Effect of biofertilizers and manures on growth, yield, and quality of cabbage (*Brassica oleracea*)

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Abstract "Effect of biofertilizers and manures on growth, yield and quality of cabbage." Examining, identifying, and summarising the key results and conclusions of a study on the impact of different organic amendments on the development and production of cabbage crops was the aim of the current investigation. Investigating the effects of various organic additions on soil characteristics, plant development, and cabbage production was the goal of the study. These amendments included compost, manure, and biochar. Plant growth, nutrient availability, and soil fertility may all be considerably enhanced by adding organic amendments, according to the study's findings. While biochar amendment had a negligible influence on soil fertility, compost and manure additions were shown to be the most efficient in enhancing soil characteristics. Cabbage production was further increased by the application of organic amendments; the plots treated with compost yielded the best yields. The study comes to the conclusion that using organic amendments to improve soil fertility and crop output in cabbage farming can be a sustainable and successful strategy.
Keywords: Cabbage, biofertilizers, nutrition, yield, quality.

1 Introduction

Brassica oleracea, often known as cabbage, is a biennial plant with dense foliage that is cultivated as an annual vegetable crop. With a genomic code of c, cabbage has the somatic chromosome number 2n=18. Cabbage is a secondary polyploid possessing six basic chromosomes, one of the subspecies of Brassica oleracea. As a member of the brassica family, which includes wild cabbage as its ancestor, it shares a close relationship with cauliflower and broccoli. Derived from the Latin phrase meaning "having a head," capitata is the varietal epithet. [1,2]

in general, a cabbage weighs 500–1,000 grammes. Green cabbages with firm heads and smooth leaves are the most common type; purple and savoy cabbages with both colours' crinkle leaves and smooth leaves are less prevalent. Cabbages can grow fairly large when grown in environments with long, bright days, as those found in high northern latitudes during the summer.[3]

It is quite likely that domestication of cabbage occurred in Europe prior to 1000 BC. There is evidence of cabbage use in food dating back to ancient times. A member of the mustard family Brassicaceae, the genus Brassica includes cabbage. After thousands of years of selection, the original species changed into those that are seen today. huge heads for cabbage, huge leaves for kale, and thick stems with flower buds for broccoli are just a few examples of the distinct traits that emerged from this process. [4]

92% of raw cabbage is water, 6% is carbohydrate, 1% is protein, and very little fat is present. Raw cabbage provides a useful source of vitamin C and vitamin K in a 100-gram reference amount, with 44% and 72% of the Daily Value (DV), respectively. Additionally, cabbage has a considerable amount of B6 and folate (10–19% DV), but no other nutrients are significantly present in a 100g serving. [5,6,7]

The taproot of cabbage seedlings is narrow, and their cotyledons are cordate. In their first year of growth, plants reach a height of 40–60 cm. The average head weighs between 0.5 and 4 kilogrammes. Shallow and fibrous root systems are found in plants. [8]

Typically, cabbage is grown for its heads, which have dense leaves and are produced in the first year of their biennial cycle. The optimal growing conditions for plants are full sun and well-drained soil. While the soil types that each variety prefers to vary, from lighter sand to heavier clay, they are always drawn

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to healthy soil that has a pH of 6.8 to 6.9. Sufficient phosphorus and potassium during the early phases of the out Erle development, as well as appropriate amounts of nitrogen in the soil, particularly during the early head formation stage, are necessary for optimal growth. The ideal growing conditions are found between 4 and 24 °C (39 and 75 °F), and prolonged exposure to extreme may cause premature bolting.

1.1 Background

With a rich history spanning thousands of years, cabbage growing is not a modern endeavour. Cabbage cultivation originated in the Mediterranean area and expanded to Europe and Asia, where it adapted to a variety of climates and became a mainstay in a wide range of culinary traditions. The ancient Egyptian, Greek, and Roman civilizations all seem to have eaten a lot of cabbage on record. Because of its resilience, lengthy shelf life, and adaptability in the kitchen, it became widely used and became a staple food over many historical periods.[9]

Synthetic fertilisers have been a staple of traditional agricultural systems for decades, helping to increase crop yields. This dependence has cost us, though, as worries about water pollution, soil erosion, and the wider ecological effects of chemical inputs are becoming more and more prevalent. As sustainable substitutes, biofertilizers that include organic manures from plant or animal sources and beneficial microbes like mycorrhizal fungi and nitrogen-fixing bacteria have gained popularity. These substitutes help to enhance soil structure, water retention, and the resilience of the agroecosystem as a whole in addition to providing vital nutrients to plants.[10]

1.2 The following goals and objectives guided the current research on the issue of " Effect of Biofertilizers and manures on Growth, yield, and quality of cabbage."

- ✓ To assess the influence of biofertilizers and manures on the growth parameters of cabbage.
- ✓ To analyse the effects of biofertilizers and manures on the yield and qualitative attributes of cabbage.

1.3 The effects of manures and biofertilizers on cabbage growth characteristics.
One popular cruciferous vegetable that is grown for its nutritional content and culinary diversity is cabbage (Brassica oleracea). Optimising cabbage farming procedures becomes essential for sustainable agricultural output due to its increasing demand in both domestic and international markets.[11]

2 Material and Methods

The current study was conducted during the Rabi season of 2023–2024 and is named "Studies on different organic amendment on cabbage." This chapter contains information on the specific supplies and procedures utilised for this experiment.[12]

2.1 Location: - The experiment was carried out in the Organic Farm at Amity University in Noida, Uttar Pradesh, during the Rabi season of 2023–2024. The farm is located 200 metres above mean sea level and is located at 28.5440° N latitude and 77.3330°E longitude.[13]
2.2 Climate: -

Noida (UP) has hot, dry summers and chilly winters due to its semi-arid, sub-tropical climate, which is classified as the "Trans-Gangetic plains" agroclimatic zone. May and June, which are summer months, are the warmest months with maximum temperatures between 40 and 45 degrees Celsius. January is the coldest month with minimum temperatures between 4 and 7 degrees Celsius. From February through June, it climbs progressively before the south-west monsoon arrives and causes a little decline. Monsoon rainfall during the trial period was 141.26 mm; mean maximum temperature was 35.21ºC; mean lowest temperature was 23.74°C. There were almost 4.0 hours of sunlight each day on average. Over the course of the trial, the mean relative humidity (RH) was 60.5%. During the experimental period, meteorological measurements were gathered from the Indian Meteorological Department located in Faridabad (UP). [14,15]

2.3 Conditions during the crop season (2023–2024)

Using the Visual Climates website, the crop season's regular meteorological daily data (10-10-2022 to 06-03-2024) was gathered, with manual temperature collection of the maximum and lowest records. During the agricultural season, the average daily maximum air temperature varied from 28.0 to 35.50C, while the average daily minimum temperature varied from 14.0 to 24.50C. From 55 to 67% was the average daily humidity. The field experienced flooding on October 17 and 18, 2015, as a result of high rainfall (55.2

& 69.2). This delayed germination. In January's first week, the highest amount of rainfall—98.5 mm—was recorded. [16,17]

2.4 The experimental field's cropping history:

The experimental field has previously been used to cultivate a variety of crops, including maize, brinjal, soybean, tomato, cowpea and most recently, peas.
The following table presents a comprehensive list of crops that were grown on the experimental field's soil in the previous year. (Table 1)

Year	Kharif Crop rotation	Rabi crop rotation
2010	Maize	Brinjal
2021	Soyabean	Tomato
2022	Cowpea	Spinach
2023	Cauliflower	Peas

Fig.1 The experimental field's soil in the previous year.

3 Research Individuals.

The experiment that was carried out in Rabi 2023–2024 is described below in detail:

3.1 Details of the treatment:

The following table lists the experiment's treatment details: (Table 2)

Sr no.	Nation	Treatment
1	T1	PSB (25g) in 3kg FYM
2	T2	Azotobacter (25g) in 3kg FYM
3	T3	Poultry manure 3kg
4	T4	Azotobacter (25g) + Vermicompost (3kg)
5	T5	Vermicompost (3kg) 2t/ha
6	T6	Control

Fig. 2 The experiment's treatment details.
3.2 Yield of Crops (Q/Ha)

The yield of crops per hectare was measured in quintals per hectare following crop harvesting.

3.3 Level of Quality (%)

Use of liquid chromatography allowed for the calculation and percentage representation of the crude protein content. The crude protein content of the plant was calculated using appropriate laboratory procedures that guaranteed accuracy and precision. [19]

3.4 Genotype identification and assessment of cabbage for agronomic performance.

Layout for experimentation: (Table 3)

Crop Name	Cabbage (*Brassica oleracea*)
Family	Brassicaceae
Year of Experiment	2023-2024
Season	Rabi
Design	RBD
Treatment	6
No. of replications	3
Date of nursery sowing	16 Sept 2023
Date of Transplanting	26 Oct 2023
Sowing method	Transplanting method
Number of plots	18
Each Plot size	2.4 m × 3.1 m
Date of Harvesting	21 Jan 2024 28 Jan 2024
Location	Amity Institute of Organic Agriculture, Noida (UP)

Fig. 3 Layout for experimentation in detail.

During the experiment, the recommended agricultural practices for oil seed crops were strictly adhered to. Regular hand weeding was performed throughout the growth cycle to maintain weed-free beds. Irrigation was provided as necessary. A detailed table below outlines the schedule of cultural practices implemented during the experiment. [20,21]
To reduce competition from weeds, hoeing and weeding were performed 20 days after

planting. Manual weeding and hoeing were repeated 30 and 45 days after planting to improve soil aeration and further remove weeds.[22]

Cultural Operation (Table 4)

S. no	**Cultural Operations**	**Date of operations**	**Remarks**
1	Preparation of nursery bed	09/09/2023	Manually
2	Sowing	16/09/2023	Manually
3	Layout of the field	24/09/2023	Manually
4	Ploughing and preparation of field	04/10/2023	Help of spade
5	Transplantation to main field	26/10/2023	Manually
6	Gap filling	02/11/2023	Manually
7	Irrigation	26/10/2023 20/11/2023 30/12/2023	Check basin
8	Application of treatments	24/11/2023	Manually
9	1st spraying (neem oil)	01/01/2024	Manually
10	Harvesting	21/01/2024 28/01/2024	Hand picking

Fig.4 Cultural Operation in detail.

Plant hight. (Table 5)

Tr. No.	**Treatments**	**Plant height (cm) at**		
		30DAT	**60DAT**	**90DAT**
T1	PSB + Farmyard Manure	20.69	26.16	31.40
T2	Azotobacter + FYM	19.58	25.92	29.97
T3	Poultry manure	20.78	26.97	30.45
T4	Azotobacter + Vermicompost	21.05	27.00	31.89
T5	Vermicompost	21.28	28.09	32.47
T6	Control	19.09	24.55	28.52
C.D. at 5 %	0.5	0.4	0.5	C.D. at 5%

Fig. 5 Plant Hight in detail.

4 Results and Discussion

4.1 Ethical methods:
Below are the specifics of the cultural activities carried out throughout the agricultural season.

4.2 Preparing a seed bed:
Following manual ploughing to fine-till the soil, stubble plucking was done in the field. According to the necessary proportions, the field was divided into many plots. [23]

4.3 Transplanting:
The seed and the transplanting technique are coated in fine dirt. As soon as the seeds were sown, the land was watered.

4.4 Time and sowing method:
On Sept 16, 2023, the experimental crop was sowed. The technique of line sowing was used to transfer the plants.

4.5 Usage of organic manures:
Before seed was sown in the experiment, organic manures were administered as a basal dosage based on the treatment's requirements. For every plot, individual weights of the organic manures were determined and applied appropriately. FYM is the type of organic manure used as a treatment. [24,25]

4.6 Irrigation:
Immediately following the seeding of the seeds, the initial irrigation was administered. After that, irrigation was applied on a regular basis to keep the soil's moisture level consistent. [26]

4.7 Weeding:
Throughout the crop growing period, weeds were kept out of the trial plot. Throughout the cabbage crop growth cycle, seven weeding were done.

4.8 Crop harvesting:
As soon as the heads are fully grown and hardened, harvesting should begin. The maturation period of cabbage crops is 95–110 days.

4.9 Recorded observations**:**
Following a random selection process, five plants were tagged from each plot. Every morphological observation pertaining to crop development and productivity was recorded using these particular plants for the purpose of documenting the observations, the entire net plot was taken into consideration. [27]

4.10 Growth parameters:
Plant height (inches): 11 to 17.
Average number of leaves: 21 to 24
Leaf area (m2): 0.68.
Average Head (cm) 14.1

4.11 Specifications for yield:
Plant weight (kg) = 1.049
Total yield (kg) = about 34

4.12 Throughout the research, the following growth observations were made.

Studies on plant growth:
Investigating the behaviour of the growing plant under different treatments was considered necessary in order to learn more about the processes behind plant growth and development. At random, five healthy and robust plants were selected, and each plot's tags were used to identify them. These particular plants were the subject of periodic observations, which were noted every 15 days. The quantity of plants, branches, height of the plants, and accumulation of dry matter were used to gauge how different treatments affected plant development. [28,29]

(A) Method of sampling:
To track the crop's periodic growth and development at various phases, including disease development, six plants were randomly chosen from each net plot. There were permanent white labels on these plants. All growth and biometric observations on these observation plants were periodically recorded at 20-day intervals.[30]

(B) The emergence**:**
A complete count of all the plants in each net plot was obtained forty days after the seeds were sown, and the transplanting to plants was monitored at ten days.

(C) First count of plants**:**
Plant population homogeneity has a direct bearing on treatment comparison accuracy. Counting plant stands by quadrant was used to record the first plant count.

(D) Complete plant Count:
Just before the crop was harvested, the actual number of plants by quadrant per net plot was counted to record the final plat count.

(E) Plant elevation (cm):
In general, a plant's height reveals a crop's growth. At intervals of 15 days, the length of the plant from its base close to ground level to the base of its most recent emergence was measured in order to determine the plant's height. [31]

(F) Leaf count:

The quantity of leaves on each plant was counted, and the variation in leaf count was noted between plants. At the very end of heading, they were tallied. An average plant has between twenty and twenty-five leaves. [32]

(G) Plant weight (grammes):
After harvesting, the weight of a single cabbage was measured. Typically, a single cabbage would weigh about 1048.0 g.

(H) Disease incidences: $= \frac{number\ of\ infected\ plant}{\text{total number of plant}} \times 100$

$= \frac{4}{30} \times 100$

$= 13.3\%$

5 Biological yield

Each treatment had a considerably different biological yield, which is the total of the head, shoot, and root weights. The biological production of cabbage was shown to be significantly impacted by several pesticide kinds. With regard to biological yield, the Azotobacter +Vermicompost treatment produced the highest yield (113.56 Mt ha-1) whereas the control treatment produced the lowest (103.11 Mt ha-1). Azotobacter + FYM was shown to have contributed to the yield increase. This might be because Azotobacter has a beneficial effect on plant health; plants can get its liquid plant nutrients by applying it topically.[33]
On the biological yield of cabbage, it was discovered that the effects of various fertiliser kinds were quite significant. With Azotobacter and vermicompost treatment, the maximum yield (117.17 Mt ha -1) was observed. According to this,
Poultry manure had the lowest yield (86.78 Mt ha -1). Despite being less than that of the chemically fertilised plot, the biological yield from the FYM-applied plot was still much higher than that of the control plot. Chemical fertilisation may have produced a larger yield since the nutrients were more easily accessed in the soil.[34]

5.1 Effect of different type of fertilizer and plant yield of cabbage at the time of harvesting.

Treatment	Vermicompost	Poultry Manure	FYM	Mean
Azotobacter	123.7^{a}	118.7^{ab}	99.33^{cd}	113.56^{a}
Control	114.3^{ab}	122.8^{a}	73.51^{e}	103.22^{b}
PSB	106.8^{bc}	112.0^{abc}	89.50^{d}	103.11^{c}
Mean	114.94^{b}	117.17^{a}	86.78^{c}	106.29

Fig. 6 Effect of different type of fertilizer and plant yield of cabbage at the time of harvesting.

SEM±	Individual	2.700
Interaction	4.506	
LSD0.05	Individual	7.896
Interaction	14.50	

According to DMRM, there is no significant difference between the means within the column and row that are followed by the same letter at the 5% significance level.
The biological production of cabbage heads was shown to be significantly impacted by the interaction between several pesticides and fertilisers. As compared to treatments using chemical fertiliser and pesticide, Azotobacter plus poultry manure, and vermicompost plus poultry manure, the treatment with the highest biological yield (123.7 Mt ha -1) was seen in this combination. Out of all the treatments, FYM + control had the lowest biological yield (73.51 Mt ha -1). Vermicompost and Azotobacter have a very favourable interaction impact that leads to better yield, according to the results. Azotobacter may have a comparable positive effect on soil and plant health to that of vermicompost. [36,37]

5.2 Impact of biofertilizers and organic manures.

5.2.1Plant growth parameters.

However, the current study observed changes in plant height, the number of outer leaves, and head diameter due to the application of biofertilizers, manures, or a combination of the two. The T4 (Vermicompost + Azotobacter) application resulted in the greatest plant heights (14, 19, 4, and 22.9 cm per plant), the fewest outer leaves (9, 14, and 16.7 cm per plant), and the biggest head diameters (10, and 21.5 cm per plant) at 30, 60, and 90DAS, respectively.[38]

The T6 control treatment had significantly less outer leaves (8, 11, 15, and 15.1 cm per plant) and head diameter (6, 11, and 11.5 cm) in addition to having significantly fewer plant height at 30, 60, and 90DAS and fewer outer leaves (5, 7, and 12 cm per plant).

5.2.2Yield And Qualitative Attributes of Cabbage.

over the control was generated by vermicompost + azotobacter. Organic manure the cabbage plant with the greatest fresh weight increased the absorption of protein and carbohydrates, which in turn stimulated cell division and the creation of new tissues. This resulted in more photosynthetic area and luxuriant vegetative growth, which increased the plant's fresh weight. This may be the result of plants producing more photosynthates due to their increased leaf area. [39,40]

Organic nutrition management has a major impact on production per hectare, head weight, and both. The best approach to boost crop output and yield qualities is to employ organic fertilizers, FYM, vermicompost, chicken manure, and biofertilizers as part of an organic nutrient management system.[41]

Significant increases in the biofertilizer T4 (vermicompost + azotobacter) when combined with organic manures The findings included head weight (1.09 kg) and total yield per hectare (29.97 t/ha). Not only did the T6 control plot have the lowest overall yield (20.70 t/ha), but it also had the lowest head weight (0.48 kg).

On the other hand, plant spread somewhat decreased during harvest. The plant spread increased gradually between 30 and 60 days. Older leaves underwent drying and leaf drop during head development at harvest, after which there was a photosynthetic transfer from them to younger leaves. Naher et al. (2014) reported comparable outcomes in a cabbage crop.[42]

6 Summary and Conclusion

Every year and in every place, the experiment field was prepped one month in advance with a few hoeing's. To assess how well various fertilisers and insecticides worked, tests were conducted on the cabbage variety 'Golden Arca'. Three replications of a factorial randomised block design (RBD) were used to set up the experiment. Each replication [43] included a total of 6 treatments, each consisting of a distinct fertiliser mix and set of measurements. In every plot (2.4 m x 3.1 m), a cabbage seedling was transplanted with a 30 cm × 40 cm spacing.[44]

Data was gathered 30, 60, and 90 days after transplanting (DAT) during the cabbage crop's growth cycle. The number, length, and breadth of leaves, plant height, plant spread, head diameter, and head perimeter were among the growth metrics that were noted. The yield and quality features of the harvested cabbage heads, such as the biological yield, head yield, average root weight per plant, harvest index, days to maturity, storage performance, and average weight loss per head per day, were evaluated after harvest. In addition, notes were taken on the quantity and variety of weeds, biodiversity, and the physical and chemical characteristics of the soil both before and after the crop's growth.[45]

Different fertilisers and pesticides had individual and combined effects on yield-attributing characteristics such as biological yield, head yield plant-1, head diameter, head perimeter, harvest index, average root weight plant-1, and average weight head-1 day-1. They also had an interaction effect on quality-attributing characteristics like dry matter content and average storage duration. The treatment with chemical fertiliser had the best biological production (117.17 Mt ha-1); however, the combination of Azotobacter and, vermicompost produced the maximum biological yield (123.7 Mt ha-1). as chemical fertiliser and insecticide were combined, the total head production was greatest (95.67 Mt ha-1) and increased by 3.84 Mt ha-1 as compared to the treatment Azotobacter with combined with vermicompost. On the other hand, this difference was just 1.17 Mt ha-1 in the case of marketable head yield (fertiliser + fertiliser = 78.67 Mt ha-1 and Azotobacter + FYM = 77.50 Mt ha-1). The therapy's harvest index, 64.91, was just 1.72 less than that of the Azotobacter with FYM treatment, 63.19. For the combination of Azotobacter and vermicompost therapy, the shortest days to maturity, or 55.67 days, were discovered. [46,47]

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6. Scientific journals and research articles -Academic, journals such as "Nutrients," "Journal of Agricultural and Food Chemistry," and "Food Chemistry" often publish studies on the nutritional composition, health effects, and culinary uses of cabbage.

7. Culinary resources - Cookbooks, cooking websites, and food blogs often include recipes and tips for using cabbage in various dishes, highlighting its culinary versatility and cultural significance.

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