Environment and Ecology 41 (2) : 877—882, April—June 2023
ISSN 0970-0420

Effect of Micronutrient, *Azotobacter*, *Azospirillum* and Chemical Fertilizers on Growth and Yield of Cabbage (*Brassica oleracea* var. Capitata L.) Under Bhubaneswar Agroclimatic Conditions

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Received 30 September 2022, Accepted 21 February 2023, Published on 27 May 2023

ABSTRACT

The present investigation "Effect of micronutrient, *Azotobacter*, *Azospirillum* and Chemical fertilizers on growth and yield of cabbage (*Brassica oleraceae* var. Capitata L.)" was carried out at Agriculture Research Station, Binjhagiri, Institute of Agricultural Sciences, BBSR, Odisha during 2020-21. The results revealed that the application of different levels of chemical fertilizers in combination with bio-fertilizers and micronutrients significantly increase the growth and yield of cabbage. Plants of cabbage gain maximum height when *Azotobacter* and *Azospirillum* was applied along with recommended dose of NPK. The findings recorded maximum head weight of cabbage when similar treatments were given. This was being statistically at par with recommended dose of fertilizer along with micronutrient application. Maximum number and fresh weight of non-wrapped leaf, stalk length, stalk diameter, spread of plant along with head diameter, length and weight is also influence by the application of *Azotobacter*, *Azospirillum* along with recommended dose of NPK. This treatment also helped in increasing the leaf length, breadth and leaf area of the cabbage plants. It was also recorded that application of *Azotobacter*, *Azospirillum* along with recommended dose of NPK was beneficial in improving the yield potential of the crop. It is thus concluded from the present investigation that 120 kg N, 100 kg P and 120 kg of k/ha along with *Azotobacter* and *Azospirillum* @ 4 kg/ha increases the growth attributes along with yield of the cabbage crop.

Keywords *Azotobacter*, Chemical fertilizers, Cabbage, Plant height, Head weight.

INTRODUCTION

Cabbage (*Brassica oleracea* var. Capitata) is one of the most widely grown throughout the world. It belongs to family Cruciferae which also includes cauliflower, broccoli and kale. Cabbage comes from the French word "coboche" which meaning "head". It is a popular vegetable all over the world in terms of area, production and availability and it is available virtually all the year round. It descends from the wild ancestor *Brassica oleracea* var. Oleracea L. (syn. sylvestris) also called as wild brassica. Cabbage is an excellent source of vitamin C, contains some B vitamins and supplies phosphorus and calcium to the diet. Cabbage is a cold season crop that can grow in a variety of soil and climates. The use of various

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Table 1. Various growth and yield parameters as influenced by micronutrients, *Azotobacter*, *Azospirillum* and chemical fertilizers (data taken on year 2021).

Treatment details	Plant height (cm)	No. of non-wrapped leaf	Fresh wt of non-wrapped leaf (g/plant)	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm^2)	Stalk length (cm)	Stalk diameter (cm)	Spread of plant (cm)	Head diameter (cm)	Head length (cm)	Head wt/single (kg)	Yield plot (kg)	Yield (q/ha)
T_1 (RDF@ 120:100: 120 kg NPK/ha)	18.81	14.71	113.86	23.00	23.41	281.09	8.94	3.47	233.18	42.96	14.07	1.57	34	27.49
T_2 (RDF+ micronutrient)	20.82	15.50	118.18	24.11	24.40	424.15	10	3.60	241.02	47.94	17.97	1.78	37.22	32.82
T_3 (RDF+ *Azospirillum* @ 4 kg/ha)	21.42	16.18	122.99	25.05	25.21	451.86	10.63	3.69	251.1	51.14	18.89	2.24	39.93	33.43
T_4 (RDF+ *Azotobacter* @ 4 kg/ha)	17.27	14.29	111.20	21.93	22.37	272.4	8.801	3.33	220.30	40.93	13.02	1.49	26.94	26.57
T_5 (RDF+ *Azotobacter* + *Azospirillum*)	24.97	17.28	131.26	26.01	26.82	520.14	1.26	4.03	278.92	54.10	19.92	2.45	42.06	41.24
T_6 (RDF+ *Azotobacter*+ *Azospirillum* +micronutrient)	20.70	14.89	117.81	24.07	24.22	342.08	9.39	3.52	239.18	44.94	15.97	1.75	33.85	29.85
SEm (±)	0.28	0.03	0.22	0.28	0.04	0.35	0.01	0.01	0.03	0.7	0.25	0.12	0.32	0.33
CD at 5%	0.86	0.10	0.68	0.85	0.13	1.08	0.04	0.04	0.91	1.12	0.75	0.36	0.98	1.01

biofertilizers, FYM and micronutrients is beneficial for the crop growth for Odisha condition as the crop is highly favored by the people of Odisha. It is also a very nutritious crop. Application of bio fertilizers and micronutrients helps in enhancing the quality and yield. Bio fertilizers boosted the fresh weight of the leaf, stem diameter, dry weight of the head and yield greatly (Bahadur *et al.* 2003). Application of biofertilizers and micronutrients on growth and yield of cabbage (*Brassica oleracea* var. Capitata) was carried out to investigate impact of biofertilizers, micronutrients and chemical fertilizers on growth and yield of cabbage in the agroclimatic conditions of Bhubaneswar.

MATERIALS AND METHODS

The present investigation is conducted to study the effect of micronutrients, *Azospirillum*, *Azotobacter* and chemical fertilizers on growth and yield of

cabbage (*Brassica oleracea* var. Capitata L.)" was carried out in form of a field trial at the Agricultural Research Station, Binjhagiri, Institute of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar during *rabi* season of 2020-21. The experiment was conducted on cabbage var. Royal Vantage. The experiment was laid out in RBD with 4 replications and 6 treatments (T_1- RDF @ 120:100:120 NPK kg/ha, T_2- RDF+ micronutrient, T_3- RDF+*Azospirillum* @ 4 kg/ha, T_4- RDF + *Azotobacter* @ 4 kg/ha, T_5- RDF + (*Azospirillum* + *Azotobacter*), T_6- RDF+ micronutrient+ (*Azotobacter* + *Azospirillum*). All the data concerning various growth and yield parameters were analyzed using statistical methods. The treatment effects were tested by 'F' test at 5% level of significance and the critical difference at 5% level was calculated for comparing treatment means.

RESULTS AND DISCUSSION

Plant height

It was observed that the maximum plant height was recorded with T_5 (24.97 cm) followed by T_3 (21.42 cm) and T_2 (20.82 cm). However, the lowest height was recorded with T_4 (17.27 cm) which was significantly inferior than all other treatment tried in this experiment (Table 1). The maximum plant height which was recorded in T_5 was significantly superior to all other treatments tried in this experiment. The combine application of NPK and Bio-fertilizers along with micronutrient have greatly influenced the plant height in cabbage crop. However, maximum height was recorded when 100% NPK was applied along with bio-fertilizers in cabbage crop. Application of bio-fertilizers might have attributed to sustain the supply of nutrient particularly in growth period. The findings corroborated with the findings of Md. Selim Reza *et al.* (2016) in cabbage and Sajana Devi *et al*. (2017) in cabbage.

No of non-wrapped leaf and fresh wt of non-wrapped leaf (g/plant)

It was found that maximum non wrapped leaves per plant was recorded in T_5 (17.28) which was significantly superior to rest of the treatments followed by T_3 (16.18) and T_2 (15.50). The lowest no. of non-wrapped leaves was recorded with T_4 (14.29) which was found to be statically inferior than other treatments (Table 1). The maximum fresh weight of non-wrapped leaf was recorded in T_5 (131.26 g per plant) which was significantly superior than other treatments tried in the experiment followed by T_3 (122.99 g/plant and T_2 (118.18 gm/plant). However, the fresh weight of non-wrapped leaf (g/plant) was minimum with T_4 (111.20 g/plant) which was statically inferior to rest of the treatments. The result revealed that number of non-wrapped leaf per plant was maximum due to the combined application of 100% NPK with bio-fertilizers. This clearly indicates that application of bio-fertilizers along with chemical fertilizers got a cumulative effect in association with nitrogen, enhancing its requirement as well as utilization by the crop. Chrolophyll pigment contains N which is the primary structural component of chlorophyll that helps in photosynthesis process. Production of non-wrapped leaves are influenced by more dry matter accumulation. The non-wrapped leaves are non-economical but contribute greatly to the process of photosynthesis. The findings corroborated with the findings of Bhagavantagoudra and Rokhade (2001) in cabbage, Choudhary and Choudhary (2005) in cabbage and Singh *et al.* (2020) in cabbage.

Leaf length (cm)

As per the analysis the maximum leaf length was recorded with T_5 (26.01 cm) followed by T_3 (25.05 cm) and T_2 (24.11 cm). However, the lowest leaf length was observed in T_4 (21.93 cm) which was statistically inferior than all other treatment tried in this experiment which is expressed in Table 1. The present investigation revealed that the combine application of 100% NPK and bio-fertilizers could influence significantly the leaf length than other treatments. Application of bio-fertilizers might have attributed to sustain the supply of nutrients particularly during growth period. Bio-fertilizers significantly influenced the parameters like leaf length which caused more photosynthetic reactions and attributed to physiological changes in plant on exposure to the action of growth promoting substance like auxin and gibberellins synthesized by inoculated micro organisms. It is also due to better mobilization of plant nutrients

particularly N and P during later stages of plant growth. These findings are in conformity with the view of Singh *et al.* (2009) and Vimala *et al.* (2002).

Leaf breadth (cm)

The mean breadth of leaves was found maximum with T_5 (26.82 cm). This was closely followed by T_3 (25.21 cm) and T_2 (24.40 cm) respectively. The least breadth of leaves was recorded in T_4 (22.37 cm) which was statically inferior than all other treatments tried in the experiment. Application of different levels of NPK in combination with bio-fertilizers enhanced the leaf breadth in an increasing order. Maximum leaf breadth was recorded with the application of 100% NPK along with bio-fertilizers which was significantly higher than other treatments. Bio-fertilizers help to increase leaf breadth which tends to increase in leaf area index resulting in more chlorophyll content by inoculated micro organisms. It might be due to efficient uptake of plant nutrients particularly N and P during later stages of plant growth. The findings corroborated with the findings of Singh *et al*. (2009) and Vimala *et al.* (2002).

Leaf area (cm^2)

According to the investigation maximum leaf area per plant recorded in T_5 (520.14 cm^2) which was significantly superior than other treatments followed by T_3 (451.86 cm^2) and T_2 (424.15 cm^2). The lowest leaf area per plant was observed in T_4 (272.4 cm^2) which was statistically inferior than other treatments (Table 1). The result revealed that leaf area was maximum due to the combine application of 100% NPK with bio-fertilizers. This clearly indicates that application of bio-fertilizers along with chemical fertilizers got a cumulative effect in association with nitrogen enhancing its requirement as well as utilization by the crop. The increase in leaf area might be due to increment in leaf length and leaf breadth with the beneficial effect of bio-fertilizers and inorganic fertilizers as they enhanced the rate of photosynthesis thereby accelerating the vegetative growth. These findings are in line with Bambal *et al.* (1998), Bhagavantagoudra and Rokhade (2001) in cauliflower, Bahadur *et al.* (2004), Gupta and Samnotra (2004) in cabbage, Vivek *et al.* (2001) in potato.

Stalk length (cm)

The stalk length was maximum in T_5 (11.26 cm) followed by T_3 (10.63 cm) and T_2 (10.01 cm). However, the lowest stalk length was recorded in T_4 (8.80 cm) which was statistically inferior than all other treatments tried in this trial and observed data are as follows in Table 1. The combine effect of 100% NPK and bio fertilizers significantly influences the stalk length of cabbage. The availability of nutrients in case of the combination of all the sources appears to be more adequate, thereby influencing the stalk length. The maximum stalk length was observed by applying 100% NPK and bio-fertilizer which may be due to the fact that nitrogen can be found in amino acids, nucleotides, nucleic acids, and in a no. of co-enzymes. Increase in nitrogenous compounds helps in cell elongation, cell enlargement and cell division which ultimately increases the plant height. It could be because of more availability of nitrogenous compounds to the plant from both organic and inorganic sources which ultimately increases the foliage of the plant or the number of leaves. These findings are in conformity with the view of Chaurasia *et al*. (2008) in cauliflower and Singh *et al*. (2019) in cabbage.

Stalk diameter (cm)

Trial revealed that maximum stalk diameter was recorded in T_5 (4.03 cm) followed by T_3 (3.69 cm) and T_2 (3.60 cm). The lowest was recorded with T_4 (3.33 cm) as it was inferior to rest of the treatment tried in the experiment (Table 1). The present investigation revealed that the combine application of 100% NPK and bio-fertilizers could influence significantly the stalk diameters than other treatment. Application of bio-fertilizer might have attributed to sustain the supply of nutrient particularly during growth period. The increase in stalk diameter as compare to other treatment might be due to the enhancement of the soil condition provided for plant growth and also due to increasing availability of nutrient especially NPK from the early stages of the crop. Regular supply of nutrients helps to regulate various biochemical processes in the plant system. The numerous compounds which participate in the dry matter production and portioning contain mineral elements. The sufficient supply of nutrients helps in photosynthesis and pro-

duction of more photosynthates helps in more growth which leads to increase in the stalk diameter. These results are in confirmation with the findings of Singh *et al.* (2009) in cauliflower and Singh *et al.* (2020) in cabbage.

Spread of plant (cm)

Maximum spread of plant was measured with T_5 (278.92 cm) followed by T_3 (251.1 cm) and T_2 (241.02 cm). The lowest spread of plant was observed with T_4 (220.30 cm) which was statistically inferior than all other treatments and the datas are presented in below Table 1. The result showed that spread of plant was maximum due to the combined application of 100% NPK with bio-fertilizers. This clearly indicates that application of bio-fertilizers along with chemical fertilizers got a cumulative effect in association with nitrogen enhancing its requirement as well as utilization by the crop. The accelerated plant spread is due to combined effect of bio-fertilizers which made the unavailable form of nutrients to available form at critical stages of crop growth. The combined effect of organic manures / bio-inoculant might have supplemented the cause with their ability to increase the photosynthesis process and secretion of growth promoting substances like IAA, GA, Kinetin and thiamine, which can result in better crop growth. These findings are in line with Kumar *et al.* (2013), Bhagavantagoudra and Rokhade (2001) in cabbage.

Head diameter (cm) and head length (cm)

Experiment revealed that maximum head diameter was observed in T_5 (54.10 cm) which was significantly higher than other treatments followed by T_3 (51.14 cm) and T_2 (47.94 cm). However, minimum value was recorded in T_4 (40.95 cm) which was statically inferior than all other treatments in this trial (Table 1). Among the different treatments tried, maximum head length was observed in T_5 (19.92 cm) followed by T_3 (18.89 cm) and T_2 (17.97 cm). The lowest head length was recorded in T_4 (13.02 cm) as it was statistically inferior to rest of the treatments tried in the experiment. The combine effect of 100% NPK and bio-fertilizers significantly influences the head diameter and head length of cabbage. The availability of nutrients in case of the combination of all the sources appear to be more adequate, thereby influencing the diameter and length of head. More vegetative growth might have helped in more photosynthesis which leads to synthesis of more amount of food material which was later translocated into the developing part i.e., head resulting in increased diameter and length. These findings are in conformity with the view of Lal and Kanauja (2013) in capsicum and Kulwinder Singh *et al.* (2019) in cabbage.

Head weight/single (kg)

The data presented in Table 1 which are obtained from analysis indicates maximum wt/head was recorded in T_5 (2.45 kg) followed by T_3 (2.24 kg) which was also remains at par but significantly differed with other treatments. The lowest weight was recorded with T_4 (1.49 kg) which was statistically inferior than other treatments. The present investigation revealed that the combine application of 100% NPK and bio-fertilizers could influence significantly the single weight than other treatments. Application of bio-fertilizers might have attributed to sustain the supply of nutrients particularly during growth period. The increase in head weight as compare to other treatment might be due to the appropriate soil condition provided for crop growth and also due to increasing availability of nutrient especially NPK from the early stages of the crop. These results are in conformation with the findings of Singh *et al.* (2015) in cabbage and Singh *et al.* (2011) in cabbage.

Yield / plot (kg) and yield (q/ha)

Maximum head yield/plot was recorded in T_5 (42.06 kg) followed by T_3 (39.95 kg) and T_2 (37.22 kg). However, the lowest yield /plot was recorded with T_4 (26.94 kg) which was statistically inferior than other treatment (Table 1). The highest yield (q/ha) was recorded in T_5 (41.24 q/ha) followed by T_3 (33.43 q/ha) and T_2 (32.82 q/ha) but which differ significantly with other treatments. The lowest value was recorded in T_4 (26.57 q/ha) which was significantly inferior to other treatments. Application of different levels of NPK in combination with bio fertilizers enhanced the yield of heads in an increasing order. Maximum yield was observed with the application of 100% NPK along with bio-fertilizers which was significantly higher

than other treatments. The enhancement in yield and yield components due to the application of RDF along with bio-fertilizers can be attributed to the release of bioactive compounds having similar effect as that of growth regulators. The findings corroborated with the findings of Shree *et al.* (2014) in cauliflower and Singh *et al.* (2019) in cabbage.

CONCLUSION

On the basis of the results obtained from the present investigation, it may be concluded that the application of NPK along with *Azotobacter*, *Azospirillum* enhance the growth, yield attributes as well as yield in cabbage. In this trial it was found that Integrated Nutrient Management (INM) system has the capacity to enhance the yield without hampering the soil quality and environmental health. Integrated Nutrient Management (INM) ensures more economic return along with better quality of the produce. So NPK (120:100:120 kg/ha) + *Azotobacter* @ 4 kg/ha + *Azospirillum* @ 4 kg/ha can be recommended for higher yield and return in cabbage cultivation under Bhubaneswar Agro-Climatic Zone, Odisha.

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