 cm × 45 cm apart in a plot size of 3 m × 2.25 m. The biofertilizer slurry was prepared by mixing bio fertilizers @1 kg/ha in 0.5 kg jaggery per 2-3 litres of water and applied as root dip treatment. Later on, the treated seedlings were dried in shade for 30 min just before transplanting. The fertilizer mixture containing calculated amount of nitrogen, phosphorous, potash, FYM, vermicompost was applied treatmentwise. The experiment comprised 14 treatment combinations, viz. T_1: 100% NPK + FYM (Rec. dose), T_2: 75% NPK + FYM + *Azotobacter,* T_3: 50% NPK + FYM + *Azotobacter*, T_4: 75% NPK+FYM +PSB, T_5: 50% NPK + FYM + PSB, T_6: 75% NPK + FYM + *Azotobacter* + PSB, T_7: 50% NPK + FYM + *Azotobacter* + PSB, T_8: 100% NPK + Vermicompost ,T_9: 75% NPK + Vermicompost + *Azotobacter,* T_{10}: 50% NPK + Vermicompost + *Azotobacter,* T_{11}: 75% NPK +Vermicompost +PSB, T_{12}: 50% NPK + Vermicompost + PSB, T_{13}: 75% NPK + Vermicompost + *Azotobacter* + PSB and T_{14}: 50% NPK + Vermicompost + *Azotobacter* + PSB laid out in Randomized Block Design (RBD) with three replications. The recommended dose of inorganic fertilizers (i.e.120:60:60kg/ha) was applied in form of Urea, DAP and MOP. Full dose of P and K along with half of N was applied as basal dose. Rest of the N was top dressed in two equal spilt doses of 30 and 45 days after transplanting. The treatments were based on vermicompost and farmyard manure along with varied levels of 100%, 75% and 50% of the recommended dose with and without the application of biofertilizers, viz. *Azotobacter* and Phosphorous Solubilizing Bacteria (PSB). Observations were recorded for 12 parameters, viz. Days to 50% head initiation, Days to 50% head maturity, Number of non-wrapper leaves, Weight of non-wrapper leaves (g), Head size (cm^2), Head compactness (%), net head weight (g), Gross head weight (g), Marketable yield per plot (kg), Marketable yield per hectare (q), Total Soluble Solids (^0B) and Ascorbic acid content (mg/100g). The vitamin C content was determined titrimetrically using 2, 6 dichlorophenol indophenol dye as per method suggested by Ranganna (1986). Total Soluble Solids was measured by using Erma Hand Refractometer (0-32^{o}B) ERMA, Japan. Five plants in each treatment combination were selected randomly and tagged properly for recording the specified observations. The data obtained during the experiment were subjected to statistical analysis as per the procedure prescribed by Gomez and Gomez (1984). Cost of cultivation along with net returns and gross income was calculated to get cost:benefit ratio of all the treatments.

Table 1 Effect of integrated nutrient management on morphological characters of cabbage

Treatment	Days to 50% head initiation	Days to 50% head maturation	No. of non-wrapper leaves	Weight of non-wrapper leaves
T_1 -100% NPK + FYM (Rec. dose)	54.33	98.67	13.33	887.33
T_2 -75% NPK + FYM + *Azotobacter*	53.00	97.00	10.67	626.00
T_3 -50% NPK + FYM + *Azotobacter*	59.67	102.00	12.33	783.67
T_4 -75% NPK+FYM +PSB	51.33	95.33	10.33	614.67
T_5 -50% NPK + FYM + PSB	58.33	101.33	11.00	645.00
T_6-75% NPK + FYM + *Azotobacter* + PSB	48.67	91.67	11.67	742.33
T_7 -50% NPK + FYM + *Azotobacter* + PSB	55.33	98.00	9.00	481.67
T_8 -100% NPK + Vermicompost	51.67	95.67	10.00	588.67
T_9 -75% NPK + Vermicompost + *Azotobacter*	50.67	93.33	8.33	432.33
T_{10} -50% NPK + Vermicompost + *Azotobacter*	55.00	99.33	9.67	552.00
T_{11} -75% NPK +Vermicompost +PSB	47.33	87.00	12.00	764.33
T_{12} -50% NPK + Vermicompost + PSB	53.67	96.67	9.33	536.00
T_{13} -75% NPK + Vermicompost + *Azotobacter* + PSB	43.33	84.67	8.67	460.33
T_{14}-50% NPK + Vermicompost + *Azotobacter* + PSB	52.67	96.33	7.67	403.00
Mean	52.50	95.50	10.28	608.38
SEm (±)	2.76	3.38	0.53	29.29
CD (P=0.05)	8.07	9.87	1.55	85.61

RESULTS AND DISCUSSION

Morphological traits: It is evident from the data (Table 1) that days to 50% head initiation was significantly affected due to the application of various integrated nutrient management treatments. Minimum days (43.33) for 50% head initiation and head maturation (84.67) were recorded in T_{13} (75% NPK + Vermicompost + *Azotobacter* + Phosphate solubilizing bacteria). It was 14 days earlier to control in which the head took 98.67 days to mature after transplanting. Earliness in head initiation in presence of vermicompost and biofertilizers (*Aztobacter* and PSB treatment) could be attributed to increased vegetative growth combined with sufficient reserved food material which improves early development of vegetative buds and simultaneously early maturity of marketable head. The early head initiation may also be due to the stimulating effect of organics and PSB, phosphorous and growth promoting substances that enhance early flowering and maturity. These results are in concurrence with the findings of Mujahid and Gupta (2010) who reported superiority of vermicompost over FYM. The results are in close confirmation with the findings of Chatterjee *et al*. (2012) in cabbage.

Data (Table 1) showed that the treatments having 50% and 75% NPK along with vermicompost + *Azotobacter* with or without PSB recorded significantly less number of non-wrapper leaves per head as compared to other treatment combinations. Minimum number (7.67) were recorded in the treatments having 50% NPK along with vermicompost+*Azotobacter* +PSB which was at par with T_9 (50% NPK along with vermicompost+Azotobacter) (8.33) and T_{13} (8.67) but significantly superior to rest of the treatments. Weight of non-wrapper leaves per head indicated similar trend as recorded for number of non-wrapper leaves. Minimum weight of non-wrapper leaves (403.0 g) was obtained in T_{14} (50% NPK + Vermicompost + *Azotobacter* + Phosphate solubilizing bacteria) which was statistically at par

Table 2 Effect of integrated nutrient management on yield and quality characters of cabbage

Treatment	Head size (cm^2)	Head compact-ness (%)	Net head weight (g)	Gross head weight (g)	Market-able yield per plot (kg)	Marketable yield (q/ ha)	B.C ratio	Total soluble solids (°B)	Ascorbic acid content (mg per 100gm)
T_1 -100% NPK + FYM (Rec. dose)	197.02	24.98	706.67	1467.67	15.72	232.96	1.96	4.77	38.67
T_2 -75% NPK + FYM + *Azotobacter*	214.55	26.19	835.00	1828.67	18.22	270.05	2.44	5.13	44.57
T_3 -50% NPK + FYM + *Azotobacter*	196.88	22.93	643.33	1345.00	14.23	210.87	1.74	5.20	47.70
T_4 -75% NPK+FYM +PSB	204.10	26.62	786.67	1749.33	17.38	257.53	2.29	5.00	41.13
T_5 -50% NPK + FYM + PSB	183.86	24.31	608.33	1262.67	13.40	198.52	1.58	5.10	44.17
T_6-75% NPK + FYM + *Azotobacter* + PSB	213.75	28.17	843.33	1974.33	19.00	281.48	2.55	5.23	48.41
T_7 -50% NPK + FYM + *Azotobacter* + PSB	195.33	25.26	675.00	1430.00	14.59	216.17	1.84	5.37	51.16
T_8 -100% NPK + Vermicompost	204.27	25.77	765.00	1677.00	17.02	252.22	1.53	5.00	40.21
T_9 -75% NPK + Vermicompost + *Azotobacter*	218.03	27.24	891.67	2067.33	19.37	286.91	1.89	5.00	42.36
T_{10} -50% NPK + Vermicompost + *Azotobacter*	202.90	23.58	701.67	1543.67	15.23	225.68	1.31	5.07	44.79
T_{11} -75% NPK +Vermicompost +PSB	207.33	27.82	866.67	2013.67	19.17	283.95	1.84	4.93	40.70
T_{12} -50% NPK + Vermicompost + PSB	191.60	25.19	695.00	1528.00	14.95	221.48	1.21	5.00	42.57
T_{13} -75% NPK + Vermicompost + *Azotobacter* + PSB	220.32	28.31	928.33	2227.33	21.92	324.69	2.24	5.07	46.10
T_{14}-50% NPK + Vermicompost + *Azotobacter* + PSB	198.30	25.78	726.67	1691.00	16.69	247.28	1.51	5.17	48.60
Mean	203.45	25.87	762.38	1700.41	16.92	250.70	-	5.07	44.37
SEm (±)	9.09	0.71	51.32	59.50	1.00	14.81	-	0.16	0.55
CD (P=0.05)	NS	2.07	150.01	173.94	2.92	43.35	-	NS	1.54

Treatment details mentioned in Table 1.

with T_9 (50% NPK along with vermicompost+Azotobacter) (432.33g) and T_{13} (75% NPK + Vermicompost + *Azotobacter* + Phosphate solubilizing bacteria) (460.33g) but superior to the rest of the treatment combinations. Number and weight of non-wrapper leaves is markedly influenced by the application of different INM practices as reported by Chaurasia *et al*. (2008) in cauliflower.

Yield contributing traits: The maximum head compactness (28.31%) was recorded in T_{13} (75% NPK + Vermicompost + *Azotobacter* + Phosphate solubilizing bacteria) which was statistically at par with T_4,T_6,T_9 and T_{11} (Table 2). The highest net head weight (928.33 g) and gross head weight (2227.33 g) was also obtained in the same treatment with maximum marketable yield of 324.69 q/ha Bhushan and Sharma (2017) reported that the treatment combination comprising 50% N + FYM (20t/ha) + seedling dip with *Azospirillum* recorded highest yield (158.8 q/ha) of broccoli under intermediate zone of Jammu & Kashmir support the present study. The probable reason might be that the organic manures would have provided micronutrients such as zinc that is involved in the biochemical synthesis of the most important plant hormone, Indole Acetic Acid (IAA) through the pathway of conversion of tryptophan to IAA and iron, that is involved in the chlorophyll synthesis pathway, in an optimum level to the plants. In addition, *Azotobacter* provides biologically fixed nitrogen to plants and beneficial growth promoting substances like IAA, GA, kinetins, riboflavin, and thiamine, which can result in higher apical and lateral head yield.

B:C ratio: Data (Table 2) clearly points out that application of vermicompost in the treatment combinations resulted in higher values in cost of cultivation, thereby lowering down B:C ratios as compared to FYM treatments. Treatment combination having 75% inorganic nitrogen resulted in B:C ratios above 2.0. Maximum B:C ratio (1:2.55) was recorded in treatment having 75% inorganic nitrogen + Vermicompost + *Azotobacter* + Phosphate Solubilizing Bacteria as compared to 1.96 in control (100%NPK + FYM). The results are in close conformity with the findings of Jaipaul *et al*. (2011) and Gopinath *et al*. (2008).

Quality contributing traits: Data (Table 2) clearly showed that ascorbic acid content was influenced by the application of FYM and biofertilizers alongwith 50% and 75%NPK. Maximum content of ascorbic acid (51.16mg/100g) was recorded in T_7 (50% NPK+FYM+*Azotobacter*) which was statistically at par with T_{14} (75% NPK + Vermicompost + *Azotobacter* + Phosphate solubilizing bacteria). However, non-significant results were recorded for TSS content. These results are in accordance with the findings of Sable and Bharmare (2007). Reason for high ascorbic acid content might be presence of loamy textured soils with medium levels of phosphorus and potassium in the experimental field that supported quality content of the leaves.

On the basis of results, it may be concluded that by integrating several organic nutrients and biofertilizers like FYM, vermicompost, *Azotobacter* or Phosphate solubilizing bacteria with inorganic fertilizers, higher yield and quality improvement in cabbage is achievable. Such treatments not only reduce the application of nitrogen to the tune of 25% but also proved profitable by giving cost:benefit ratio of more than 2.0. From the study, it was found that FYM, being cheap and readily available at farm, reduced input costs in all the treatments and maximized net profits. Since maximum benefit:cost ratio of 2.55 was obtained in T_6 (75% NPK + FYM + *Azotobacter* + PSB), hence it can be recommended to the farmers of the region for successful cultivation of cabbage under subtropical conditions of Jammu region.

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