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STUDIES ON INTEGRATED NUTRIENT MANAGEMENT AND BIOFERTILIZERS ON ROWTH AND YIELD OF RED CABBAGE (*BRASSICA OLERACEA VAR. CAPITATA F. RUBRA*)

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ABSTRACT

A field experiment entitled "Studies on integrated nutrient management and biofertilizers on growth and yield of red cabbage (*Brassica oleracea var. Capitata f. rubra)*" was conducted during the year 2023-24 at experimental field of Department of Horticulture, VNMKV, Parbhani with a view to study the integrated nutrient management on growth and yield of red cabbage. The application of 50 % RDF + 50 % VC + PSB (T9) was observed beneficial for producing better growth parameters are plant height (37.34 cm), stem height (15.15 cm), leaf area (216.35 cm^2), number of outer leaves per plant at 60 DAT (20.21), number of leaves per head at harvest (34.74), minimum days taken for head initiation (33.74 days) and minimum days taken for head maturity (67.85 days), yield parameters like weight of head (1126.31 g), yield per plot (28.15 kg) and yield per ha (417.15 q/ha).
Keywords **:** Azotobacter, PSB, KSB, RDF, Red cabbage, Vermicompost.

Introduction

Red cabbage (*Brassica oleracea var. capitata f. rubra*) called as purple cabbage or red kraut. Since its leaves are purple or red in colour due to the pigment called anthocyanin. The leaves are used as raw or in pickle or cooked (Matlob *et al*., 1989). Brassicaceae vegetables represent an important part of the human diet and consumed by people all over the world and considered important food crops in China, Japan, India and European Countries. This vegetable is generally grown in most of the European countries, mainly France, Africa and minor Asia (Smith, 1995). In India, cabbage including red cabbage is cultivated in an area of 4.36 lakh hectares producing 102.54 lakh million tonnes and in Maharashtra it is cultivated in an area of 8.87 thousand hectares producing 205.08 lakh tonnes (Anonymous 2023-2024).

Red cabbage synthesized and accumulated anthocyanin at all the developmental stages of vegetative growth (Yuan *et al.,* 2009). It is a rich source of anthocyanin, proteins, fats and minerals like calcium, phosphorus, potassium, sulphur etc. and vitamins *viz.* A, B1, B2 and C. Red cabbage distinguished by the presence of 2 exceptional health enhancing properties like anticancer properties due to the presence of Indole 3-Carbinol and many beneficial sensory traits, which has become more and more important in recent year (Wojciechowska and Koltan, 2007). An important advantage of red cabbage is the fact that it is generally consumed raw, which permits the preservation of vitamins sensitive to thermal processing and some polyphenol compounds (Ismail *et al*., 2004).

Integrated nutrient management (INM) is to optimize the benefits from all potential plant nutrient sources in an integrated way while maintaining or

improving soil fertility and plant nutrient supply to an optimal level for maintaining the targeted crop productivity. Biofertilizers can serve as alternative to mineral fertilizers for improving soil structure and microbial biomass for sustainable increased production. Azotobacter represents the main group of heterotrophic, non-symbiotic free-living nitrogen fixing bacteria, synthesize growth substances that greatly enhance plant growth and development. While the potassium-solubilizing bacteria (KSB) plays a vital role in solubilizing potassium from insoluble forms by producing organic acids. The potassium uptake of plants gets increased that ultimately increases the crop production. Vermicompost (VC) is an excellent source of nutrients for plants and organic matter. Its porosity, aeration, drainage and water-holding capacity are all extremely good.

Red cabbage in India demand is growing very fast with time there has been a change in the eating habits. Because of this, now new appealing type of vegetable demand is increasing in the market. Health-conscious people are now starting to include nutritious fruits and vegetables in their diet. Farmers are earning profit by growing new coloured vegetable with organic farming according to the demand in the market. Red cabbage is vegetable of the same category, whose demand has increased a lot in recent times and fetching premium price in the market. Therefore, considering above points, the present investigation carried out to know the effect of integrated nutrient management and biofertilizers on growth and yield of red cabbage.

Materials and Methods

The experiment on "Studies on integrated nutrient management and biofertilizers on growth and yield of red cabbage (*Brassica oleracea var. capitata f. rubra)*" was carried out during *rabi,* 2023- 2024 at Department of Horticulture, V.N.M.K.V., Parbhani. The experiment was laid out in Randomized Block Design in 10 treatments with 3 replications. The treatments were 100 % RDF, 75 % RDF+ Azotobacter (AZ), 75 % RDF+PSB, 75 % RDF+ KSB, 75 % RDF+ 25 % VC + AZ, 75 % RDF + 25 % VC + PSB, 75 % RDF + 25 % VC + KSB, 50 % RDF + 50 % VC + AZ, 50 % RDF + 50 % VC + PSB, 50 % RDF + 50 % VC + KSB. There were tree biofertilizers namely azotobacter, PSB, KSB and vermicompost applied as per treatments. Four-week-old seedlings were selected for transplanting. Transplanting of seedlings was done in October month. Biofertilizers were taken at 3 lit /ha each and slurry was prepared. Seedlings were dipped in this slurry for 5 minutes before transplanting and planted in respective treatment plots. After 30 days of transplanting applied all the biofertilizers to the plants by drenching method in respective treatment plots. Vermicompost @ 5 t/ha were applied after 30 days of transplanting of seedlings in respective treatments. Weeding was done manually at 25 days after transplanting and earthing up at 30 days after transplanting.

Observations were taken with respect to the growth parameters are plant height, stem height, number of outer leaves per plant, number of leaves per head at harvest, leaf area, minimum days taken for head initiation and minimum days taken for head maturity, yield parameters like weight of head, yield per plot and yield per ha. The statistical analysis was done as per the methods suggested by Panse and Sukhatme (1985).

Results and Discussion

Growth parameters

Significant difference was observed in plant height, stem height, number of outer leaves per plant, number of leaves per head at harvest, leaf area, minimum days taken for head initiation and minimum days taken for head maturity due to integrated nutrient management and biofertilizers. Increase in growth parameters is due to application of required fertilizers in combination with vermicompost and PSB. Vermicompost helps to increase the soil fertility, porosity of soil and water holding capacity of soil. Standard management and cultural practices were implemented. Five plants are tagged in each treatment plot, observation were made on several growth parameters like plant height (cm) at (30, 60 and at harvest), stem height at (30, 60 and at harvest), leaf area (cm^2), number of outer leaves per plant (30 and 60 days), number of leaves per head at harvest, minimum days taken for head initiation and minimum days taken for head maturity, yield parameters like weight of head (g), yield per plot (kg) and yield per ha (q/ha).

Plant height (cm)

Among all the treatments 50 % RDF + 50 % VC + PSB (T_9) recorded significantly maximum plant height (24.61, 31.18, 37.34 cm) at 30, 60 and at harvest respectively. This increased plant height might be due to the favorable effect of chemical fertilizers along with vermicompost and FYM which might have enhanced the soil fertility coupled with improved soil moisture retention capacity (Chaudhary *et al.,* 2015). Earlier workers attributed this to application of biofertilizers helped in secretion of growth promoting substances, which might have led to better root development, transportation of water, uptake and deposition of nutrients (Tekasangla *et al.,* 2015). Results of the present study are in line with findings of

Maurya *et al*. (2008) in broccoli and Singh *et al*. (2009) in cauliflower, Komma *et al.* (2020) in red cabbage and Nupane *et al*. (2020) in cauliflower.

Stem height (cm)

Among all the treatments application of 50 % RDF + 50 % VC + PSB (T_9) recorded significantly maximum stem height (6.30, 8.68 and 15.15cm) at 30, 60 and at harvest respectively. This might be the result of improved cell division and elongation caused by the increased absorption and continuous supply of primary nutrients. Earlier investigations associated this to the plant's integrated utilization of nutrients, which has improved cell elongation, division and multiplication in the meristematic region, thus promoting the plant's vegetative growth (Kumar *et al*., 2013). Present findings are in agreement with those reported by Maurya *et al*. (2008) in broccoli and Singh *et al.* (2009) in cauliflower.

Leaf area per plant (cm^2)

Leaf area per plant of red cabbage was influenced significantly by application of different source of nutrients at 30, 60 DAT and at harvest. Among all the treatments application of 50 % RDF + 50 % VC + PSB (T9) recorded significantly maximum leaf area per plant (80.96, 147.26, 216.35 cm^2) and minimum leaf area per plant (66.09, 112.73, 151.0 cm^2) at 30, 60 and at harvest respectively. INM enhances overall plant growth, which can lead to an increase in leaf area. Proper nutrient management ensures that red cabbage plants receive essential nutrients in the right proportions, supporting robust leaf development. Biofertilizers might enhance nutrient availability, uptake by plants and improve soil fertility and plant health. They often promote better root development and nutrient absorption, contributing to increased leaf area. The results are in conformity with findings by Maurya *et al.* (2008) in broccoli and Singh *et al.* (2009) in cauliflower and Komma *et al.* (2020) in red cabbage.

Number of outer leaves per plant

Number of outer leaves per plant were recorded at 30 and 60 days after transplanting. Results showed that number of leaves per plant at (15.26 and 20.21 days) at 30 and 60 days was found maximum in 50 % RDF + 50 % VC + PSB (T_9). According to Singh *et al*. (2009) reason for an increase in leaf count in treatments that include biofertilizers, organic manures and inorganic fertilizers might be due to the adequate availability of essential elements like potassium, phosphate and nitrogen. Besides this azotobacter is also associated with the production of growth promoting substances, antifungal compounds and cytokinin which in turn might have led to better root development, better uptake and transport of nutrients. These results are consistent with the findings of Maurya *et al*. (2008) in broccoli, Akbar *et al.* (2009) while in working with cabbage, Singh *et al.* (2009) in cauliflower and Komma *et al*. (2020) in cabbage.

Number of leaves per head at harvest

At harvest application 50 % RDF + 50 % VC + PSB (T_9) recorded significantly highest number of outer leaves per head (34.74) at harvest which was followed by treatment T_8 (31.58) and T_6 (30.69). Lowest number of outer leaves per head was recorded in treatment T_1 (25.59) which was at par with T_3 (26.50), T_4 (26.69) and T_2 (27.58). The increase in number of outer leaves per plant might be attributed to greater absorption of primary nutrients, which in turn resulted to higher synthesis of proteins, lipids and carbohydrates which are essential for the cellular construction of new cells. Biofertilizers could stimulate root growth and increase nutrient uptake efficiency, potentially leading to a greater number of leaves. These results are consistent with the findings of Maurya *et al*. (2008) in broccoli, Akbar *et al.* (2009) while in working with cabbage, Singh *et al.* (2009) in cauliflower and Komma *et al*. (2020) in cabbage.

Days taken for head initiation

The significantly minimum days taken for head initiation (33.74 days) was found in treatment 50 % RDF + 50 % VC + PSB (T_9) and maximum days taken for head initiation (42.68 days) was found in 100% RDF (T_1). The minimum days taken for head initiation may be due to higher NPK and increased nutrient transport from root to the aerial parts and increased rate of photosynthesis and assimilation of photosynthates resulting in early head formation (Kumari *et al.,* 2015). In broccoli, high nutritional doses caused the various reproductive development stages to begin earlier, but low or no nutrient concentrations caused the commencement of the various reproductive phases to occur much later (Kumar *et al.*, 2013). A sufficient amount of stored food material combined with increased vegetative growth may have allowed for early head initiation. These results are in conformity with findings of Pawar and Barkule *et al.* (2017) in cauliflower and Komma *et al*. (2020) in red cabbage.

Days taken for head maturity

The significantly minimum days taken for head maturity (67.85 days) was found in treatment 50 % RDF + 50 % VC + PSB (T_9) and maximum days taken for head maturity (81.65 days) was found in 100% RDF (T_1). This balanced approach can enhance plant growth, leading to more uniform and possibly faster

head maturity. It ensures that the plants receive comprehensive nutrient supply, which supports better overall development. Biofertilizers can potentially accelerate head maturity by improving nutrient availability and enhancing plant resilience against stress. Both INM and biofertilizers can reduce the time taken for head maturity in red cabbage. Chaubey *et al.* (2006) found that the process of growth and development was slower at lower fertility levels, greater fertility levels increase maturity period.

Yield parameters

Weight of head (g)

The highest weight of head was recorded in treatment 50 % RDF + 50 % VC + PSB (T_9) recorded significantly maximum weight of head (1126.31 g) and was followed by treatment T_8 (1098.06 g) and T_7 (1080.34 g). However, minimum weight of head (803.00 g) was recorded in 100 % RDF (T_1). Increase in head weight of red cabbage might be due to the fact that biofertilizers in combination with inorganic and organic fertilizers helped in better root proliferation and rhizosphere development, uptake of nutrients and water, higher leaf area development ultimately higher rate of photosynthetic activity (Chaudhary *et al.*,2015).

Yield per plot (kg)

Maximum yield per plot was found in treatment T_9 (28.15 kg) receiving 50 % RDF + 50 % VC + PSB which was followed by treatment T_8 (27.44 kg) and T_7 (27.08 kg). Minimum yield per plot was recorded in treatment T_1 (20.07 kg) which was at par with treatment T_2 (20.33 kg).

Yield per hectare (q/ha)

Maximum yield per hectare (417.15 q ha^{-1}) was found in treatment 50 % RDF + 50 % VC + PSB (T_9) which was followed by treatment T_8 (406.69 q ha^{-1}) and T_7 (400.12 q ha^{-1}). Minimum yield was recorded in treatment T_1 (297.41 q ha^{-1}) which was followed by treatment T_2 (301.26 q ha^{-1}) he more yield in this treatment could be directly related to higher values of head diameter, head weight and photosynthetic rate. The increase in yield might be due to the performance of the vegetative growth which might have influenced the production of more amounts of carbohydrates accumulated in head and thereby increased the yield. This is because of appropriate dose of nitrogen, as nitrogen is a constituent of protein and chlorophyll and it play vital role in photosynthesis process. These results are in correlated with those reported by Chaudhary *et al*. (2015) in cauliflower, Tekasangla *et al.* (2015) in cabbage, Komma *et al.* (2020) in red cabbage and Nupane *et al.* (2020) in cauliflower.

Conclusions

On the basis of present study, it can be concluded that the growth parameters like plant height, stem height, number of outer leaves per plant, number of leaves per head at harvest, leaf area (30, 60 and at harvest), minimum days taken for head initiation and minimum days taken for head maturity were found significant in treatment 50 % RDF + 50 % VC + PSB (T_9). Yield parameters like weight of head, yield per plot and yield per hectare were found significantly maximum in in treatment 50 % RDF + 50 % VC + PSB (T_9). Hence, application of 50 % RDF + 50 % VC + PSB (T_9) is found significantly superior over rest of the treatments to increase growth and yield parameters in red cabbage during *rabi* season under Marathwada region.

Table 1: Effect of integrated nutrient management and biofertilizers on plant height, stem height, leaf area per plant, number of outer leaves per plant, number of leaves per head (at harvest) of red cabbage

Treatments	Plant height (cm)			Stem height (cm)			Leaf area per plant (cm^2)			Number of outer leaves per plant		Number of leaves per head (at harvest)
	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	
T_1- 100 % RDF	18.80	25.74	26.28	4.39	6.36	11.06	66.09	112.73	151.0	8.22	13.32	25.59
T_2- 75 % RDF+ Azotobacte(AZ)	19.87	26.30	29.28	4.79	6.79	11.49	67.37	116.05	157.09	11.53	14.65	27.58
T_3- 75 % RDF+ PSB	21.34	27.76	29.71	4.97	6.91	12.74	68.96	123.96	174.83	10.29	13.47	26.50
T_4- 75 % RDF+ KSB	20.18	26.87	30.70	5.54	7.53	12.80	68.53	118.10	168.14	10.37	13.77	26.69
T_5- 75 % RDF+ 25 % VC + AZ	20.63	25.64	32.21	5.92	7.93	13.96	76.36	137.44	168.31	13.68	15.86	28.66
T_6- 75 % RDF + 25 % VC + PSB	24.61	29.80	35.28	6.30	8.30	14.75	77.91	136.35	203.36	12.56	14.68	30.69
T_7- 75 % RDF + 25 % VC + KSB	21.66	26.95	33.02	5.11	7.03	14.30	75.91	128.03	207.41	13.48	16.59	28.69
T_8- 50 % RDF + 50 % VC + AZ	21.60	30.44	35.57	6.25	8.23	13.76	72.06	141.42	183.55	14.27	18.46	31.58
T_9- 50 % RDF + 50 % VC + PSB	22.03	31.18	37.34	5.60	8.68	15.15	80.96	147.26	216.35	15.26	20.21	34.74
T_{10}-50 % RDF + 50 % VC + KSB	22.01	28.97	32.90	4.84	6.73	12.95	73.78	132.37	177.90	12.57	17.73	29.56
SEm±	**0.40**	**0.54**	**0.60**	**0.06**	**0.08**	**0.18**	**0.32**	**0.88**	**1.23**	**0.54**	**0.61**	**0.67**
CD at 5 %	**1.18**	**1.67**	**1.81**	**0.19**	**0.25**	**0.54**	**0.94**	**2.64**	**3.64**	**1.60**	**1.82**	**2.02**

Table 2: Effect of integrated nutrient management and biofertilizers on days taken for head initiation, days taken for head maturity, weight of head, yield per plot and yield per hectare of red cabbage

Treatments	Days taken for head initiation	Days taken for head maturity	Weight of head (g)	Yield per plot (kg)	Yield per hectare (q/ha)
T_1- 100 % RDF	42.68	81.65	803.00	20.07	297.41
T_2- 75 % RDF+ Azotobacter (AZ)	39.54	80.56	813.41	20.33	301.26
T_3- 75 % RDF+ PSB	36.49	79.40	848.14	21.20	314.13
T_4- 75 % RDF+ KSB	40.55	77.43	947.82	23.70	351.04
T_5- 75 % RDF+ 25 % VC + AZ	35.90	76.63	995.07	24.88	368.54
T_6- 75 % RDF + 25 % VC + PSB	34.58	72.61	1049.55	26.23	388.72
T_7- 75 % RDF + 25 % VC + KSB	35.62	73.79	1080.34	27.08	400.12
T_8- 50 % RDF + 50 % VC + AZ	34.48	70.60	1098.06	27.44	406.69
T_9- 50 % RDF + 50 % VC + PSB	33.74	67.85	1126.31	28.15	417.15
T_{10}-50 % RDF + 50 % VC + KSB	36.95	74.88	963.98	24.09	357.03
SEm±	**0.28**	**0.94**	**1.25**	**0.16**	**0.49**
CD at 5 %	**0.83**	**2.82**	**3.77**	**0.49**	**1.45**

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Conflict of interest

The authors declare no conflicts of interest. They bear sole responsibility for the content and composition of the paper.

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