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EXPLORING BIOFERTILIZER EFFICIENCY IN OPTIMIZING CABBAGE (*BRASSICA OLERACEA* VAR. *CAPITATA* L.) GROWTH DYNAMICS CV. GOLDEN ACRE

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ABSTRACT

A field experiment titled "Exploring Biofertilizer Efficiency in Optimizing Cabbage (*Brassica oleracea* var. *capitata* L.) Growth Dynamics cv. Golden Acre" was carried out during the Rabi season of 2020-21 at the Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Lucknow. The study aimed to evaluate the impact of various biofertilizer and nutrient combinations on cabbage growth and development. Thirteen treatments were designed, including: T_0 (Control), T_1 (100% RDF), T_2 (100% FYM), T_3 (100% PSB), T_4 (100% Garden Boom), T_5 (100% VAM), and combinations such as T_6 (RDF 50% + FYM 50%), T_7 (RDF 50% + PSB 50%), T_8 (RDF 50% + Garden Boom 50%), T_9 (RDF 50% + VAM 50%), T_{10} (FYM 50% + PSB 50%), T_{11} (FYM 50% + Garden Boom 50%), and T_{12} (FYM 50% + VAM 50%). The experiment was laid out in a Randomized Block Design with three replications. The treatment RDF 50% + PSB 50% (T_7) recorded the highest values in plant height (23.40 cm), number of leaves (13.41), leaf length (24.86 cm), leaf width (18.60 cm), leaf area (206.30 cm²), plant spread (43.30 cm), stem diameter (13.83 mm), and the shortest time to maturity (62 days). These findings highlight the potential of integrating biofertilizers with reduced chemical inputs to improve cabbage growth and sustainability.

Keywords: Biofertilizer, Efficiency, Garden Boom, PSB and Golden Acre.

Introduction

Cabbage (*Brassica oleracea* var. *capitata* L.) is one of the most significant vegetable crops in the Brassicaceae family, cultivated extensively across the globe (Yadav *et al*., 2012). It is consumed both fresh, as in salads, and as a cooked or fried vegetable. Cabbage heads are a rich source of essential vitamins, minerals, and dietary fibers (Chatterjee *et al*., 2012). In India, during 2017-18, cabbage was grown over 399 thousand hectares, yielding 9,037 thousand tonnes with a productivity rate of 22.5 tonnes per hectare (Anonymous, 2017-18). However, the intensive use of chemical fertilizers and pesticides has disrupted the natural balance of soil, plant systems, and microbial populations, leading to potential health risks and soil degradation (Upadhyaya *et al*., 2012). Over time, reliance on chemical fertilizers depletes soil fertility, necessitating the adoption of sustainable practices to maintain and enhance soil health (Jaiswal *et al*., 2020). Several factors influence cabbage growth and yield, including soil fertility, cultivars, and climatic conditions. Incorporating organic inputs and biofertilizers offers a pathway to not only improve soil health but also boost cabbage growth and productivity (Singh *et al*., 2020). Biofertilizers consist of beneficial microorganisms capable of converting nutrients from an unavailable form to a plant-usable one (Sarkar *et al*., 2010). They serve as an eco-friendly, cost-effective, and non-bulky source of plant nutrients, making them an ideal supplement for vegetable cultivation. Among the most important biofertilizers are *Azospirillum*, Phosphate Solubilizing Bacteria (PSB), and Vesicular Arbuscular Mycorrhiza (VAM), which have the capacity to fix atmospheric nitrogen and solubilize phosphorus, respectively (Singh *et al*., 2020).

Materials and Methods

The experimental phase was conducted during the rabi season of 2020-21 at the Horticultural Research Farm-1 of the Department of Horticulture, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University (A Central University), Lucknow, Uttar Pradesh. Lucknow is geographically located at 26°50'N latitude, 80°52'E longitude, and an altitude of 111 meters above mean sea level (MSL). The region experiences a humid subtropical climate with an average annual rainfall of approximately 110 cm. Winters are severe, while summers are dry and hot, with temperatures reaching up to 43°C during summer and dropping to as low as 8°C in winter. The experiment was designed using a Randomized Block Design (RBD) with three replications and 13 treatments. The treatments included: T_0 (Control), T_1 (100% RDF), T_2 (100% FYM), T_3 (100% PSB), T_4 (100% Garden Boom), T_5 (100% VAM), T_6 (50% RDF + 50% FYM), T_7 (50% RDF + 50% PSB), T_8 (50% RDF + 50% Garden Boom), T_9 (50% RDF + 50% VAM), T_{10} (50% FYM + 50% PSB), T_{11} (50% FYM + 50% Garden Boom), and T_{12} (50% FYM + 50% VAM). Statistical analysis was performed following the Randomized Block Design method described by Panse and Sukhatme (1967). The study focused on the cabbage variety ‘Golden Acre’. Seeds were sown in a seed bed (4 m × 1 m), treated with Vitavax 200 WP (2.5 g/kg of seed) to prevent diseases like damping-off and leaf spot. Sown at a depth of 2 cm and spaced 5 cm apart, the seeds were covered with vermicompost and lightly watered. No chemical fertilizers were used during seedling growth (Ullah *et al*., 2013). One-month-old, 15 cm-long healthy seedlings were transplanted, seedlings treated with PSB (@100ml/liter), soil application with VAM @ 5 kg/acre (Kumar and Kumar, 2019) and Garden Boom @0.3% as plant spray. FYM was applied at 25 tonnes/ha, and the recommended doses of fertilizers (RDF) were applied at a rate of 150:100:100 kg/ha for N:P: K in which, full dose of phosphorus and Potassium with half dose of the nitrogen applied during field preparation and the remainder nitrogen applied 30 days after transplanting (DAT). Transplantation was carried out on November 21, 2020, followed by light irrigation for four consecutive days. Data were recorded on four randomly selected plants from each plot, observing various growth parameters including plant height (cm), stem diameter (mm), plant spread (cm), number of leaves per plant, leaf length (cm), leaf width (cm), leaf area (cm²), and days to maturity

Result and Discussion

Growth parameters

For plant height**,** seventy-five days after transplanting (DAT), cabbage plants treated with ‘RDF 50% + PSB 50%’ in T_7 treatment exhibited the tallest height, measuring 23.40 cm. Close behind, cabbage plants treated with FYM 50% + Garden Boom 50% in T_{11} treatment reached a height of 22.76 cm. Conversely, plants in the control treatment T_0 displayed the shortest height (18.73 cm). This variation in plant height is likely due to the influence of growth-promoting substances released by microbial inoculants, which enhance overall plant growth. Enhanced plant height under diverse nutrient sources was reported earlier by Chandel *et al.* (2021) and Yadav *et al.* (2001) in cabbage. For number of leaves**,** the treatment T_7 combining ‘RDF 50% + PSB 50%’ resulted in the highest recorded number of leaves per plant (13.41), followed closely by the combination of ‘FYM 50% + Garden Boom 50%’ in treatment T_{11} (13.31), which was notably superior to all other treatments. Conversely, the lowest number of leaves (10.75) was observed in the control treatment T_0. The enhanced vegetative growth of the plants could possibly be attributed to improved growth, elongation, and leaf count associated with the application of microbes. Enhance in leaf number, these findings are in agreement with those of Dragon *et al.* (2007) in cabbage and Solunki (2011) in broccoli. For leaf length (cm), the treatment T_7 ‘RDF 50% + PSB 50%’ exhibited the highest leaf length (24.86 cm), while treatment T_{11} ‘FYM 50% + Garden Boom 50%’ showed a slightly lower leaf length (23.98 cm), yet significantly outperformed other treatments. Conversely, the control treatment T_0. demonstrated the fewest leaves length (17). The enhanced growth of the plants may be credited to improved development and elongation facilitated by microbial application. Increase in leaf length through the organic amendments earlier find out by Yadav *et al.* (2012) in cabbage. For leaf width (cm), under treatment T_7, the application of 'RDF 50% + PSB 50%' resulted in the maximum leaf width (18.60 cm). Following closely, treatment T_{11}, which involved 'FYM 50% + Garden Boom 50%', exhibited leaf width of 18.10 cm, significantly superior to all other treatments. The control treatment T_0 displayed the lowest width of leaves (15.46 cm). The increased leaf width observed with microbial application could be attributed to improved leaf growth and elongation. This finds out by Verma and Yadav (2011) in cauliflower. For leaf area (cm^2), the maximum leaf area (206.30) was observed with the application of 'RDF 50% + PSB 50%' under treatment T_7, followed by an area of leaf (198.30) with the application of 'FYM 50% + Garden Boom 50%' under treatment T_{11}, which was significantly superior to all other treatments. Additionally, the lowest area of leaves (120.34) was observed in the control treatment T_0. This was further affirmed by Sharma *et al.* (2008) in broccoli. For spread of plant (cm), the application of 'RDF 50% + PSB 50%' under treatment T_7 observed the maximum spread of the plant (43.30), followed by the application of 'RDF 50% + FYM 50%' under treatment T_6 (42.40), which was significantly superior to all other treatments. Additionally, the lowest spread of plant (38.20) was observed in the control treatment T_0. These findings are in agreement with those of Dragon *et al.* (2007) in cabbage and Solunke (2011) in broccoli. For diameter of stem (mm), in the treatment T_7, the application of 'RDF 50% + PSB 50%' resulted in the maximum recorded stem diameter of 13.83mm. This was followed by the application of FYM 50% + Garden Boom 50% in the treatment T_{11}, which recorded a stem diameter of 11.36 mm. This treatment was significantly superior to all other treatments, with the lowest stem diameter (8.56mm) observed in the control treatment T_0. This finding is in agreement with those of Singh (2008) and Mankar (2015) in cabbage. For days to maturity (Days), through the application of 'RDF 50% + PSB 50%' in the treatment T_7, minimum days to maturity (62 days) was observed. Second best treatment was treatment T_6 (RDF 50% + FYM 50%) which observed the 64 days and it was significantly superior over to all other treatments and highest days to maturity (66.34 days) observed in control in T_0 treatment. These findings are in agreement with Solunki (2011) in broccoli. The rapid growth and maturation of the heads could be attributed to the increased accessibility of vital nutrients like nitrogen, phosphorus, and potassium. This enhancement is made possible by the incorporation of biofertilizers, which play a vital role in chlorophyll and protein synthesis Rana *et al.* (2020).

Table 1 : Exploring Biofertilizer Efficiency in Optimizing Cabbage (*Brassica oleracea* var. *capitata* L.) Growth Dynamics cv. Golden Acre

S.N.	Treatments	Plant height (cm)	Number of leaves	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)	Spread of plant (cm)	Diameter of stem (mm)	Days to maturity
1	Control (T_0)	18.73	10.75	17.00	15.46	120.34	38.20	8.56	66.34
2	RDF 100% (T_1)	20.30	11.34	18.96	16.86	157.00	38.90	9.20	65.00
3	FYM 100% (T_2)	19.93	11.16	18.56	16.53	149.50	38.80	9.06	64.00
4	PSB 100% (T_3)	20.40	11.25	18.70	16.30	152.50	38.73	9.16	63.34
5	Garden Boom 100% (T_4)	19.86	11.16	18.93	15.83	145.00	38.66	9.06	64.00
6	VAM 100% (T_5)	19.90	11.08	18.66	16.20	136.20	38.60	9.23	64.66
7	RDF 50% + FYM 50% (T_6)	19.83	13.16	22.50	18.06	180.00	42.40	10.70	64.00
8	RDF 50% + PSB 50% (T_7)	23.40	13.41	24.86	18.60	206.30	43.30	13.83	62.00
9	RDF 50% + Garden Boom 50% (T_8)	22.16	13.23	22.53	17.00	183.80	41.86	10.50	64.34
10	RDF 50% + VAM 50% (T_9)	22.43	13.00	23.26	16.50	193.00	41.23	10.40	65.00
11	FYM 50% + PSB 50% (T_{10})	22.10	12.91	22.86	17.16	185.10	41.36	10.56	64.66
12	FYM 50% + Garden Boom 50% (T_{11})	22.76	13.31	23.98	18.10	198.30	41.40	11.36	63.00
13	FYM 50%+ VAM 50% (T_1)	22.26	13.08	22.26	17.76	177.10	41.23	7.03	63.34
	SE(m)±	0.23	0.138	0.211	0.230	0.244	0.230	0.23	0.68
	S.D. at 5%	0.674	0.406	0.620	0.674	0.083	0.674	0.674	1.998

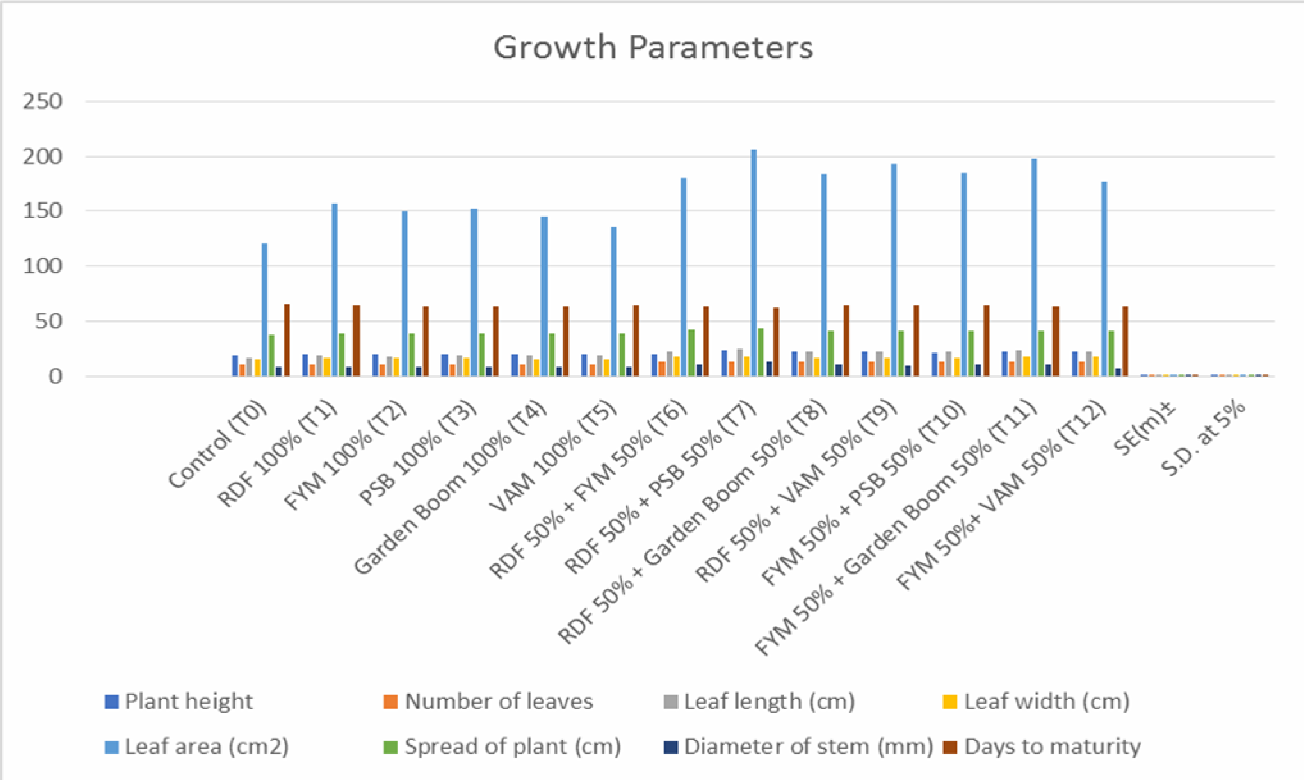

Fig. 1 : Explanation of Growth parameters

Conclusion

It may be fairly concluded, based on the above findings of the experiment, that the application of biofertilizers along with organic and inorganic fertilizers resulted in obtaining the highest plant height, number of leaves, leaf length, width of leaves, area of leaves, spread of plant, stem diameter, and days to maturity. This variation in plant growth is likely due to the influence of growth-promoting substances released by microbial inoculants, which enhance overall plant growth.

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