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Response of N, P, K and biofertilizers on growth and yield attributes of cabbage (*Brassica oleracea* var. capitata L.)

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Abstract
The present experiment was conducted during the *Rabi* season of the year 2020-2021 at Instructional cum Research Farm at S.G. College of Agriculture and Research Station, Jagdalpur (C.G.) to study the influence of N, P, K and biofertilizers on growth and yield attributes of Cabbage (*Brassica oleracea* var. capitata L.) consisting of seventeen treatments and replicated thrice in RBD. The results revealed that the application of 75% RDF + PSB + KSB recorded the maximum plant height (31.87 cm), leaf width (23.56 cm), leaf length, minimum days to head maturity (70.10), diameter of cabbage head (16.57) and yield ha^{-1} (381.60 q). However, the application of 75% RDF + *Azotobacter* + PSB) recorded the maximum (24.87) non-wrapper leaves in cabbage at harvest.

Keywords: Cabbage, biofertilizers, *Azotobacter*, PSB, KSB

Introduction
Cabbage (*Brassica oleracea* var. Capitata L.) belongs to the family Brassicaceae, is an herbaceous biennial plant that produces "heads" (Hague KMF 2006) [3] and it has short stem upon which is crowned with a mass of green leaves. It is commonly known as Band Gobhi or Patta Gobhi and varieties of the plant include the red, white and Savoy cabbages. The word "Cabbage" is derived from the French word "Coboche" means head. Its heads are used as salad, boiled vegetable and dehydrated vegetable as well as in cooked curries and pickles. Cabbage is an excellent source of vitamin C, potassium and calcium (Hasan and Solaiman, 2012) [4]. It has cooling effect and helps in preventing constipation, increase appetite, speed up digestion and very useful for the patients of diabetes (Yadav *et al*., 2000) [15]

Bio-fertilizers are also living cells of different types of micro-organisms (bacteria-algae and fungi) which are capable of mobilizing nutritive elements from non-usable from. Therefore, the current trend is of organic farming using organic fertilizers like bio-fertilizers of microbial origin with limited use of chemical fertilizers. 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, regarded as Plant Growth Promoting Rhizobacteria (PGPR) synthesize growth substances that greatly enhance plant growth and development and inhibit phytopathogenic growth by secreting inhibitors. There is a great importance of *A. chroococcum* in plant nutrition and its contribution to soil fertility. It is thus an important component of integrated nutrient management system (Wani *et al*., 2016) [14]. It fixes nearly 20 to 40 kg N ha^{-1}. PSB solubilizes insoluble fixed phosphates present in the soils. Its inoculation secretes acetic substances and solubilizes the otherwise unavailable insoluble soil phosphorus, thereby increasing the yield of crops by 10 to 30 percent (Devi *et al*., 2017) [2]. solubilizes insoluble fixed phosphates present in the soils. 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. It helps in uptakes of other elements like nitrogen, phosphorus and calcium etc.

Material and Methods
The present study was laid out in Randomized Block Design with seventeen treatments which were replicated thrice during the *Rabi* season of 2020-2021 at Instructional cum Research Farm at S.G. College of Agriculture and Research Station, Jagdalpur (C.G.).

The treatments consisted *viz*., 75% RDF + *Azotobacter* (T1),75% RDF + PSB (T2), 75% RDF + KSB (T3), 75% RDF + *Azotobacter*+ PSB (T4), 75% RDF + *Azotobacter* + KSB (T5), 75% RDF + PSB + KSB (T6), 75% RDF + *Azotobacter* + PSB + KSB (T7), 50% RDF + *Azotobacter* (T8), 50% RDF + PSB (T9), 50% RDF + KSB (T10), 50% RDF + *Azotobacter* + PSB (T11), 50% RDF + *Azotobacter* +KSB (T12), 50% RDF + PSB + KSB (T13), 50% RDF + *Azotobacter* + PSB + KSB (T14), *Azotobacter* + PSB + KSB (T15), 100% RDF (T16) and Control (T17).

The region has a sub-tropical monsoon climate with three distinct seasons i.e. summer, monsoon and winter. The southwest monsoon starts from June and continues till middle of September, winter season spreads from October to February whereas; summer season extends from March to middle of June. Rainfall is the major source of ground water recharge in the area and receives maximum (85%) rainfall during the southwest monsoon season. The winter rainfall is meagre (10 -15%). The land of the experimental site was irrigated prior to sowing for optimum moisture level. Seedlings were transplanted at a spacing of 60 x 45 cm. The recommended package and practice methods were followed during the experiment to maintain a healthy population of crop. The results of various observations recorded during the experiment were statistically analyzed in order to find out the significance of different treatments.

Result

The perusal of data revealed that fertilizers (N, P and K) along with biofertilizers alone or in combination were found to have significant effect on the growth, yield and qualitative characters of cabbage as compared to control (Table 1). The plant height of cabbage was recorded at 30, 45 and 60 days after transplanting and at harvest. The average plant height was recorded at the different treatments at 45, 60 DAT and at harvest. The maximum plant height (31.87 cm) of cabbage at harvest was recorded in treatment T7 (75% RDF + Azotobacter + PSB + KSB) which was statistically at par (31.37 and 31.07cm respectively) with the treatment T10 (50% RDF + KSB) and T6 (75% RDF + PSB + KSB). This might be attributed to the fact that higher fertility levels increase the photosynthetic capacity and auxin levels in the plant. The increase in plant growth induced by NPK may result in more assimilation of carbohydrates. These finding are in close agreement with those reported by Powar and Barkule (2017) [11] and Jaiswal *et al.* (2020) [5]. The leaf width of cabbage at harvest was recorded to be the highest (23.56 cm) in T7 (75% RDF + *Azotobacter* + PSB + KSB) which was at par (22.77, 22.47 and 22.23 cm respectively) with the treatments T13 (50% RDF + PSB + KSB), T6 (75% RDF + PSB + KSB) and T15 (*Azotobacter* + PSB + KSB). Higher vegetative growth of plant in case of microbe's application might be due to better growth and elongation of leaves. These results are in close consonance with the findings of Mohapatra *et al.* (2013) [8] and Negi *et al.* (2017) [10]. The leaf length significantly increased by the different doses of N, P, K and biofertilizers and was the maximum (26.43 cm) in treatment T6 (75% RDF + PSB + KSB) which was closely followed by the treatment T7 (75% RDF + *Azotobacter* + PSB + KSB) having a length of 25.37 cm. However; the minimum leaf length (13.20, 18.10, 20.40 and 22.97 cm respectively) at all the growth stages was observed in T17 (control). According to Negi *et al.* (2017) [10] and Powar & Barkule (2017) [11] the higher vegetative growth of plant might be due to better growth and elongation of leaves in case of microbe's application. The treatment T4 (75% RDF + *Azotobacter* + PSB) recorded the maximum (24.87) non-wrapper leaves in cabbage at harvest which was at par (23.60 and 22.63 respectively) with the treatment T5 (75% RDF + *Azotobacter* + KSB) and T9 (50% RDF + PSB). The increase in phosphorus content might be due to increased availability of soil phosphorus because of solubilizing effect of organic acids, which are produced from decomposing organic manures. Further, PSB helps in solubilizing the insoluble phosphorus into soluble form and also reduce the fixation of phosphorus, hence, the availability and the absorption of phosphate by the plant was more. The integrated approach was found to be superior and in agreement with the results by Choudhary *et al*. (2012) [1] and Sharma *et al.* (2014).

application of T7 (75% RDF + *Azotobacter* + PSB + KSB) recorded the minimum (70.10) number of days for head maturity. This might be due to the fact that biofertilizers acts as an important constituent of chlorophyll and protein, which ultimately results in early growth and development of heads. The findings are in agreement with Sharma *et al*. (2018) [12]. The maximum diameter of head (16.57 cm) in cabbage was recorded in the treatment T7 (75% RDF + *Azotobacter* + PSB +KSB). The increase in head diameter might be due to the combined use of fertilizers and biofertilizers that provided better nourishment to the plants which increased the growth parameters and ultimately increased the head diameter in cabbage Narayan *et al*. (2018) [9]. Application of 75% RDF + *Azotobacter* + PSB +KSB produced the maximum (381.60 q) yield ha^{-1} followed by 75% RDF + PSB + KSB and 50% RDF + *Azotobacter* + PSB + KSB with 359.51 and 334.05 q ha^{-1}.the head yield of cabbage increased by application of 75% RDF + *Azotobacter* + PSB +KSB over control (230.52 q ha^{-1}). Increased nitrogen level favoured the large uptake of nutrients and effective utilization of utilized nutrients for increased metabolism and and synthesis of carbohydrates, greater vegetative growth and subsequent partitioning and translocation from leaf (source) to the head (sink) and also release of energy rich organic compounds by biofertilizers which might have been increased auxin activities, growth and activity of microbial saprophytes and phosphates activity which ultimately influenced the yield and yield attributes. Kumari *et al.* (2015) [7], Kumar *et al.* (2017) [6] and Narayan *et al.* (2018) [9].

Table 1: Effect of various treatments on growth and yield of cabbage.

Treatment	Plant height (cm)				Leaf length (cm)	Leaf width (cm)	Number of non-wrapper leaves	Days taken to head maturity	Diameter of head (cm)	Yield (q. ha^{-1})
	30 DAT	45 DAT	60 DAT	At harvest						
T1 75% RDF + *Azotobacter*	20.9	24.9	27.9	28.5	74.67	20.6	21.23	74.67	13.60	290.36
T2 75% RDF + PSB	21.5	26.1	30.1	30.3	75.00	21.8	22.37	75.00	13.90	286.81
T3 75% RDF + KSB	21.8	26.9	29.3	29.6	75.33	21.4	21.50	75.33	13.77	297.83
T4 75% RDF + *Azotobacter*+ PSB	21.8	25.9	28.8	29.0	74.67	20.6	24.87	74.67	13.50	331.80
T5 75% RDF + *Azotobacter*+ KSB	22.3	23.4	28.4	28.8	76.57	21.0	23.60	76.57	13.37	277.42

T6 75% RDF + PSB + KSB	22.1	27.1	30.2	31.0	73.00	22.4	21.23	73.00	15.13	359.51
T7 75% RDF + *Azotobacter*+ PSB +KSB	22.5	28.1	31.7	31.8	70.10	23.5	21.10	70.10	16.57	381.60
T8 50% RDF + *Azotobacter*	22.0	23.7	29.8	30.0	76.00	21.1	20.93	76.00	14.07	279.99
T9 50% RDF + PSB	20.8	26.6	29.7	29.9	75.00	20.7	22.63	75.00	13.20	281.52
T10 50% RDF + KSB	21.4	25.7	28.3	31.3	76.13	21.4	20.93	76.13	13.93	258.63
T11 50% RDF + *Azotobacter* + PSB	22.3	27.2	29.5	29.7	78.20	19.7	19.73	78.20	13.20	280.80
T12 50% RDF + *Azotobacter* +KSB	21.7	26.5	29.4	27.2	77.00	21.4	20.20	77.00	13.17	272.95
T13 50% RDF + PSB + KSB	22.1	27.3	28.9	29.0	77.57	22.7	21.47	77.57	13.50	285.14
T14 50% RDF + *Azotobacter* + PSB + KSB	21.2	26.0	28.4	28.5	77.23	20.7	22.30	77.23	14.57	334.05
T15 *Azotobacter*+ PSB +KSB	20.8	25.1	29.9	30.4	80.67	22.2	20.20	80.67	12.20	264.01
T16 100% RDF	21.4	25.6	29.5	29.6	79.10	21.0	20.13	79.10	12.13	257.02
T17 Control	19.4	22.0	26.4	26.8	81.33	19.1	21.10	81.33	11.83	230.52
S.Em±	0.60	0.94	0.50	0.49	0.96	0.56	20.25	0.96	0.69	292.29
C.D. (P=0.05)	N/A	2.73	1.45	1.40	2.79	1.49	0.79	2.79	1.99	5.68

Conclusion

On the basis of the present investigation, it can be concluded that application of 75% RDF + *Azotobacter* + PSB + KSB significantly increase the plant height**,** leaf width, days taken to head maturity, and yield ha^{-1} .While; the maximum leaf length was recorded in the treatment 75% RDF + PSB + KSB and 75% RDF + *Azotobacter* + PSB recorded the maximum non-wrapper leaves. Thus, the study indicated that application of N: P: K and biofertilizers *viz*., *Azotobacter*, PSB and KSB in different combinations were efficient in improving the growth and yield attributes of cabbage.

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