



Comparison of Compound and Single-Nutrient Fertilizer Sources on Cabbage Growth and Production

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Abstract. This study evaluated the effects of compound and single-nutrient fertilizers on the growth and yield of cabbage (*Brassica oleracea* L.). The experiment was conducted using a randomized complete block design with seven fertilization treatments, including varying doses of compound fertilizer and a single-nutrient control. Results showed that the application of a 1.0× dose of compound fertilizer significantly improved plant height at 3 and 4 weeks after transplanting (WAT), and increased leaf number at 5 WAT. Yield components, including yield per plant, per plot, and hectare, were significantly higher in the 1.0× treatment, with an average yield of 1.92 kg per plant—an increase of 86.4% and 11.6% compared to the control and single-nutrient treatments, respectively. The relative agronomic effectiveness of the 1.0× dose reached 139%, indicating superior performance over the standard fertilizer. Economic analysis confirmed its viability, with the highest benefit-cost ratio (R/C) of 2.23 and a net profit of IDR 14,487,900. These findings suggest that compound fertilizer is both agronomically effective and economically profitable. The recommended application rate for cabbage is 211 kg/ha, applied one week after transplanting.

Keywords: Agronomic Performance, Benefit-Cost Ratio (R/C), Economic Viability, Fertilizer Efficiency, Vegetative Growth Parameters.

1. INTRODUCTION

Cabbage (*Brassica oleracea* L.) is a widely cultivated vegetable crop valued for its nutritional content and economic significance. As a leafy vegetable, its growth and productivity are highly dependent on the availability of essential nutrients, particularly nitrogen (N), phosphorus (P), and potassium (K) (Monib et al., 2023). These macronutrients play critical roles in plant physiological processes, including chlorophyll synthesis, energy transfer, and enzymatic regulation (Oliveira et al., 2019; Cecilio Filho et al., 2016). Inadequate nutrient supply can lead to stunted growth, reduced leaf development, and lower yields (Wang et al., 2013; Ashik et al., 2022).

Fertilization is a key agronomic practice to ensure optimal nutrient availability. Inorganic fertilizers are commonly used in vegetable production and are available in both single-nutrient forms—such as urea (N), SP-36 (P), and KCl (K)—and compound formulations that combine multiple nutrients in balanced proportions (McDonald et al., 2019). Compound fertilizers offer practical advantages, including simplified application and potential nutrient synergy, which may enhance plant growth and yield (Sikora et al., 2019). However, the effectiveness of compound fertilizers compared to single-nutrient sources can vary depending

on crop type, soil conditions, and application rates (da Silva et al., 2024; Song et al., 2023; Abou-Zied et al., 2018; Tamburini et al., 2017; Timilsena et al., 2015).

Despite the widespread use of fertilizers in cabbage cultivation, there is limited comparative research on the agronomic and economic performance of compound versus single-nutrient fertilizers under field conditions. Understanding the relative effectiveness of these fertilizer types is essential for developing efficient and sustainable fertilization strategies.

The objective of this study was to evaluate the effects of compound and single-nutrient fertilizer applications on the growth and yield of cabbage, and to assess their agronomic and economic effectiveness under field conditions.

2. MATERIALS AND METHODS

Study Site and Duration

The experiment was conducted at the IPB Experimental Farm located in Pasir Sarongge, Pacet Subdistrict, Cianjur Regency, West Java. The study was carried out over a three-month period, from October 2016 to January 2017.

Materials and Equipment

The primary materials used in this study included cabbage seeds, compound NPK fertilizer, and single-nutrient fertilizers such as urea, SP-36, and KCl. Cultivation tools comprised hoes, hand weeders, sprayers, sample markers, measuring tapes, and digital scales. Data analysis was performed using a computer equipped with the SAS statistical software package.

Experimental Design

A randomized complete block design (RCBD) was employed, consisting of seven fertilization treatments: no NPK fertilizer (P0), single-nutrient fertilization (P1), 0.5× recommended NPK dose (P2), 0.75× dose (P3), 1× dose (P4), 1.25× dose (P5), and 1.5× dose (P6). Each treatment was replicated four times, resulting in a total of 28 experimental plots. Each plot measured 25 m². A detailed description of the treatments is provided in Table 1. The addition of urea and KCl to the compound fertilizer treatment ensures the same amount of nutrient uptake by the plant as a single fertilizer treatment.

Table 1. Detailed fertilizer treatment dosage for compound and single-nutrient fertilizers.

Treatment	NPK Dosage (kg/ha)	Urea Dosage (kg/ha)	KCl Dosage (kg/ha)	SP-36 Dosage (kg/ha)
Control	-	-	-	-
Reference	-	200	100	100
0.5 dosage of NPK	105	51	20	-
0.75 dosage of NPK	158	76	30	-
1.0 dosage of NPK	211	102	40	-
1.25 dosage of NPK	264	127	50	-
1.5 dosage of NPK	316	153	60	-

Field Implementation

The land was prepared through two rounds of hoeing to ensure optimal soil conditions for planting. Raised beds measuring 1 meter in width and 5 meters in length were constructed, with 50 cm spacing between beds. Each experimental plot consisted of five beds. Cabbage seedlings were transplanted 21 days after sowing, with one seedling per planting hole.

The planting distance was set at 60 cm × 40 cm, with one plant per hole. Fertilizer was applied one week after transplanting, according to the designated treatment levels. Pest and disease management was conducted as needed, using targeted pesticide applications based on observed infestation levels.

Data Collection

Growth parameters observed included plant height and number of leaves, measured on five randomly selected plants per plot. Yield and yield components were assessed based on yield per plant, yield per plot, and extrapolated yield per hectare.

Data Analysis

Collected data were subjected to analysis of variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level to determine treatment differences. Economic analysis of the cropping system was conducted using profitability and benefit-cost ratio (R/C) as key indicators.

3. RESULTS AND DISCUSSION

Effect of Compound and Single-Nutrient Fertilizers on Cabbage Growth

Application of compound fertilizers significantly influenced cabbage plant height at 3 and 4 weeks after transplanting (WAT), but no significant differences were observed at 5 and 6 WAT (Table 2). The 0.5× dose of compound fertilizer resulted in greater plant height compared to the control at 3 WAT. At 4 WAT, the 1.0× dose produced the tallest plants, significantly outperforming the control. However, no significant differences in plant height were observed among treatments at 5 and 6 WAT.

Table 2. Effect of Compound and Single-Nutrient Fertilizer Application on Cabbage Plant Height.

Treatment	Plant Height (cm)			
	3 WAT	4 WAT	5 WAT	6 WAT
Control	18.5b	23.7b	28.4a	30.0a
Reference	19.2ab	25.2ab	28.9a	31.7a
0.5 dosage of NPK	19.4a	25.6ab	28.9a	31.6a
0.75 dosage of NPK	19.3ab	25.5ab	28.4a	29.0a
1.0 dosage of NPK	18.9ab	25.9a	28.9a	29.9a
1.25 dosage of NPK	19.3ab	24.8ab	28.0a	31.5a
1.5 dosage of NPK	18.9ab	24.8ab	28.7a	30.9a

Note: Values in the same column followed by the same letter are not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level.

Compound fertilizer treatments also significantly affected leaf number at 5 WAT, while no differences were found at 3, 4, and 6 WAT (Table 3). Treatments ranging from 0.5× to 1.5× doses resulted in a higher leaf count compared to the control at 5 WAT.

Table 3. Effect of Compound and Single-Nutrient Fertilizer Application on the Number of Cabbage Leaves.

Treatment	Leaves Number			
	3 WAT	4 WAT	5 WAT	6 WAT
Control	7.5a	10.3a	13.3b	21.7a
Reference	7.5a	10.9a	14.1a	22.3a
0.5 dosage of NPK	7.7a	10.6a	14.4a	22.3a
0.75 dosage of NPK	7.5a	10.6a	14.2a	22.1a

1.0 dosage of NPK	7.5a	11.0a	14.8a	22.7a
1.25 dosage of NPK	7.5a	10.3a	14.2a	22.4a
1.5 dosage of NPK	7.5a	10.9a	14.4a	21.8a

Note: Values in the same column followed by the same letter are not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level.

Effect of Compound and Single-Nutrient Fertilizers on Cabbage Yield

Compound fertilizer application had a significant impact on yield per plant (Table 4). Different fertilizer doses produced varying yield responses. The 1.0× dose yielded the highest output per plant, significantly surpassing both the control and the single-nutrient fertilizer treatment. Plants receiving the 1.0× dose produced an average of 1.92 kg of cabbage, compared to 1.03 kg and 1.72 kg from the control and comparison treatments, respectively—an increase of 86.4% and 11.6%.

Table 4. Effect of Compound and Single-Nutrient Fertilizer Application on Cabbage Yield.

Treatment	Yield/plant (g)	Yield/plot (kg)	Yield/ha (kg/ha)
Control	1030.0e	24.3e	9700e
Reference	1720.0b	38.3c	15300c
0.5 dosage of NPK	1545.0d	37.8dc	15100dc
0.75 dosage of NPK	1540.0d	37.0d	14800d
1.0 dosage of NPK	1920.0a	43.8a	17500a
1.25 dosage of NPK	1710.0b	36.8d	14700d
1.5 dosage of NPK	1660.0c	41.8b	16700b

Note: Values in the same column followed by the same letter are not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level.

Similarly, compound fertilizer significantly influenced yield per plot and per hectare (Table 4). The 1.0× dose resulted in the highest yield per plot (43.8 kg), outperforming the control (24.3 kg) and comparison treatment (38.3 kg). This trend was consistent with the yield per plant, indicating a positive correlation among yield parameters. Consequently, higher yield per plant and per plot translated into greater yield per hectare.

Relative Agronomic Effectiveness

Relative agronomic effectiveness (RAE) is a key metric for evaluating fertilizer performance. A fertilizer is considered agronomically effective if its RAE exceeds 100%,

indicating a greater yield increase compared to the standard fertilizer treatment. RAE values for compound fertilizer treatments are presented in Table 5.

Table 5. Relative Agronomic Effectiveness of Compound and Single-Nutrient Fertilizer Treatments.

Treatment	Relative Agronomic Effectiveness (%)
Control	-
Reference	-
0.5 dosage of NPK	96
0.75 dosage of NPK	91
1.0 dosage of NPK	139
1.25 dosage of NPK	89
1.5 dosage of NPK	125

The 1.0× and 1.5× doses of compound fertilizer achieved RAE values of 139% and 125%, respectively. The 1.0× dose was the most effective, enhancing yield by 1.39 times compared to the increase observed with the standard fertilizer.

Farm Business Analysis

Economic effectiveness of compound fertilizer was assessed using profit and the benefit-cost ratio (R/C). These indicators determine the economic feasibility of the farming practice. Results of the farm business analysis are shown in Table 6.

A fertilizer is considered economically viable if the R/C ratio exceeds 1. All compound fertilizer treatments met this criterion, indicating profitability for farmers. The 1.0× dose yielded the highest R/C ratio of 2.23, with a net profit of IDR 14,487,900.

Table 6. Farm Business Analysis Results for Various Treatments in the Evaluation of Compound and Single-Nutrient Fertilizer Effectiveness.

Treatment	Cost (Rp)	Revenue (Rp)	Benefit (Rp)	R/C
Control	9,425,000	14,550,000	5,125,000	1.54
Reference	12,035,000	22,950,000	10,915,000	1.91
0.5 dosage of NPK	10,589,800	22,650,000	12,060,200	2.14
0.75 dosage of NPK	11,174,800	22,200,000	11,025,200	1.99
1.0 dosage of NPK	11,762,100	26,250,000	14,487,900	2.23
1.25 dosage of NPK	12,347,100	22,050,000	9,702,900	1.79

1.5 dosage of NPK	12,926,900	25,050,000	12,123,100	1.94
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Discussion

Compound fertilizer application improved cabbage growth and yield. It enhanced plant height (at 3 and 4 WAT), leaf number (at 5 WAT), and yield parameters including yield per plant, per plot, and hectare. While early growth stages showed significant differences, later stages did not. However, yield components consistently favored the 1.0× dose, which increased yield per plant by 86.4% and 11.6% compared to the control and comparison treatments, respectively. Yield per plot and hectare also increased by 80.2% and 14.4%.

Nitrogen, supplied via inorganic fertilizers, is rapidly taken up by plants and transformed into ammonium and nitrate through microbial activity. This element is crucial for vegetative growth and chlorophyll synthesis, with deficiencies leading to suboptimal growth, thin stems, and narrow leaves (Živčák et al., 2014). Research has shown that nitrogen-deficient plants exhibit significantly lower photosynthetic efficiency and chlorophyll content, corroborating the essential role nitrogen plays in plant health (Doncheva et al., 2001; Redillas et al., 2011). Similarly, phosphorus is vital for carbohydrate formation and metabolic processes such as photosynthesis. It directly affects chloroplast activity and overall plant vigor, as its deficiency hinders energetic and structural functions (Manaroinsong et al., 2014). Potassium, another critical macronutrient, supports enzymatic reactions and stomatal regulation; lack of potassium impairs carbohydrate translocation and nitrogen metabolism, making plants increasingly vulnerable to stressors such as lodging and diseases (Fang et al., 2022; Šustr et al., 2019). Thus, an adequate supply of these macronutrients is essential for fostering plant resilience and productivity.

The effectiveness of compound fertilizer was evident both agronomically and economically. The 1.0× dose demonstrated the highest agronomic effectiveness (139%) and economic viability, with the highest R/C ratio and profit.

4. CONCLUSION

The results of this study indicate that the application of a 1.0× dose of compound fertilizer significantly improved yield components compared to both the control and the single-nutrient fertilizer treatment. This treatment was effective both agronomically and economically, yielding a benefit-cost ratio (R/C) of 2.23 and a net profit of IDR 14,487,900. Overall, compound fertilizer proved to be agronomically effective and economically

advantageous. The recommended dosage for cabbage cultivation is 211 kg/ha per application, administered one week after transplanting.

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