
Research Article

Evaluation of different organic and inorganic fertilizer combinations on the growth and yield of cabbage

Dipak Aryal, Asmita Tamang*, Rishikesh Gharti Magar

Institute of Agriculture and Animal Science (IAAS), Gauradaha, Jhapa, Nepal

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*Corresponding author:

E-mail:

asmitatamang805@gmail.com

Abstract

Cabbage (*Brassica oleracea* var. *capitata*) is the most important winter leafy vegetable in the world and belongs to the Cruciferae family. An experiment was conducted at the Horticultural farm of Gauradaha Agriculture Campus, Tribhuvan University, Jhapa, Nepal from 26th December 2022 to 2nd April 2023 to evaluate the different organic and inorganic fertilizer combinations on the growth and yield of cabbage (*Brassica oleracea* var. *capitata* L. cv. Green coronet). The experiment was conducted as a randomized block design with 7 treatments replicated 3 times and the treatments are T1: 25-ton FYM/ha, T2: 25-ton PM/ha, T3: 25-ton FYM/ha + NPK (RDF), T4: 25-ton PM/ha + NPK (RDF), T5: 20-ton FYM/ha + 10-ton PM/ha + NPK (RDF), T6: 10-ton FYM/ha + 20-ton PM/ha + NPK (RDF) and T7: control. Significant variation was found among the treatments. The result showed treatment had a significant role in different parameters. T3- The highest number of leaves, T5- the highest (leaf area, weight with roots, net head yield, horizontal head diameter), T4-highest (plant height, gross yield), T6- highest (stem girth, vertical head diameter) was obtained. On the result basis T5 (20-ton FYM/ha + 10-ton PM/ha + NPK (RDF)) can be adopted as sustainable crop production. This study not only provides valuable insights into optimizing cabbage production but also underscores the importance of tailored fertilizer combinations for sustainable agriculture. Furthermore, the findings contribute to the broader discourse on enhancing crop yield while minimizing environmental impact. By elucidating the efficacy of specific fertilizer blends, this research paves the way for more efficient and eco-friendly farming practices, thereby promoting food security and environmental sustainability on a global scale.

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1. Introduction

Cabbage (*Brassica oleracea* var *capitata*) is considered an important cool season leafy vegetable it belongs to the Cruciferae family and it is supposed to be originated in Western Europe (Chaudhary et al., 2018). It is an herbaceous, biennial, dicotyledonous flowering plant with a short stem crowned with a mass of leaves, often green, which when matured, form a distinctive compact and globular cluster (cabbage head) (SMR et al., 2022). Being a good source of vitamins (A, C, and K), fiber, proteins, and strong anti-cancer properties owing to the presence of "Inole-3-carbinol," cabbage is mostly consumed as a raw but also as a cooked vegetable (GAHATRAJ et al., 2019).

Inorganic fertilizers become costlier (Snr et al., 2020). They need to be replaced by organic sources. Nutrients play a crucial role in crop growth and yield (Hassan et al., 2018). Plants require 17 elements for their proper growth and development. Nitrogen (N), Phosphorous (P), Potassium (K), Calcium (Ca), Magnesium (Mg), and Sulphur (S) are considered macro-nutrients and are required in higher amounts while Iron (Fe), Copper (Cu), Zinc (Zn), Boron (B), Molybdenum (Mo), Chlorine (Cl), and Manganese (Mn) are micro-nutrients and are required in less amount (N & Saju, 2018). Organic fertilizer enhanced water holding capacity, nutrient availability, crop yields, shape, aroma, and quality of crops (Timsina, 2018). Despite these immense benefits, crops treated with organic fertilizer yield 20% less than that inorganic fertilizer-treated crops (Ramesh et al., 2020; Santhoshkumar, 2017).

Cabbage has its origins in Europe and has subsequently expanded its presence to Asia and the Americas. It now accounts for a significant portion of the world vegetable market. Where, Asia produced more than three-fourths of the world's vegetable production in 2020, with cabbage placing fourth (Adhikari et al., 2023). According to the Ministry of Agriculture and Livestock Development of Nepal, cabbage is cultivated in an area of 29,638ha and its production of 494,053Mt with an average yield is 16.67Mt/Ha (Ministry of Agriculture and Livestock Development, 2021) Cabbage grows well in cool, moist climates and is extremely hardy to frost. Well-hardened seedlings can withstand temperatures between 20° and 25° Fahrenheit. Generally, cabbage is considered a winter-season crop and it prefers a cool climate (Shrestha, 2019). it prefers pH range of soil between 5.5 to 6.5 (Alemayehu et al., 2021). Organic and inorganic nutrients significantly affect the growth and productivity of crops It is commonly known that using inorganic fertilizer on crops has negative health effects due to its long-term effects, while organic fertilizer avoids this issue while also improving soil productivity, crop quality, and crop production (Islam & Mondal, 2018). The right amount of plant nutrients is necessary for the cultivation of cabbage. organic manures, chemical fertilizers, or a mix of both are important sources of plant nutrients. Taking into account all of the above, the current research was carried out to choose the most efficient source of plant nutrients for improved cabbage development and yield. This study fills a crucial gap by examining how organic and inorganic fertilizers affect cabbage growth. By comparing their influence on nutrient levels, soil quality, and crop yield, the research aims to guide better fertilizer use in cabbage farming, promoting sustainable agriculture.

2. Materials and methods

2.1 Experimental site

The experiment was carried out in the Horticultural farm of Gauradaha Agriculture Campus, Tribhuvan University, Jhapa, Nepal from 26th December 2022 to 2nd April 2023, and is situated at an altitude of 182 m above sea level at 26°33'41.0"N latitude and 87°43'13.6"E longitude. The soil composition of the experimental site was found to be sandy loam to clay loam with pH ranges around 5.5 (Kandel & Shrestha, 2020).

2.2 Planting materials

Only one variety “Green coronet” was used as planting materials which were widely grown in Nepal. Seeds of cabbage cultivars were obtained from commercial seed traders. Seeds were sown in plastic trays and coco-peat was used as a growing media for germination of seeds. After three weeks seedlings were ready to transplant in the main field (Shrestha, 2019).

2.3 Organic and inorganic materials

Within this investigation, Cow dung was identified as Farm Yard Manure (FYM), and well-decomposed poultry feces and poultry litter were referred to as Poultry Manure (PM). Both FYM and PM were collectively classified as organic fertilizers. In contrast, synthetic chemicals, namely Urea, DAP (Diammonium Phosphate), and Muriate of Potash, were categorized as inorganic fertilizers. In the context of inorganic and combined treatments, Urea, DAP, and Muriate of Potash were utilized to meet the NPK (Nitrogen, Phosphorus, Potassium) requirements for cabbage cultivation. Here, Table 1 summarizes the origin of fertilizers and their respective nutrient content, specifically focusing on NPK values.

Table 1. Fertilizer source and their nutrients (NPK) content

Fertilizer/Nutrient content	Nitrogen (N) %	Phosphorous (P ₂ O ₅) %	Potash (K ₂ O) %	Character
Farm yard manure	2.18	2.21	2.48	Medium
Poultry Manure	3.84	3.36	3.74	High
Urea	46	0	0	High
Di-Ammonium phosphate	46	18	0	High
Muriate of potash	0	0	60	High

2.4 Characteristics of soil

Prior to initiating the study, soil samples were randomly collected from various points within the study area at a depth of 15 cm. These individual soil samples were then thoroughly mixed to create a composite sample, which was subsequently dispatched to the soil laboratory located in Tarhara, Jhumka. This laboratory was designated for further soil testing to examine and assess the soil's physical and chemical properties. Conducting such soil testing is essential as it provides crucial insights before commencing any crop cultivation. Soil analysis involved determining parameters such as soil pH, available nitrogen, phosphorous, potassium, organic matter, and bulk density using standard methodologies. Soil pH was assessed with a pH meter, while available nitrogen, phosphorous, and potassium were analyzed through conventional methods. Organic matter content was determined using the Walkley-Black method, and bulk density was measured employing the core method. The resulting data, including the findings from the soil laboratory, are summarized in Table 2, outlining the comprehensive characteristics of the soil in the designated experimental region.

Table 2. Physical and chemical properties of experimental site

Soil type	PH	Available nitrogen	Available phosphorous	Available potassium	Organic matter	Bulk density
Clay loam	6.2	0.21%	0.23	0.8	1.4%	1.27 gm/cm ³

2.5 Experimental design and treatments

In the research, "Green Coronet," a hybrid variety of cabbage which is grown especially for the fresh market, was the variety selected for the study. The experiment was conducted in Randomized Complete Block Design (RCBD) with 3 replication and there were 7 treatments (Table 3) with different organic and inorganic fertilizers. Three weeks old seedlings were transplanted into the main plot at the spacing of 40cm * 40cm (PP * RR) with plot size 4m²(2m*2m) and the total number of plots was 21. The distance between the two replications and two plots were 1 m and 0.5 m respectively. 25 seedlings were transplanted in a plot and 525 seedlings in 21 plots of 180m²(18m*10m) area. Complete dose of FYM, PM were applied at the time of field (plot) preparation. Nitrogenous fertilizer (Urea) was applied as 3 split doses. Half dose of nitrogen was applied during field preparation and remaining doses were applied at 45 and 60 days after transplanting (DAT).

Table 3. Treatments details and their application dose

Treatment code	Treatment details	Application rate (kg/plot)
T ₁	25-ton FYM/ha	10
T ₂	25-ton PM/ha	10
T ₃	25-ton FYM/ha +NPK(RDF)	10: 0.08: 0.072: 0.032
T ₄	25-ton PM/ha + NPK(RDF)	10: 0.08: 0.072: 0.032
T ₅	20-ton FYM/ha + 10-ton PM/ha + NPK (RDF)	8: 4: 0.08: 0.072: 0.032
T ₆	10-ton FYM/ha + 20-ton Pm/ha + NPK (RDF)	4: 8: 0.08: 0.072: 0.032
T ₇	Control	0

2.6 Growth condition of cabbage and measurements of parameters

Manures and fertilizers were applied in accordance with treatment. Half of the N dose, as well as the full doses of P₂O₅ and K₂O, were applied as a basal dose. The final half of N was administered at 25 and 50 DAT respectively. Healthy seedlings were transplanted in the main field and the field was immediately watered using rose cane to maintain moisture conditions. According to the state of the field's moisture, furrow irrigation was carried out. To get rid of leaf caterpillars, Malathion 50% EC 1L/250L of water per ha was sprayed twice, with a 15-day interval between each application. Hand weeding was done frequently whenever weeds were spotted. Harvesting was done from April 1 to April 3 since the head was not matured at the same time. Different yield-contributing data have been recorded from the mean of 8 harvested plants which were selected at random for each unit plot. To prevent the border effect, the plants at the ends of the middle rows and the outside rows were not included in the random selection.

2.7 Data collection and analysis

The data was recorded for plant height (cm), number of leaves, and leaf area (cm²) as growth parameters at 15 days intervals. Yield contributing parameters like horizontal head diameter(cm), vertical head diameter (cm), stem length (cm), stem girth (cm), weight with roots (MT/Ha), gross yield (MT/Ha), and net curd yield (MT/Ha) data were collected at the time of harvesting. Scale was used to measure the plant height, leaf area, and stem length, Vernier caliper was used to measure stem and head diameter of cabbage, digital weighing balance was used to measure the yield of cabbage.

All yield contributing traits were recorded and entered in MS -Excel. The significant difference between treatments was determined using the least significant difference (LSD) test at a 5% level

of significance. Mean, coefficient of variance (CV), and analysis of variance (ANOVA) were computed from SPSS version 25

3. Results

3.1 Effect of different treatments on the growth parameter of Cabbage

This study examined the effects of different nutrient sources on the growth and development of cabbage plants. At 15, 30, 45, 60 and 75 days after transplanting, the number of leaves was counted. The findings displayed in Table 4 demonstrated that, at various phases of plant growth, the effects of various fertilizer sources on number of leaves were significant. While the insignificant effect was observed at 15 DAT. The result shows that the highest number of outer/unwrapped leaves 10.20, 13.29, 16.70, 17.41 was observed in T3 (25-tonfym/ha + NPK) at 30, 45, 60, and 75 DAT respectively. On the other hand, the lowest number of leaves 8.20 was obtained in control at 30 DAT, 10.16 and 14.08 in T1(25-ton FYM/ha) at 45 and 60 DAT respectively and 14.83 in T6(10-ton FYM/ha + 20-ton PM/ha + NPK) at 75 DAT. Overall, incorporating Farm yard manure with NPK was found to be beneficial in enhancing the growth of cabbage plants. Leaf area plays a vital role in the production of higher yield, result shows that applied organic and inorganic fertilizers significantly influenced the production of leaf area (Table 5). The highest and lowest leaf area was obtained in T5 (20-tonFYM/Ha + 10-ton PM/Ha +NPK) and T1 (25 Ton FYM/ha) i.e., 1162.25 and 220.85 cm² respectively. Where T4, T5, and T6 are at par. Variety is an important factor considering plant height. The results presented in Table 5 showed that different sources of fertilizer had a significant effect on plant height at harvesting stage. Combined application of poultry manure and NPK resulted in the highest plant height (23.99 cm) in T4 (25-ton PM/ha +NPK) which is at par with T2, T3, T5, T6, and control. Similarly, the lowest plant height (15.70 cm) was obtained in T1 (25ton FYM/Ha) which is statistically different from other treatments.

This study examined how different nutrient sources affected the stem length and steam girth of cabbage plants. The results (Table 5) indicated that Organic, and inorganic fertilizers and their combination significantly affected stem diameter. Highest stem girth was obtained in T6(10-ton FYM/ha + 20-ton PM/ha + NPK), which is at par with T4(25-ton PM/ha + NPK) and T5(20-ton FYM/ha + 10-ton PM/ha + NPK). Similarly, the lowest stem girth was obtained in T1(25-ton FYM/ha) which was at par with T2, T3, and control. There was insignificant effect of treatment on stem length (Table 5) and also all the treatments are at par. These Findings examined that how various nutrient sources affect cabbage plant growth. Combining farmyard manure with NPK positively impacted leaf number, leaf area, and plant height. Stem diameter was significantly influenced by organic and inorganic fertilizers, with the combined use of farmyard manure, poultry manure, and NPK resulting in the largest stem girth. Stem length remained unaffected by the treatments. Overall, the findings highlight the importance of nutrient source selection for optimizing cabbage plant growth and yield.

Table 4. Effect of different treatments on the number of leaves

Number of leaves					
Treatment	15 DATP	30 DATP	45 DATP	60 DATP	75 DATP
T1	3.29 ^a	8.75 ^{ab}	10.16 ^a	14.08 ^a	16.54 ^{ab}
T2	3.66 ^{ab}	9.29 ^{abc}	12.37 ^b	16.33 ^c	16.38 ^{ab}
T3	4.07 ^b	10.20 ^c	13.29 ^b	16.71 ^c	17.41 ^b
T4	3.45 ^{ab}	9.29 ^{abc}	12.54 ^b	16.29 ^{bc}	15.95 ^{ab}
T5	3.08 ^a	9.25 ^{abc}	13.08 ^b	15.79 ^{bc}	14.95 ^a
T6	4.04 ^b	9.49 ^{bc}	13.16 ^b	15.58 ^{bc}	14.83 ^a
Control	3.54 ^{ab}	8.20 ^a	10.99 ^a	15.16 ^b	17.00 ^a

Continued Table 4.

Treatment	15 DATP	30 DATP	45 DATP	60 DATP	75 DATP
Grand mean	3.59	9.21	12.22	15.71	16.15
CV %	10.8	6.5	3.9	3.8	5.6
f- value	NS	*	*	*	*
p-value at 0.05	0.061	0.033	<0.001	0.002	0.025
LSD	0.68	1.04	0.84	1.04	1.58

DATP = Days after Transplanting *Significant at 5% level of significance, ^{NS}Non-significant

Table 5. Effect of different treatments on leaf area, stem length, plant height and stem girth

Treatment	Leaf area (cm²)	Stem length (cm)	Plant height at harvest (cm)	Stem girth (cm)
T1	220.9 ^a	10.10 ^a	15.71 ^a	2.98 ^a
T2	709.5 ^c	10.31 ^a	21.92 ^b	3.10 ^a
T3	738.1 ^c	10.62 ^a	21.12 ^b	3.16 ^a
T4	1146.3 ^d	10.91 ^a	24.00 ^b	3.54 ^b
T5	1162.3 ^d	10.99 ^a	23.00 ^b	3.56 ^b
T6	1059.2 ^d	10.83 ^a	23.68 ^b	3.59 ^b
Control	391.6 ^b	10.33 ^a	17.53 ^b	3.01 ^a
Grand mean	775	10.58	20.99	3.28
CV%	11.4	4.6	7.1	4.9
f- test (p>0.05)	*	NS	*	*
P-value at 0.05.	<0.001	0.257	<0.001	<0.001
LSD	155.0	0.86	2.62	0.28

*Significant at 5% level of significance, ^{NS}Non-significant

3.2 Effect of different treatments on yield parameters of cabbage

The study explored how various organic and inorganic nutrient sources impact the growth and yield of cabbage plants (Table 6 and Table 7). Head formation became visibly apparent 7 to 8 weeks after transplantation, with 50% head maturity achieved within 4 to 5 weeks thereafter. Harvesting commenced 13 weeks after transplantation. The characteristics of size and shape in cabbage heads are vital traits for the cultivar, and these attributes can be molded by various cultivation factors, particularly fertilization. Here, Table 6 provides an analysis of how the combination of organic and inorganic fertilizers collectively influences the head diameter (Horizontal and Vertical) at the time of harvest. Also, the head diameter plays a significant role in the economic sector. The highest horizontal head diameter (16.39 cm) was found in T5(20-ton FYM/Ha + 10-ton PM/Ha + NPK) which was statistically at par with T4 and T6. Similarly, the lowest head diameter (11.54 cm) was found in T1(25-ton FYM/ha). The depth and compactness of the head are directly proportional to the economic weight of the head. The combined application of FYM, PM, and NPK resulted in the highest vertical head diameter, measuring 11.49 cm, observed in T6(10-ton FYM/ha + 20-ton PM/ha + NPK), statistically comparable to T4 and T5. Conversely, the lowest vertical head diameter of 11.54 cm was found in the sole application of FYM, represented by T1(25-ton FYM/ha).

The study delved deeper into examining how various organic and Inorganic nutrient sources impact both the growth and yield of cabbage plants. Significant variations in yield were observed when employing diverse combinations of organic and inorganic fertilizers, as detailed in Table 7. Particularly in terms of weight with roots. Notably, the Combined application of 20-ton FYM/Ha + 10-ton PM/Ha + NPK (T5) gives the highest yield i.e., 5.93 MT/Ha. This outcome was statistically

comparable to the yield achieved with T4. On the contrary, the lowest yield i.e., 2.15 MT/Ha, was observed in T1(25-ton FYM/ha). These results underscore the significant impact of specific fertilizer combinations on the overall weight, including roots, in cabbage plant cultivation. The study revealed that the application of 25 tons of PM per hectare (T4) resulted in the highest gross yield, reaching 5.60 MT/Ha. This performance was statistically comparable to T5, indicating similar effectiveness in enhancing the overall cabbage yield. On the contrary, the lowest gross yield of 1.97 MT/Ha was observed when applying 25 tons of FYM per hectare(T1). These findings emphasize the influence of specific fertilizer choices on the overall productivity of cabbage cultivation, with T4 and T5 demonstrating notable performance in this regard. Also, the study highlighted a significant impact on yield with the combined application of FYM, PM, and NPK across all treatments, as indicated in Table 7. Specifically, the application of 20 tons of FYM per hectare, 10 tons of PM per hectare, and NPK (T5) resulted in the highest net head yield at 3.91 MT/Ha. This performance was statistically comparable to T4, suggesting similar effectiveness in enhancing the net head yield. Conversely, the lowest net head yield of 1.23 MT/Ha was observed when applying 25 tons of FYM per hectare. These findings underscore the substantial influence of specific fertilizer combinations on the net head yield in cabbage cultivation. Overall, the study underscores the significance of tailored nutrient combinations in shaping cabbage characteristics and optimizing overall yield. The findings highlight specific fertilization strategies, such as the combined application of 20-ton FYM, 10-ton PM, and NPK, as key contributors to achieving favorable outcomes in cabbage growth and productivity.

Table 6. Effect of different treatments on the diameter of the head at the time of harvest

Treatment	Horizontal head diameter (cm)	Vertical head diameter (cm)
T1	11.54 ^a	7.64 ^a
T2	14.51 ^c	9.71 ^b
T3	14.04 ^c	9.77 ^b
T4	16.18 ^d	11.13 ^c
T5	16.39 ^d	11.34 ^c
T6	15.55 ^d	11.49 ^c
Control	12.52 ^b	8.59 ^b
Grand mean	14.39	9.96
CV%	3.7	7.1
f-value	*	*
P-value at 0.05	<0.001	<0.001
LSD	0.93	1.23

*Significant at 5% level of significance

Table 7. Effect of Different treatments on the yield parameter

Treatment	Weight with roots (MT/Ha)	Gross yield (MT/Ha)	Net head yield (MT/Ha)
T1	2.15 ^a	1.97 ^a	1.23 ^a
T2	3.94 ^c	3.67 ^c	2.44 ^c
T3	3.91 ^c	3.62 ^c	2.56 ^c
T4	5.92 ^e	5.60 ^e	3.89 ^e
T5	5.93 ^e	5.54 ^e	3.98 ^e
T6	5.21 ^d	4.92 ^d	3.48 ^d
Control	2.74 ^b	2.51 ^b	1.69 ^b

Continued Table 7.

Treatment	Weight with roots (MT/Ha)	Gross yield (MT/Ha)	Net head yield (MT/Ha)
<i>Grand mean</i>	4.26	3.97	2.75
<i>CV%</i>	6.7	6.2	6.4
<i>f-value</i>	*	*	*
<i>P-value at 0.05</i>	<0.001	<0.001	<0.001
<i>LSD</i>	0.50	0.43	0.30

*Significant at 5% level of significance

4. Discussion

The effective use of organic or inorganic fertilizers plays a key role in improving the yield and quality of cabbage (Hasan & Solaiman, 2012; M. A. Islam et al., 2017). Numerous studies emphasize the significance of both organic and inorganic fertilizers in influencing cabbage growth and nutritional quality. Integrating various nutrient sources like inorganic fertilizers, FYM, and, PM is essential for achieving high-quality and timely growth while sustaining soil health (Singh et al., 2023). In this research, we examined how Farm Yard Manure (FYM), Poultry manure (PM) and, NPK (a synthetic fertilizer) on the growth and yield parameters of cabbage plants. Our findings indicate that plants treated with FYM, PM, and NPK showed the highest growth parameters and yield. This may due to Organic manure and inorganic fertilizers alone are insufficient to achieve a high cabbage yield. However, combining them enhances fertilizer efficiency, sustains nutrient levels over time, and promotes sustainable, high-quality yields (Singh et al., 2020).

Applying a combination of NPK, FYM, and PM, exhibited the highest values for leaf area, weight with roots, net head yield, stem girth and head diameter. The result of this study was in agreement with ss Mojeremane (2015), who reported that organic fertilizer helps to a continuous supply of nutrients to the entire crop period and enhances the production of higher leaf area. Maximum Leaf Area at T5 might result from improved nutrient uptake by the plants, and readily available nutrients and carbohydrate synthesis might be responsible for the treatment's superiority. All of these elements contributed to cabbage's increased leaf area production (Chatterjee, 2010). Also, the experiment's findings about the length and width of each plant's leaves could be explained by the varietal influence, the kind of soil, the availability of nutrients, etc (Hasan & Solaiman, 2012). Applying a combination of organic and inorganic fertilizers increases the head diameter of cabbage. Similar results were observed by (Asomah et al., 2021; Chaudhary et al., 2018; Islam et al., 2021). Reza et al., (2016), also reported similar result that When inorganic and other organic fertilizers were used, cabbage's head height increased more successfully. Bhattarai et al., (2023) and Sher & Mishra, (2023), they also reported that due to higher and continuous supply of nitrogen from PM leads to rapid cell division of crops and consequently increased the yield of cabbage. Crop yield is ultimately influenced by vegetative growth (M. A. Islam et al., 2017). Chaudhary et al., (2018), reported that combined application of organic and synthetic fertilizer increases the stem girth of cabbage which support to our study. In order to improve soil structure and microbial biomass, organic fertilizers can be used as an alternative to mineral fertilizers. Here, the results of the current experiment could be attributed to soil characteristics that affect water and nutrient availability, resulting in higher and lower root length of plants (Hasan & Solaiman, 2012). Chávez-mejía et al., (2019), found that the application of poultry manure increases the biological yield as well as improves the soil nutrient status. Asomah et al., (2021), reported that the application of poultry manure with NPK fertilizer results in a higher head yield. This highest yield in T5 might be due to balance supply of plant nutrient that resulted proper shape, size and compactness of head (Kumar Chaudhary & Kumar Yadav, 2018). Also, this observation was supported by Ibukunoluwa Moyin-Jesu (2015), that the balanced nutrient contents of poultry manure may have contributed to the

best cabbage head weight that was attained from its treatment. Additionally, a lower C/N ratio of poultry manure promoted quicker nitrogen release and breakdown for increased crop absorption and head yield characteristics.

Poultry manure is abundant in essential nutrients like nitrogen (N), phosphorus (P), and potassium (K), along with secondary nutrients and amino acids. These elements are crucial for promoting enhanced photosynthesis, cell division, and cell enlargement in plants (Adhikari et al., 2023). Poultry manure contained significantly higher amounts of major nutrients like nitrogen (N), phosphorus (P), and potassium (K) compared to cow dung, with increases of 56.7%, 39%, and 27.3%, respectively (M. Islam & Mondal, 2018). T4, treated with both poultry manure (PM) and NPK, displayed the highest values for both plant height and gross yield. Similar findings by Asomah et al., (2021) and, also suggests that the combining inorganic and organic fertilizers is more effective in increasing crop productivity compared to using them separately. Obidola et al., (2019), also demonstrated that the use of poultry manure and other organic methods for supplementing plant nutrients significantly influenced plant height when compared to the control. Also, this result could be attributed to inorganic fertilizer's rapid performance on growth characteristics and rapid release of nutrients for plant height (Souza et al., 2008). Results under the present experiment on plant height was supported by this finding Yadav et al., (2022), who reported that due to the last-ing supply of nutrients from organic sources increases the plant height. Amoah et al., (2017), found that the gross yield of cabbage was increased by the application of poultry manure due to the continuous supply of nutrients to the crop.

The number of leaves per plant specially wrapped, is a crucial parameter in cabbage cultivation due to its significant impact on achieving the highest head yield performance (Chaudhary et al., 2018; Kumar & Khare, 2015). T3 (25-tonfym/ha + NPK) showed the highest number of outer/unwrapped leaves at 30, 45, 60, and 75 DAT, respectively. The application of NPK along with FYM clearly enhances the nutrient absorption by cabbage because it acts as a storehouse for plant nutrients, which are the ideal amount for a given crop. These outcomes align with the findings reported by (Jat et al., 2013). Also, the large leaf count is mostly due to the timely and efficient supply of nutrients to the plant, which comes through healthy plant development and timely leaf wrapping (Kumar Chaudhary & Kumar Yadav, 2018). The primary pigment in plants that absorbs light, chlorophyll, is crucial to metabolic processes and, ultimately, the crop's economic yield (Chatterjee, 2010). Dhamala et al., (2020), also found that the application of FYM improves the physio-chemical property of soil and that enhancing the vegetative growth of cabbage. In comparison to other treatments, the control treatment had the lowest number of leaves. This was primarily because there was no fertilization applied during the cropping period and the soil had a low nutrient status. This conclusion was supported by Ibukunoluwa Moyin-Jesu (2015), who investigated the effects of fertilizers on cabbage growth and yield and found that a sufficient supply of nutrients was a key component in achieving increased cabbage leaf count and ultimately to yield. Also, the application of Farm Yard Manure (FYM) alone resulted in the lowest values for various components contributing to cabbage growth and yield, including leaf area, stem girth, plant height, Horizontal and Vertical head diameter, weight with roots, gross yield and overall net head yield, when compared to other treatments. The possible reason for this could be that the combination of organic and inorganic fertilizers, which likely provided sufficient plant nutrients than the organic manure alone. This combination might have led to increased microbial activities in the soil, consequently promoting earlier head formation in plants (Dash et al., 2015). Also due to the lower content of nitrogen(N) in farm yard manure as compared to poultry manure which performed best among organic manures (Kaur, 2020).



Figure 1. Cabbage plot treated with different fertilizers



Figure 2. Harvesting stage cabbage

5. Conclusion

Based on the results obtained, it can be concluded that T5 treatment (20-ton FYM/ha + 10-ton PM/ha + NPK (RDF) showed the best overall performance in terms of various growth and yield parameters. This treatment combination can be recommended as a sustainable approach for cabbage production, indicating that a balance between organic and inorganic fertilizers can lead to improve growth and yield.

Author's declaration and contribution

The authors declare no conflicts of interest. All authors contributed equally in all stages of the preparation of this manuscript. Similarly, the final version of the manuscript was approved by all authors.

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