

Increase in Growth N, P, and K Absorption and Production of Corn (*Zea mays L.*) on Rainfed Paddy Fields Through Application of NPK 16-16-16 Fertilizer

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Article Information	ABSTRACT
Article History Received : June 05, 2025 Revised : June 21, 2025 Published : July 10, 2025	One of the national strategic foodstuffs is maize, whose production can still be increased because the actual yield in the lower than the potential yield. Problems that often arise is low fertility, especially nutrients N, P, and K. The aims of this research is to know the effect of NPK 16:16:16 fertilizer application on the growth, production and uptake of corn plants. The research was conducted in Mojokerto rainfed paddy fields with a randomized group design. The treatments given are 8 in the form of different doses of NPK 16:16:16 fertilizer and control in the form of no fertilizer and NPK 15:15:15 according to the recommended dose. Observation parameters observed were soil analysis, number of leaves, plant height, plant dry weight, NPK nutrient uptake and weight of 100 grains. Data analysis used ANOVA f test at 5% level and DMRT further test at 5% level. The application of NPK 16-16-16 fertilizer at 1/4 dose significantly increased the growth of corn plant and nutrient uptake. NPK 16:16:16 fertilizer at 1/2 dose significantly increased production.
Keywords: <i>Corn;</i> <i>Fertilizer;</i> <i>Nutrient;</i> <i>Soil.</i>	

INTRODUCTION

Rainfed paddy fields in Indonesia have an area of 3.71 ha (Sefrian et al., 2024). However, the obstacles faced in crop cultivation on this land are the soil is low availability of nitrogen, phosphorus, and potassium. Rainfed paddy fields in the Mojokerto district have relatively low fertility. The results of research by (Fitria et al., 2024) showed that C-organic, N, and K in the land were 0.92%, 0.07%, and 0.18 ppm per 100 grams. The contents of P, Na, Ca, and CEC were 5.12 ppm, 0.25 ppm, 2.18 ppm, and 10.76 ppm per 100 grams, respectively, so in cultivating crops, it is necessary to pay attention to suitable varieties and additional use of fertilizers.

One of the national strategic foodstuffs is maize, whose production can still be increased due to the fact that the yield in the field is less than expected output. The variety used in rainfed rice fields in Mojokerto is BISI 18, which has a production potential of 9.1 tons per ha. However, BPS (2020) data shows that the average maize productivity in irrigated rice fields reaches 7.8 tons/ha. Based on this fact, it can be seen that there is a significant distinction between the potential for production, one of which is caused by low soil fertility (Otieno, 2021). This condition is an opportunity to increase maize productivity through intensification, considering that plants require optimal conditions to achieve maximum yields (Kelley, 2020).

Intensification efforts are made to meet the needs of essential nutrients such as potassium, nitrogen and phosphorus by applying inorganic fertilizers such as urea, SP 36, and KCl (Hapsoh et al., 2023). potassium (K), Nitrogen (N), phosphorus (P) are essential nutrients that are needed by

plants for growth and development (Kumar et al., 2021). However, plants cannot fully absorb the elements of N, P, and K applied through fertilization (Sultanbawa & Sultanbawa, 2023). Previous research found that plants can only absorb nitrogen as much as 55-60%, P 20%, and K 50%-70%. So, efforts can be made by increasing the content of nutrients in the soil so it must have a strategy for fertilizing one of them through fertilizer nutrient levels. Another compound NPK fertilizer being developed contains 16% N, 16% P, and 16% K. This fertilizer advantage is that the content of each nutrient is the same, which is expected to meet the soil's nutrient needs and increase corn plant growth and uptake.

Various NPK fertilization efforts on corn plants have been carried out with various treatment combinations. Research conducted by (Hasan et al., 2020) showed that the application of NPK fertilizer at a dose of 300 kg/ha showed an increase in growth in corn plants because the addition of appropriate fertilizer will increase chlorophyll levels, which in turn can affect energy transport in plants. Another study by (Chávez-mejía et al., 2019) found that the ring pit planting layout method combined with 300-400 kg/ha of fertilizer showed a significant increase in the growth and yield of sweet corn plants in Ponorogo Regency. However, there have not been many studies related to increasing growth, N, P, and K nutrient uptake and production in rainfed paddy fields due to the application of NPK 16-16-16 fertilizer. Therefore, the aims of this research was to determine the correct fertilizer dosage to increase the growth and uptake of N, P, and K of maize plants.

RESEARCH METHODS

This study was carried out in rainfed rice fields of Kebondalem Village, Mojosari District, Mojokerto Regency. This research used a Randomized Group Design (RGD) with 8 treatments and 3 replications. The treatment used was the dose level of NPK 16-16-16 fertilizer added with single fertilizers such as urea and KCl. The treatment used as a control is NPK 15-15-15 + urea + KCl fertilizer and treatment without additional fertilizer. The fertilizer dose treatments used are presented in Table 1.

Table 1. Fertilizer dose treatment

Treatment code	Treatment	Fertilizer (kg/ha)			
		NPK 15:15:15	NPK 16:16:16	Urea	KCl
N1	Control	0	0	0	0
N2	NPK 15-15-15	256	0	393	181
N3	NPK 16-16-16	0	240	393	181
N4	3/4 Dose NPK 16-16-16	0	180	293	136
N5	1/2 Dose NPK 16-16-16	0	120	195	91
N6	1/4 Dose NPK 16-16-16	0	60	98	45
N7	3/2 Dose NPK 16-16-16	0	360	585	275
N8	7/4 Dose NPK 16-16-16	0	420	683	320

Land Preparation

Land preparation includes clearing the planting area of weeds and making beds 5 m long and 4 m wide. Between beds are limited with drainage channels with a width of 20 cm and a depth of 25 cm. This aims to prevent the influence of fertilizer treatment between plots through surface flow on plants.

Planting

BISI 18 corn seeds were planted as many as 2 seeds with a distance of 70 x 20 cm with a planting hole depth ranging from 2-4 cm from the soil surface.

Fertilization

The application of inorganic fertilizers NPK 16-16-16, NPK 15-15-15, Urea, and KCl was done gradually by making holes at a distance of 5 cm from the plant, namely at 14, 30, and 45 DAP, as much as 1/3 of the fertilizer dose.

Replanting

Replanting was done at 7 DAP to replace dead plants with abnormal growth, plants attacked by pests and diseases and seeds that did not germinate.

Weeding and watering

Manual weeding of weeds in the observation beds was done once a week. Watering is done every 3 days in the afternoon.

Pest control

Pest control is done manually using a peck to remove urets in the field.

Observations

Observations included growth observation and nutrient uptake of corn plants at the age of 27 and 54 DAP. The following are the observation parameters.

Table 2. Observation Parameters

Observation	Variabel	Metode	Time (DAP)
Soil Analysis	1. pH (H ₂ O)	Glass elektroda	Before Planting
	2. Total-n	Kjedhal	
	3. Available-P	Bray	
	4. Exchangable K	NH ₄ OAc 1NpH7	
	5. Exchangable Na	NH ₄ OAc 1NpH7	
	6. Exchangable Ca	NH ₄ OAc 1NpH7	
	7. Exchangable Mg	NH ₄ OAc 1NpH7	
	8. CEC	NH ₄ OAc 1NpH7	
	9. BS	Calculation	
	10. C-organic	Walkey and Black	
	11. Texture	Pipette	
Plant Analysis	1. Plant Height	measurements	27 and 54
	2. Number of leaves	Calculation	27 and 54
	3. Dry weight	Oven	27 and 54
	4. Plant N content	Kjedhal (H ₂ SO ₄)	27 and 54
	5. Plant P content	(HNO ₃ and HClO ₄)	27 and 54
	6. N Uptake	%N X BK	27 and 54
	7. P Uptake	%P X BK	27 and 54
	8. K Uptake	%K X BK	27 and 54
Production	1. Cob weight/plant weight	Weighing	100
	2. Cob weight /ha	Weighing	100
	3. Weight of 100 grains	Weighing	100

Data analysis

Analysis of variance (ANOVA) with a 5% confidence interval was used to analyze the data. If there were significant differences, further tests with Duncan's Multiple Range Test (DMRT) were conducted to determine differences between treatments.

RESULTS AND DISCUSSION

Soil Analysis

Soil analysis was conducted to determine the nutrient content of the soil before planting corn plants. The analysis of this research soil included pH, C-Organic, total N, available P, Kdd, Nadd, Cadd, Mgdd, CEC, BS and soil texture. The results of the initial soil analysis are presented in the following table:

Table 3. Results of Soil Analysis

Parameters	unit	Result	criteria*)
pH H ₂ O	-	6,37	Slightly acidic
pH KCl	-	5,24	
C-organic	%	0,92	Very Low
Total-N	%	0,07	Very Low
P ₂ O ₅	ppm	5,20	Low
Exchangable K	Cmol (+)/kg	0,18	Very Low
Exchangable Na	Cmol (+)/kg	0,25	Low
Exchangable Ca	Cmol (+)/kg	2,18	Low
Exchangable Mg	Cmol (+)/kg	3,60	High
CEC	Cmol (+)/kg	10,76	Low
BS	Cmol (+)/kg	75,71	Low
Texture			Sandy Loam
Fraction			
Sand	%	56	
Silt	%	25	
Clay	%	19	

The results showed that the pH value of 6.37 was slightly acidic, organic C, N, and K values were very low at 0.92%, 0.07%, and 0.18 milligrams per 100 grams, respectively; and P, Na, Ca, and CEC values were very low at 5.20 ppm, 0.025 milligrams per 100 grams, and 2.18 milligrams per 100 grams, respectively. The value of Mg in the high criteria is 3.60 milligrams per 100 grams. This aligns with (Al Viandari et al., 2022) that the soil in rainfed paddy fields in Jakenan, Pati, has a clay texture and is slightly acidic (5.4). Soil analysis in the area also showed that levels of organic C, N, P, K, Ca, Mg and cation exchange capacity (CEC) were low, which could be a limiting factor in crop cultivation in Pati. Based on these conditions, in general, rainfed paddy fields need to get external inputs such as fertilization. According to (Wang et al., 2024), corn cultivation without fertilization on land with nutrient limiting factors will not produce optimal production.

Effect of NPK Fertilizer Dosage on Maize Plant Growth

The following are the results of observations during the study and analysis of the effect of various doses of NPK fertilizer on the growth of corn plants (*Zea mays* L.). The parameters observed include plant height and number of leaves. Each parameter was analyzed to see the plant's response to variations in the dose of NPK fertilizer given to determine the most optimal dose for supporting corn plant growth.

Table 4. Effect of NPK Fertilizer Dosage on Maize Plant Growth

Treatment Code	Plant Height (cm)		Number of leaves (strands)		Dry Weight (g)	
	27 DAP	54 DAP	27 DAP	54 DAP	27 DAP	54 DAP
N1	15,40 ab	59,6 a	5	9	1,99	27,94 a
N2	12,40 a	64,9 a	4	8	2,27	33,13 ab
N3	22,40 bc	130,5 b	5	11	5,27	50,96 abc
N4	24,40 c	128,3 b	6	11	6,27	50,79 abc
N5	22,00 bc	134,7 b	6	11	5,69	53,15 bc
N6	19,50 bc	123,6 b	6	11	4,24	52,90 bc
N7	19,39 bc	123,8 b	6	11	4,17	64,49 c
N8	20,37 bc	144,3 b	6	11	4,76	72,04 c

The results of observations on the number of leaves parameter did not show significant differences between parameters. According to research conducted by (Liu et al., 2020) the growth parameters of plants tend to be influenced by the varietal factors used so the relationship with this study is that the dose of fertiliser does not affect the number of plant leaves. Fertilizer application did not significantly affect the number of leaves of the plant; a similar thing was explained in the study (Made et al., 2023) the application of N fertilizer at 100% N to 50% N did not show significant differences in the number of leaves.

The parameters of plant height and plant dry weight showed variations between treatments at 27 DAP and 54 DAP. At 27 DAP, the N4 treatment showed the highest plant height of 24.40 cm, significantly different from the control treatment, while the N2 treatment, the control treatment, had the lowest plant height of 12.40 cm. At 54 DAP, the N8 treatment produced the highest plant height of 144.3 cm, statistically significantly different from the N1 treatment, which showed the lowest plant height of 59.6 cm. However, it is not different from the lower dose treatment up to N8 (recommended dose) so it can be concluded that there is no significant impact with the addition of fertilizer. This condition can occur because the recommended dose is able to fulfill the nutrient needs of a plant to grow optimally so that if the dose is added there is no significant impact and can even cause toxic effects on plants and nutritional imbalances.

At 27 DAP, dry weight parameters showed no significant differences between treatments, but the highest was in the N4 treatment and the lowest in N1. Observation of 54 DAP showed a significant difference between treatments with the control, the highest value was in N8 at 72.04 grams and significantly different from the lowest value of 27.94 grams in treatment N1. According to (Sakamoto et al., 2021), if the plant experiences nutrient deficiency or the availability of nutrients is small, the growth rate will decrease, one of which is in the parameters of plant height and dry weight.

On the other hand, the maximum dose of NPK 16-16-16 fertilizer reached 7/4 of the recommended dose, but the plant height and dry weight were not significantly different except for the N1 and N2 treatments. This can be because plants have optimal nutrient absorption, so excessive fertilizer application cannot be absorbed and used for plant growth (Alaoui et al., 2022). Research by (Romadona & Islami, 2023) found that applying NPK fertilizer doses of 150 kg/ha and 500 kg/ha did not show significant differences in plant length, stem diameter and number of leaves. Another factor that can affect plant growth is the period of fertilization which will increase the optimal absorption of nutrients.

Effect of NPK Fertilizer Dosage on Maize Crop Production

Indicators to test the effectiveness of fertilizers require data on the production of maize plants at harvest time, in addition to analyzing plant growth. The following presents the results of the average cob weight of each plant, production data per plant, cob weight per hectare, and 100-grain weight to determine the production resulting from the fertilizer application treatment.

Table 5. Effect of NPK Fertilizer Dosage on Maize Plant Productivity

Treatment Code	Cob weight (g/plant)	Cob weight (ton/ha)	Weight of 100 grain (g/plant)	Dry kernel weight (ton/plant)
N1	81,92 a	5,85 a	5,50a	3,66a
N2	105,11 ab	7,50 ab	10,57ab	4,83a
N3	157,71 d	11,27 d	18,90cd	7,98bc
N4	130,42bc	9,31 bc	15,10bcd	6,85b
N5	141,03 cd	10,07 cd	15,53bcd	6,77b
N6	129,35 bc	9,23 bc	13,13bc	7,31b
N7	155,72 cd	11,12 cd	17,87cd	7,79bc
N8	153,53 d	10,96 d	20,67d	8,96c

The result of analysis variance showed that the application of NPK fertilizer doses had a significant effect on the production of maize plants, including the weight of cobs per plant, the weight of cobs per hectare and the weight of 100 dry kernels. The highest average cob weight per plant was found in the N3 treatment (NPK 16-16-16) at 157.7 g/plant. The highest average weight of 100 dry kernels was obtained in the N8 treatment (NPK 16-16-16 7/4 recommended dose), which was 20.67, significantly different from the control treatment. The highest average dry crackers per hectare weight was found in the N8 treatment (NPK 16-16-16 7/4 recommended dose) at 8.96 tonnes/ha and significantly different compared to the control. Based on these results, it shows that the N5 treatment (NPK 16-16-16 ½ dose) of 120 kg/ha can increase the production of corn plants in the weight of cobs per plant, the weight of cobs per hectare and the weight of 100 grains per hectare.

According to the research was conducted by (Pusparini et al., 2018) that increasing the dose of NPK fertiliser up to 400 kg/ha did not have a significant effect on the weight of 100 dry kernels in line with the results of the study. Fertilization and other environmental factors influence cultivation success (Fauziah et al., 2023) . Since the light intensity and quality received by each plant are relatively the same, the effect on flowering hormone activity is also relatively the same. In addition, the response of plants to certain fertilizers is determined by many factors, including plant genetics, climate, and soil, as these factors are interrelated (Jumiatun et al., 2023). A plant needs a sufficient amount of available nutrients, adding more will not enhance growth and could even be harmful. This is known as the Law of Minimums and diminishing returns. In addition, adding more fertilizer can cause root stress because fertilizers contain salts that can cause osmotic stress (Beyk-Khormizi et al., 2023).

Effect of NPK Fertilizer Dosage on the Uptake of N, P, and K Nutrients in Maize Plants

Uptake observations were made in the vegetative and early generative phases at 27 and 54 DAP, respectively. This was done to determine the dynamics of nutrient uptake in maize plants that can affect the growth and yield of maize plants.

Table 6. Effect of NPK Fertilizer Dosage on Nutrient Uptake of Maize Plants

Treatment code	Nitrogen Uptake (g/plant)		Phosphor Uptake (g/plant)		Potassium Uptake (g/plant)	
	27 DAP	54 DAP	27 DAP	54 DAP	27 DAP	54 DAP
N1	0,02	0,42 a	0,0026	0,05 a	0,015 a	0,0239 a
N2	0,02	0,76 ab	0,0025	0,05 a	0,015 a	0,0290 ab
N3	0,07	0,98 b	0,0075	0,09 ab	0,039 b	0,0419 ab
N4	0,10	0,96 b	0,0074	0,08 ab	0,043 b	0,0441 ab
N5	0,05	1,13 bc	0,0064	0,12 b	0,039 b	0,0362 ab
N6	0,06	1,02 bc	0,0057	0,11 b	0,024 ab	0,0362 ab
N7	0,06	1,21 bc	0,0058	0,12 b	0,029 ab	0,0517 b
N8	0,07	1,45 c	0,0061	0,18 c	0,035 ab	0,0544 b

Observations showed that plant nitrogen uptake increased significantly from 27 DAP to 54 DAP in all treatments. At 27 DAP, N uptake ranged from 0.02-0.10 g/plant, with the highest value shown by treatment N4. However, at 54 DAP, the highest N uptake was obtained from treatment N8 at 1.45 g/plant and significantly different from other treatments, while the lowest value was still shown by N1 (0.42 g/plant). P uptake also increased from 27 DAP to 54 DAP. At 27 DAP, the value of P uptake ranged from 0.0025-0.0075 g/plant, with a not-too-significant difference. However, at 54 DAP, there was a more apparent variation, where treatment N8 showed the highest P uptake of 0.18 g/plant, significantly different from treatments N1 and N2 (0.05 g/plant each). The highest potassium (K) uptake at 27 DAP was obtained from treatment N4 at 0.043 g/plant, while the lowest value was shown by treatments N1 and N2 (0.015 g/plant). At 54 DAP, treatment N8 again showed the highest results (0.0544 g/plant), significantly different from treatment N1. However, in general, all treatments showed that N, P, and K uptake did not show significant differences with treatment N4 (1/4 recommended dose (60 kg NPK + 98 kg urea + 45 kg KCl). Based on these results, it can be concluded that treatment F (NPK 16-16-16 ¼ recommended dose) is the optimal dose for increasing the K uptake of maize plants at 27 and 54 DAP. The treatment has increased the K uptake of maize plants by 51.42% compared to the control, so fewer fertilizer needs can be said to be more effective. This condition can occur because the ability to absorb nutrients is limited, and plants can know the optimal needs of nutrients so that they do not always the more fertilizers given can be absorbed entirely by plants (Selzer & Schubert, 2021). This aligns with the research by (Canatoy, 2018) applying 70 kg/ha of N fertilizer, 50 kg/ha of P fertilizer and no K fertilizer to increase potassium uptake by 58.48%.

CONCLUSION

The results of this study provide an important contribution to the fertilization efficiency of maize crops, especially with the use of NPK 16-16-16 fertilizer. The use of 1/2 dose of the recommendation proved to be able to increase production significantly, while 1/4 dose was able to increase nutrient uptake more efficiently than NPK 15:15:15 fertilizer. This research has practical implications for saving production costs and reducing the environmental impact of excessive fertilizer use, while still promoting optimal productivity of maize farming.

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