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Organic and Inorganic Fertilizer Application on the Growth and Yield of Cabbage *(Brassica Oleracea)* under Protected Agriculture

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Abstract. Protected agriculture is a modern and scientific method of farming that give an authority to farmers to produce high-value crops at maximum productivity in an effective and environmentally-opened way. This method brings the possibility to produce crops year-round without being affected by extreme weather events and climate conditions. Hence, it creates a huge increase in output with less input. This put into practice, with reduced use of fertilizers, water, pesticides, has changed the growing environment. The purpose of a controlled environment is to provide protection to the crops from cold or heat and from the undesirable pests to the crops and also maintains the good quality of crops

This study was aimed to determine the growth and yield performance of cabbage applied with organic and inorganic fertilizer under protected environment. It was conducted in Nueva Ecija University of Science and Technology Gabaldon Campus Research Area, Gabaldon, Nueva Ecija. The treatments used were as follows; T1 (100% organic fertilizer), + T2 (100% inorganic fertilizer), + T3 (50% organic fertilizer and 50% inorganic fertilizer, and T4 (no fertilizer).

Combine application of organic and inorganic fertilizer performed well in most of the parameters: average number of days to head formation, average head diameter, average weight of head, average number of marketable head, least number of nonmarketable head and average yield/ha.This findings has the potential to decrease the usage of inorganic fertilizer, leading to enhanced soil health and improved environmental conditions in the long term."

Keywords: Cabbage; Inorganic Fertilizer; Organic Fertilizer; Protected Agriculture

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1. Introduction

Cabbage is one of the most popular *Brassica* vegetables in the human diet due to its affordability, availability, and range of health benefits and thus it forms a huge part of worldwide cuisines and diets. Many epidemiological studies and interventional trials have shown this cruciferous vegetable to be beneficial in reducing the risk of several types of cancer as well as other chronic diseases such as cardiovascular disease, cataracts, Alzheimer's disease, and diabetes, which is owed to its nutritious composition with its wide array of antioxidants and phytochemicals including carotenoids, glucosinolates, isothiocyanates, phenolic compounds, and vitamins E and C (Moreb, 2020).

According to PSA Cordillera Regional Director Villafe Alibuyog, recent Philippine Statistics Authority (PSA) records show Benguet is considered as the country's top producer of cabbage, with 77.8 percent supply all over the country. "By far, these agricultural products from the entire Cordillera region's agriculture industry, play a top producer of cabbage in the market which is distributed in every country," (Fabian, 2017).

Cabbage is a source of fiber that has an indigestible part of carbohydrate, one cup of raw, and every part of cabbage contains only 22 calories and 2.2 grams of fiber. The half of carbohydrates found in cabbage is derived from fiber that provides the heart a healthy food choice. It is an important nutrient in the diet as it keeps one full, can pull cholesterol away from the heart, regulates bowels, and maintains steady blood sugar. Studies have found that to have healthier weight and decrease risk of heart diseases and certain diseases, cabbage can create sufficient amounts of fiber that are recommended. Aside from fiber, cabbage is a good source of folate, manganese, and vitamin K. It is also one of the cruciferous vegetables shown to have anti-cancer properties (Cervoni, 2017).

In the Philippines, the largest producer of cabbage is the Cordillera Administrative Region (77%) since this is the widest farming area while other places include Northern Mindanao Region (5.3%), Central Visayas (5.0%), Davao Region (3.4%), Ilocos Region (2.7%), Negros Island Region (2.1%), Cagayan Valley (1.3%), SOCCSKSARGEN (1.1), Zamboanga Peninsula (0.7%), Calabarzon (0.6), ARMM (0.4%), Western Visayas (0.3%), Eastern Visayas (0.1%) and Bicol Region (0.1%) (PSA, 2017).

Cabbage production slightly dropped by 0.2 percent from 50.41 thousand metric tons in the period of October to December 2016 to 50.30 thousand metric tons for the

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same quarter of 2017. Cabbage production in some parts of Central Visayas harvested small heads due to frequent rains, while Davao region's losses are due to high cost of inputs for cabbage production (PSA, 2017).

To augment the shortage in the cabbage production facing by the largest producer of cabbage in the Philippines. This study may find way on how to produce good quality cabbage here in Gabaldon, Nueva Ecija under protected agriculture. Utilizing protective structures in agriculture presents a promising opportunity for the vegetable industry in the Philippines. It enables farmers to employ advanced cultivation methods, effectively combat unfavourable weather conditions, and efficiently control pests and diseases. Therefore, to meet the growing food demand in the country, one effective approach to boost vegetable production is by embracing the intensified utilization of protected agriculture (Estigoy, 2022).

Methodology

1.1. Experimental Design

The study used a single factor experiment with Randomized Complete Block Design (RCBD) with four (4) treatments and three (3) replications. Treatments were composed of organic and inorganic fertilizers. A total area of 81.25m was divided into 12 experimental plots measuring 81.25 m (6.5m x 12.5m). Each plot has an area of 3.75 m^2 (1.5 m x 2.5), with 0.5meter distance between plots and blocks. Plots have three (3) rows and 18 seedlings on the planting distance of 25 cm between hills and 50 cm between furrows. Data was gathered in central rows with four (4) plant samples. All gathered data were subjected to Analysis of Variance (ANOVA) and Least Significant Difference (LSD) were used.

1.2. Soil Analysis

Soil Analysis before of the study was conducted to determined N. P, and K requirements of the soil. Prior to land preparation soil sample were gathered randomly in the field and was subjected to analysis.

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Cultural Management

The seeds were sown in the seedling tray singly with a mixture of garden soil and animal manure in a 1:1 ratio. After 28 days, seedlings were transplanted singly in plot with planting distance of 25 cm x 40 cm inside the net house build before the start of the study for protection to outside biotic and abiotic factors. The organic fertilizer was applied basal base on the recommendation of the organic fertilizer manufacturer (Treatment 1 (6.37kl/plot and 2.12 kl/plot in Treatment 3). The first application of inorganic fertilizer in Treatment 2 with the rate of 137.3 grams (6-20-0) and 41.1 grams (46-0-0-) and Treatment 3 in the rate of (1.05kg) organic fertilizer 16-20-0 (18.8), 46-0-0 (20.5) was done 10 days after transplanting. Watering was done after transplanting of seedlings with a two-day interval and the succeeding watering schedule was dependent on the weather condition or as the need arises with the use of water sprinklers. Weed control was done manually two (2) weeks after transplanting. Regular weeding was done to avoid competition between crops and weeds. Regular monitoring was done to prevent the infestation of pest and diseases. Eighty (80) days after transplanting the cabbage was harvested. The head was cut off from the top of the soil while a few outer leaves were kept to protect the head.

1.3. **Statistical Analysis.** Data gathered was analysed using Analysis of Variance (ANOVA). The Duncan Multiple Range Test (DMRT) was applied at 0.5 and 0.1 probability levels to compare treatment means.

2. Results and Discussion

2.1. Growth Performance of Cabbage

The growth performance of cabbages was determined in terms of the average size of canopy, average number of days to head formation, and average number of leaves to head formation.

3.1.1. Average Size of Leaf Canopy (cm)

TREATMENTS	MEAN ^{ns}
Treatment 1-100% Organic Fertilizer	53.16
Treatment 2-100% Inorganic Fertilizer	59.00
Treatment 3- 50% Organic+50% Inorganic Fertilizer	57.75
Treatment 4- No Fertilizer	52.16

ns- not significant

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T2- 100% inorganic Fertilizer applied in cabbage obtained the highest average size of leaf canopy compared to treatments applied with T1-100% organic fertilizer with a mean of 59.00 cm and 53.16 cm respectively. It is evidently resulting to the high nutrient content of inorganic fertilizer compared to organic fertilizer and also inorganic fertilizer are readily available to plants compared to organic fertilizer.

The results indicated that application of organic fertilizers and inorganic fertilizers combined showed improved growth and the maximum plant spread. These findings are in agreement with the reports where vermicompost or poultry manure along with inorganic fertilizer application yielded high plant spread [(Rai, 2013)(Sultana, 2012)].

3.1.2. Average Number of Days to Head Formation

TREATMENTS	MEAN**
Treatment 1-100% Organic Fertilizer	46.08[c]
Treatment 2-100% Inorganic Fertilizer	57.58[a]
Treatment 3- 50% Organic+50% Inorganic Fertilizer	47.00[c]
Treatment 4- No Fertilizer	55.75[b]

*** Highly Significant*

Means with the same letter are not significantly different at 0.05, LSD.

In terms of number of days to head formation the data above shows that T1- 100% organic fertilizer gave the shortest day to harvest with a mean of 46.08 followed by T3 with a mean of 55.75, T4 with a mean of 55.75, while T2- 100% Inorganic Fertilizer application obtained the longest days to harvest.

The results indicate that Treatment 2 (100% Inorganic Fertilizer) took the longest number of days to form a cabbage head. Application of inorganic fertilizer improperly damaged the crop resulting to leaf scorching that causes the delay of cabbage head formation.

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3.1.3. Average Number of Leaves to Head Formation

Treatment	Mean ^{ns}
Treatment 1–100% Organic Fertilizer	13.08
Treatment 2–100% Inorganic Fertilizer	13.08
Treatment 3– 50% Organic+50% Inorganic Fertilizer	12.75
Treatment 4– No Fertilizer	13.17

ns– Not Significant

In terms on average number of leaves of cabbage to head formation. The maximum number of leaves were observed in Treatment 4 (No Fertilizer) with the mean of 13.17, followed by T1 (100% Organic Fertilizer) and T2 (100% Inorganic Fertilizer) that has a comparable result. On the other hand, Treatment T3 (50% Organic + 50% Inorganic) obtained the lowest number. The result revealed that there were no significant differences among treatments.

The higher the amount of inorganic fertilizer application, the higher the chance of improvement and increased production of leaves, but can also resulting in longer of days and smaller head formation of cabbage. It found that the integrated application of organic and inorganic fertilizers significantly increased the vegetative growth of cabbage (Sharma, 2020).

Yield Performance of Cabbage

The yield performance of cabbage was determined in terms of average head diameter, average weight of head, and average number of marketable and unmarketable heads and yield per hectare.

3.2.1. Average Head Diameter (cm)

Treatment	Mean**
Treatment 1–100% Organic Fertilizer	9.15^{b}
Treatment 2–100% Inorganic Fertilizer	7.69^{c}
Treatment 3– 50% Organic+50% Inorganic Fertilizer	10.71^{a}
Treatment 4– No Fertilizer	7.85^{c}

*** Highly Significant*

Means with the same letter are not significantly different at 0.05, LSD.

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The biggest head diameter obtained was observed in Treatment 3 (50% Organic + 50% Inorganic) with a mean of 10.71, followed by Treatment 1(100% Organic) with a mean of 9. 15, Treatment 4(No fertilizer) with a mean of 7.85, and the lowest head diameter was obtained by Treatment 7.69 (100% Inorganic).

Therefore, combined application of organic and inorganic fertilizers can meet the needs of cabbage yield and simultaneously improve the harvest quality. Haque reported as cited by Islam, 2017, that the effect of the mixed fertilizer application (organic and inorganic) resulted in the highest thickness of the cabbage head. This compactness also has the rational trend of the combination where a higher yield was obtained.

These results are in agreement with previous reports where organic fertilizer (poultry manure) and NPK had a higher head diameter compared to the control (Znidarcic, 2007). Kedino et al., 2009, reported a higher head diameter in combined organic and inorganic fertilizer (FYM + NPK) applications.

3.2.2. Average Weight of Head (g)

TREATMENTS	MEAN**
Treatment 1–100% Organic Fertilizer	391.50[b]
Treatment 2–100% Inorganic Fertilizer	99.70[d]
Treatment 3– 50% Organic+50% Inorganic Fertilizer	489.90[a]
Treatment 4– No Fertilizer	117.00[c]

*** Highly Significant*

Means with the same letter are not significantly different at 0.05, LSD.

The results show that Treatment 3 applied with 50% organic + 50& inorganic fertilizer obtained the highest weight of cabbage with a mean of 489.9g, followed by Treatment 1 with a mean of 391.5g, Treatment 4 with a mean of 117g, and the one which obtained the lowest weight is treatment 2 with a mean of 99.7g.

The average yield of cabbage was significantly influenced by the combination of organic and inorganic fertilizers. Organic fertilizer growth promoting constituents like enzymes and hormones present make them useful for the improvement of soil fertility

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and productivity and also serve as excellent soil conditioners due to higher holding capacity and microbial activity.

3.2.3 Average Number of Marketable and Unmarketable Heads

TREATMENTS	MARKETABLE	UNMARKETABLE
Treatment 1–100% Organic Fertilizer	12	0
Treatment 2–100% Inorganic Fertilizer	11	1
Treatment 3– 50% Organic+50% Inorganic Fertilize	12	0
Treatment 4– No Fertilizer	11	1

ns– not significant

The table shows that Treatment 1 and Treatment 3 obtained the highest number of marketable heads while Treatment 2 and Treatment 4 got one unmarketable. According to Mrs. Alona Collado, a vegetable vendor at Gabaldon Public Market cabbages with the size of an adult person's fist regardless of its weight are considered as unmarketable while those cabbages bigger than the adult person's fist can be considered marketable.

3.2.4 Average Yield per Hectare (kg/ha)

TREATMENTS	MEAN**
Treatment 1–100% Organic Fertilizer	19,419.20^{b}
Treatment 2–100% Inorganic Fertilizer	5,497.60^{c}
Treatment 3– 50% Organic+50% Inorganic Fertilizer	25,664.00^{a}
Treatment 4– No Fertilizer	5,102.40^{d}

** Highly Significant

The table presents the yield per hectare of cabbage. It shows that the Treatment 3 applied with 50% Organic + 50% Inorganic obtained the highest yield with a mean of 25,664.00g followed by Treatment 1 with a mean of 19,419.20g and Treatment 2 with a mean of 5,497.60g while Treatment 2 got the lowest yield with a mean of 5,497.60g.

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4. Conclusions

Cabbage production under protected environment applied with 50% organic fertilizer and 50% inorganic fertilizer obtained the least no of days to head formation, biggest head formation in diameter, average weight of head, average number of marketable yields, no unmarketable cabbage head, and highest average yield kg/ha. Combine application of organic and inorganic fertilizer made the cabbage less susceptible to pest and disease incidence. It made the soil healthier and the nutrients present in the soil is easy to absorb by plants. While net house provides the adequate temperature for cabbage production even not planted in elevated area.

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