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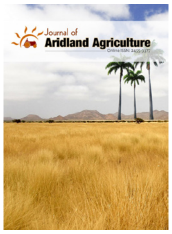
Research Article



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The effect of balanced N, P, K, Ca, Mg fertilizer on soil and leaf nutrient and its correlation with growth and corn yield (*Zea mays* L.)

Jauhari Syamsiyah[1]*, Sri Hartati[1], Lily Rahmanisa[2], Siti Maro'ah[1], Ganjar Herdiansyah[1]

[1]Department of Soil Science, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, Central Java, Indonesia,
[2]Undergraduate Program, Soil Science, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, Central Java, Indonesia

ABSTRACT

Fertilization in agricultural cultivation is important in increasing the supply of necessary nutrients for plants to achieve high yield and quality. This study aims to examine the balance of N,P,K,Ca, and Mg against nutrients in soil and plants and its correlation with the growth and yield of corn. There were 9 treatments of N, P, K, Ca, Mg fertilizer balance used, namely: control (A) and 1: 1: 1: 0: 0 (B); 0.25: 0.25: 0.25: 1: 1 (C); 0.5: 0.5: 0.5: 1: 1 (D); 0.75: 0.75: 0.75: 1: 1 (E); 1: 1:1: 1: 1 (F); 0.75: 0.75: 0.75: 0.25: 0.25 (G); 0.75: 0.75: 0.75: 0.5: 0.5 (H); 0.75: 0.75: 0.75: 0.75: 0.75 (I). Parameters observed included nutrients N, P, K, Ca, and Mg in soil and leaf, plant height, stem diameter, number of leaves, cob weight with and without husks, and cob length and diameter. The results showed that nutrient balance significantly affected nutrient levels in soil and leaf, plant growth, and yield of corn. N, P, K, Ca, Mg Fertilizer application with ratio 0.5: 0.5: 0.5: 1: 1 (D) increased soil N 100%, P 40%, K 108.33%, Ca 28.08%, Mg 30.17% higher than the control and plant leaf N, P, K, Ca, Mg about 101.60%, 12.50%, 10.13%, 50.98%, 101.41% respectively, thus providing higher growth and yield. There was a significant correlation between plant height with leaf N and K, stem diameter correlated with leaf Ca, and number of leaves correlated with Mg in corn leaf. Meanwhile, yield correlated with P.

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***Corresponding author:**
Jauhari Syamsiyah
E-mail: ninukts@staff.uns.ac.id

KEYWORDS: Fertilizer balance, Nutrient status, Plant growth, Corn yield

INTRODUCTION

Plants will get optimal results if the nutrients are adequate and balanced (Weil & Brady, 2017). An imbalance in nutrient supply will affect uptake and utilization, thus reducing yield (Bado & Bationo, 2018). Nutrient-deficient plants generally have slow growth and low yields, so fertilization is very important to increase growth and yield. Corn plants require 16 essential nutrients (Salisbury & Ross, 1978) and to produce 1 kg of corn requires nutrients N.P.K.Ca.Mg amounting to 12.9 g/kg N; 3.8 g/kg P; 4.8 g/kg K; 0.28 g/kg Ca; 1.45 g/kg Mg (Heckman *et al.*, 2003), while Bundy (1998) said it was 20.34 g/kg N, 3.67 g/kg P, 18.53 g/kg K, 3.56 g/kg Ca, 3.45 g/kg Mg.

Meanwhile, the most widely used fertilizer in Indonesia is NPK fertilizer, which is readily available and easy to obtain. In addition, policies on using NPK fertilizers are determined uniformly without regard to soil heterogeneity in an area (Agriculture Minister Regulation No. 13 of 2022). Many studies have also been conducted related to NPK fertilizers, such as those conducted by Arifin (2019), who studied liquid NPK fertilizers on corn growth. Other researchers, Miftakhurrohmat and Putrianingsih (2017), studied NPK fertilizers and Growth Regulators (ZPT) on sweet corn plant growth and production. Meanwhile, the use of NPK fertilizer affects the performance of corn plants (Pertaminingsih *et al.*, 2018).

Besides traditional practices such as fertilization, the resistance of crop varieties is important in improving growth and yield. Disease resistance will have an impact on plant quality and production levels. The fungus *Peronosclerospora maydis* is a parasite of corn plants that often causes downy mildew (Hoerussalam *et al.*, 2013; Adhi *et al.*, 2021). Infected plants experience obstacles in photosynthesis, which decreases chlorophyll content. As a result, plants become stunted or even immature, causing crop failure (Agustamia *et al.*, 2016). Downy mildew caused a 10-90% reduction in corn production in Kediri District, East Java (Hoerussalam *et al.*, 2013). Downy mildew-resistant varieties can be used for disease control (Putri & Kasiamdari, 2023). Hybrid corn variety Pioneer is one of the varieties suitable for planting in the lowlands because of its high production and resistance to leaf rust, leaf spot C, Zeae-maydis, somewhat resistant to Diplodia cob rot, viruses, and cob rot, somewhat susceptible to stem rot and downy mildew (Irawan *et al.*, 2013). In this study, resistant pioneer hybrid corn varieties were also used to improve growth and yield in addition to fertilizer management practices.

The level of disease attack also will decrease if K nutrients are sufficient. K elements increase the formation of fungicidal phenol compounds and reduce inorganic N content in plant leaves. These two factors increase plant resistance to disease (Subandi, 2013). So far, the nutritional needs of plants are met mainly by applying NPK fertilizers because most plants have a high need for these elements. However, besides NPK, Ca and Mg also play an important role in plant metabolism. Thor (2019) reported that calcium increases the absorption of other nutrients and nutrient translocation within the plant, while magnesium increases nitrogen utilization (Gaj *et al.*, 2018). Calcium (Ca) and magnesium (Mg) limit crop yields less frequently than N, P, and K, so Ca and Mg are referred to as secondary macro-nutrients because they are required by plants in relatively large quantities (Bekele & Birhan, 2021). Nguyen *et al.* (2017)looked at the effect of the ratio of K, Ca, and Mg on the uptake and fruit quality of citrus plants, and Sitohang *et al.* (2019)examined the growth and number of cocoa pods applied with N.P.K.Ca.Mg fertilizer.

Meanwhile, research on the balance of N.P.K.Ca.Mg in corn plants is still very limited. If carried out continuously, this policy will cause serious nutrient imbalances in the soil, low nutrient use efficiency, and low plant yields (Rustiana *et al.*, 2021). This study aims to assess the balance of N.P.K.Ca.Mg in soil and plant nutrient levels and its relationship with the growth and yield of corn.

MATERIALS AND METHODS

Location and Soil Characteristics

The research was conducted in Trayu, Banyudono District, Boyolali Regency, Central Java Province, Indonesia (7°31'00.9" S; 110°41'19.0" E) from May to December 2022. Soil types include Entisols. The soil has low C-Organic, N, P, and K nutrients, medium Ca, Mg, low CEC, and high base saturation (Table 1). Generally, the soil has low fertility (Agustian & Simanjuntak, 2018).

Experimental Design and Treatments

This field experiment used a randomized complete block design (CRD) with 9 treatments of N.P.K.Ca.Mg fertilizer balance as follows: control (A) and 1: 1: 1: 0: 0 (B); 0.25: 0.25: 0.25: 1: 1 (C); 0.5: 0.5: 0.5: 1: 1 (D); 0.75: 0.75: 0.75: 1: 1 (E); 1: 1: 1: 1: 1 (F); 0.75: 0.75: 0.75: 0.25: 0.25 (G); 0.75: 0.75: 0.75: 0.5: 0.5 (H); 0.75: 0.75: 0.75: 0.75: 0.75 (I). Fertilizer doses were given for each treatment (Table 2). N fertilizer (urea) is given 3 times, 0, 28, and 42 Days after planting (DAP). P (SP36) and K (KCl) fertilizers were applied simultaneously at planting time. Ca Mg fertilizer was applied when the plants were 14 days after planting. Corn seeds were planted with a 25 x 75 cm spacing in each plot with an area of 4 x 5 m. Maintenance was carried out as practiced by local farmers.

Soil samples were taken at 0-20 cm depth during the vegetative period (Subekti *et al.*, 2007). The soil was air dried, crushed, and sieved <0.5 mm before analysis. The analysis carried out includes total N (Kjeldahl method) (Lin *et al.*, 2020), available P (Olsen method) (Zhan *et al.*, 2015), exchangeable K, Ca, Mg (ammonium acetate saturation method) (Yu *et al.*, 2017).

Plant sampling (leaf) and plant growth observation were conducted during the maximum vegetative phase (56 days after planting). For plant leaf analysis, leaf samples were dried at 60 °C, and then dry samples were pulverized using a grinding mill machine. Leaf analysis carried out includes N (Kjeldahl method) (Lin *et al.*, 2020), P, K, Ca, and Mg (wet soaking method with HNO_3 and $HClO_4$) (Vj *et al.*, 2023). Plant growth measurements include plant height, stem diameter, and number of leaves. Yield measurements were carried out when the plants reached the generative phase (84 days after planting) with the measured parameters including cob weight with husk, cob weight without husk, cob length, and cob diameter.

Table 1: Soil characteristics of the study area

Parameter	Unit	Value	Classification*
pH		6.2	Slightly acid
C-Organic	%	1.94	Low
Total N	%	0.10	Low
Available P	ppm	5	Low
Exchangeable K	me/100 g	0.12	Low
Exchangeable Ca	me/100 g	7.12	Medium
Exchangeable Mg	me/100 g	3.00	High
CEC	me/100 g	15.63	Low
Base Saturation	%	72.12	High

(*)Eviati and Sulaeman (2009)

Table 2: Fertilizer Dosage of N, P, K, Ca, and Mg

Ratio N.P.K.Ca.Mg	Fertilizer Dosage				
	N (kg/ha)	P (kg/ha)	K (kg/ha)	Ca (kg/ha)	Mg (kg/ha)
(A) control	0	0	0	0	0
(B) 1: 1: 1: 0: 0	157.5	23.6	31.1	0	0
(C) 0.25: 0.25: 0.25: 1: 1	39.4	5.9	7.8	0.4	0.08
(D) 0.5: 0.5: 0.5: 1: 1	78.8	11.8	15.6	0.4	0.08
(E) 0.75: 0.75: 0.75: 1: 1	118.1	17.7	23.3	0.4	0.08
(F) 1: 1: 1: 1: 1	157.5	23.6	31.1	0.4	0.08
(G) 0.75: 0.75: 0.75: 0.25: 0.25	118.1	17.7	23.3	0.1	0.02
(H) 0.75: 0.75: 0.75: 0.5: 0.5	118.1	17.7	23.3	0.2	0.04
(I) 0.75: 0.75: 0.75: 0.75: 0.75	118.1	17.7	23.3	0.3	0.06

Statistical Analysis of Data

The data obtained were analyzed with a one-way ANOVA test to determine the effect of fertilizer balance on the observation parameters, a continued DMR test at a 95% confidence level to determine differences between treatments, and a Pearson correlation test to determine the relationship between parameters. All statistical analyses were performed using the IBM SPSS Statistic 22 Software.

RESULTS

Effects of N.P.K.Ca.Mg Ratio on Soil Nutrient Content

Soil nitrogen (n) total

There is a significant effect of N.P.K.Ca.Mg fertilizer balance with various ratios on total soil N. The results showed that the balance of N.P.K.Ca.Mg fertilizer with a ratio of 0.5: 0.5: 0.5: 1: 1 (D) increased soil total N by 100% higher and significantly different from the control (A) and other treatments except for the ratio of 1: 1: 1: 0: 0 (B) and 1: 1: 1: 1: 1 (F) (Tabel 3).

Phosphorus (P)

N.P.K.Ca.Mg fertilizer balance with various ratios significantly increased available P in the soil. Application of N.P.K.Ca. Mg fertilizer with a ratio of 0.5: 0.5: 0.5: 1: 1 (D) produced lower available P than the ratio 1: 1: 1: 0: 0 (B) although not significantly different, but higher than the control (A). Likewise, there was no significant difference between 0.5: 0.5: 0.5: 1: 1 (D) with the highest fertilizer ratio 1: 1: 1: 1: 1 (F) on soil available P (Table 3).

Potassium (K)

N.P.K.Ca.Mg fertilizer balance with various ratios significantly increased the exchangeable K content in the soil. The higher the K_2O ratio, the more exchangeable K in the soil (Table 3). The results showed that the balance of N.P.K.Ca.Mg fertilizer with a ratio of 0.5: 0.5: 0.5: 1: 1 (D) was significantly different from the control (A) with an increase in exchangeable K of 108.33% and 0.5: 0.5: 0.5: 1: 1 (D) showed significantly different results lower than 1: 1: 1: 0: 0 (B) with a decrease of 26.47%.

Calcium (Ca)

The balance of N.P.K.Ca.Mg fertilizers with various ratios affects the exchangeable Ca in the soil. The resulting average soil exchangeable Ca levels ranged from 7.69-9.85 me/100 g (Tabel 3) and increased with increasing Ca fertilizer doses. The highest soil exchangeable Ca content was found at a fertilizer ratio of 0.5: 0.5: 0.5: 1: 1 (D), which gave significantly different results from 1: 1: 1: 0: 0 (B) with an increase of 27.26% and the control (A) at 28.08%.

Magnesium (Mg)

The balance of N.P.K.Ca.Mg fertilizers with various ratios significantly affected the exchangeable Mg in the soil (Table 3). The results showed that the balance of N.P.K.Ca.Mg fertilizer with a ratio of 0.5: 0.5: 0.5: 1: 1 (D) was significantly different with a presentation of 6.38% lower than 1: 1: 1: 1: 1 (F), but 29.41% higher than 1: 1: 1: 0: 0 (B) and 30.17% of the control (A).

Effects of N.P.K.Ca.Mg Ratio on Plant Leaf Nutrient Content

Nitrogen (N)

The analysis showed that N.P.K.Ca.Mg fertilizer balance with various ratios significantly increased leaf N. N.P.K.Ca.Mg fertilizer balance with a ratio of 0.5: 0.5: 0.5: 1: 1 (D) succeeded in providing the highest N by supplying 2.52% N which was not significantly different from 1: 1: 1: 1: 1 (F) with a higher increase of 22.92% and 18.30% higher than 1: 1: 1: 0: 0 (B) and significantly different from the control (A) (Table 4) with an increase of 101.60%.

Phosphorus (P)

The analysis showed that N.P.K.Ca.Mg fertilizer balance with various ratios significantly increased leaf P. The ratio fertilizer of 0.5: 0.5: 0.5: 1: 1 (D) increased P by 12.50%, which was significantly different from control (A), and not significantly different from 1: 1: 1: 0: 0 (B) and 1: 1: 1: 1: 1 (F), with a lower increase of 5.26% against 1: 1: 1: 1: 1 (F) (Table 4).

Table 3: Nutrient status of N, P, K, Ca, and Mg

Ratio N.P.K.Ca.Mg	Nutrient Status				
	Total N (%)	P (ppm)	K (me/100 g)	Ca (me/100 g)	Mg (me/100 g)
(A) control	0.09^{d}	5e	0.12f	7.69^{d}	3.38^{d}
(B) 157.5: 23.6: 31.1	0.17^{ab}	8^{a}	0.34^{b}	7.74^{d}	3.40^{d}
(C) 39.4: 5.9: 7.8: 0.4: 0.08	0.11^{cd}	7^{cd}	0.24e	9.78^{a}	4.42^{b}
(D) 78.8: 11.8: 15.6: 0.4: 0.08	0.18^{a}	7^{ab}	0.25e	9.85^{a}	4.4^{b}
(E) 118.1: 17.7: 23.3: 0.4: 0.08	0.12^{cd}	5e	0.32^{c}	9.54^{ab}	4.46^{b}
(F) 157.5: 23.6: 31.1: 0.4: 0.08	0.15^{abc}	7^{bc}	0.37^{a}	9.55^{ab}	4.70^{a}
(G) 118.1: 17.7: 23.3: 0.1: 0.02	0.14^{bc}	6^{d}	0.31^{c}	8.68^{c}	4.10^{c}
(H) 118.1: 17.7: 23.3: 0.2: 0.04	0.13^{bc}	6^{d}	0.31^{c}	8.73^{c}	4.17^{c}
(I) 118.1: 17.7: 23.3: 0.3: 0.06	0.12^{cd}	7^{ab}	0.29^{d}	9.37^{b}	4.47^{b}

Potassium (K)

N.P.K.Ca.Mg fertilizer balance with various ratios significantly increased leaf K (Table 4). The balance of N.P.K.Ca.Mg fertilizer at a ratio of 0.5: 0.5: 0.5: 1: 1 (D) supplied 2.50% K which was significantly different from control (A), with a higher increase up to 10.13% but had a lower increase of 7.40% from 1: 1: 1: 0: 0 (B) and 10.07% lower than 1: 1: 1: 1: 1 (F).

Calcium (Ca)

N.P.K.Ca.Mg fertilizer balance with various ratios significantly increased leaf Ca (Table 4). The balance of N.P.K.Ca.Mg fertilizer at a ratio of 0.5: 0.5: 0.5: 1:1 (D) supplied the highest Ca of 1.54%, which was significantly different and 6.20% higher than 1: 1: 1: 1: 1 (F), 28.33% higher than 1: 1: 1: 0: 0 (B), and 50.98% of the control (A).

Magnesium (Mg)

N.P.K.Ca.Mg fertilizer balance at various ratios significantly increased leaf Mg. N.P.K.Ca.Mg fertilizer balance at the ratio of 1: 1: 1: 1: 1 (F) gave the highest Mg level of 0.69% higher and was not significantly different from 0.5: 0.5: 0.5: 1: 1 (D), and significantly different higher by 93.24% against 1: 1: 1: 0: 0 (B) (Table 4) and 101.40% higher than the control (A).

Plant Growth

Plant height

The analysis showed that N.P.K.Ca.Mg fertilizer balance with various ratios significantly affected plant height. N.P.K.Ca.Mg fertilizer balance at the ratio of 0.5: 0.5: 0.5: 1: 1 (D) increased plant height by 228 cm, which was not significantly different from 1: 1: 1: 0: 0 (B), and 1: 1: 1: 1: 1 (F) with lower values. The ratio of 0.5: 0.5: 0.5: 1: 1 (D) also showed significantly different results from the control (A) (Table 5).

Stem diameter

N.P.K.Ca.Mg fertilizer balance with various ratios had a significant effect on stem diameter. N.P.K.Ca.Mg fertilizer balance with a ratio of0.5: 0.5: 0.5: 1: 1 (D) gave the largest diameter of 2.71 cm, which was not significantly different from 1: 1: 1: 1: 1 (F) or 1: 1: 1: 0: 0 (B), but significantly different from the control (A) (Table 5).

Number of leaves

N.P.K.Ca.Mg fertilizer balance with various ratios significantly affected the number of leaves (Table 5). N.P.K.Ca.Mg fertilizer balance at a ratio of 0.5: 0.5: 0.5: 1: 1 (D) gave results on the number of leaves as many as 13 strands, which were not significantly different from the ratio of 1: 1: 1: 0: 0 (B) and 1: 1: 1: 1: 1 (F) with lower values and significantly different from the control (A).

Corn Yield

Cob weight

The analysis showed that N.P.K.Ca.Mg fertilizer balance with various ratios significantly affected the weight of cob with and without husk. N.P.K.Ca.Mg fertilizer balance with a ratio of 0.5: 0.5: 0.5: 1: 1 (D) gave different results that did not significantly increase the weight of cob with cob and without husk with a percentage of 8.57% and 20.31% lower than 1: 1: 1: 0: 0 (B) respectively, but significantly increased cob weight with cob by 60.08% and cob weight without cob by 55.98% against the control (A) (Figure 1).

Length and diameter of cob

The analysis showed that N.P.K.Ca.Mg fertilizer balance with various ratios significantly affected cob length and diameter. N.P.K.Ca.Mg fertilizer balance with a ratio of 0.5: 0.5: 0.5: 1: 1 (D) gave results of cob length and cob diameter that were not significantly different with percentages of 5.31% and 2.13% lower than 1: 1: 1: 1: 1 (F), by 3.85% and 1.07% lower than 1: 1: 1: 0: 0 (B), but significantly increased cob length and cob diameter by 21.23% and 8.57% against the control (A) (Figure 2).

DISCUSSION

Nutrient Status on Soil and Leaf

Soil nutrient status needs to be known to assess the condition of available nutrients in the soil that can be absorbed

Table 4: Plant leaf nutrient status of N, P, K, Ca, and Mg

Ratio N.P.K.Ca.Mg	Plant leaf nutrient content				
	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
(A) control	1.25^{c}	0.16^{d}	2.27^{e}	1.02^{g}	0.71^{d}
(B) 157.5: 23.6: 31.1	2.13^{ab}	0.18^{ab}	2.70^{ab}	1.20^{f}	0.74^{d}
(C) 39.4: 5.9: 7.8: 0.4: 0.08	1.79^{bc}	0.17^{bc}	2.50^{cd}	1.37^{cd}	1.33^{b}
(D) 78.8: 11.8: 15.6: 0.4: 0.08	2.52^{a}	0.18^{abc}	2.5^{cd}	1.54^{a}	1.43^{a}
(E) 118.1: 17.7: 23.3: 0.4: 0.08	1.74^{bc}	0.18^{abc}	2.66^{b}	1.42^{bcd}	1.32^{b}
(F) 157.5: 23.6: 31.1: 0.4: 0.08	2.05^{ab}	0.19^{a}	2.78^{a}	1.45^{bc}	1.44^{a}
(G) 118.1: 17.7: 23.3: 0.1: 0.02	1.62^{bc}	0.17^{c}	2.52^{c}	1.34^{e}	1.13^{c}
(H) 118.1: 17.7: 23.3: 0.2: 0.04	1.64^{bc}	0.18^{abc}	2.42^{d}	1.39^{cde}	1.20^{c}
(I) 118.1: 17.7: 23.3: 0.3: 0.06	1.94^{ab}	0.18^{ab}	2.68^{b}	1.46^{b}	1.34^{b}

Table 5: Corn plant growth

Ratio N.P.K.Ca.Mg	Plant Growth		
	Height (cm)	Stem diameter (cm)	Number of leaves (strands)
(A) control	147^{d}	2^{d}	12^{c}
(B) 157.5: 23.6: 31.1	228^{ab}	2.51^{abc}	13^{ab}
(C) 39.4: 5.9: 7.8: 0.4: 0.08	190^{c}	2.47^{bc}	13^{ab}
(D) 78.8: 11.8: 15.6: 0.4: 0.08	228^{ab}	2.71^{a}	13^{ab}
(E) 118.1: 17.7: 23.3: 0.4: 0.08	215^{b}	2.38^{c}	12^{bc}
(F) 157.5: 23.6: 31.1: 0.4: 0.08	238^{a}	2.66^{ab}	14^{a}
(G) 118.1: 17.7: 23.3: 0.1: 0.02	218^{ab}	2.15^{d}	12^{c}
(H) 118.1: 17.7: 23.3: 0.2: 0.04	195^{c}	2.36^{c}	12^{c}
(I) 118.1: 17.7: 23.3: 0.3: 0.06	218^{ab}	2.47^{bc}	13^{ab}

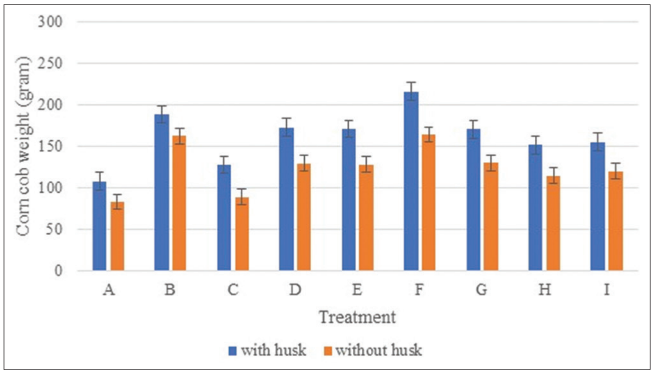

Figure 1: Corn cob weight

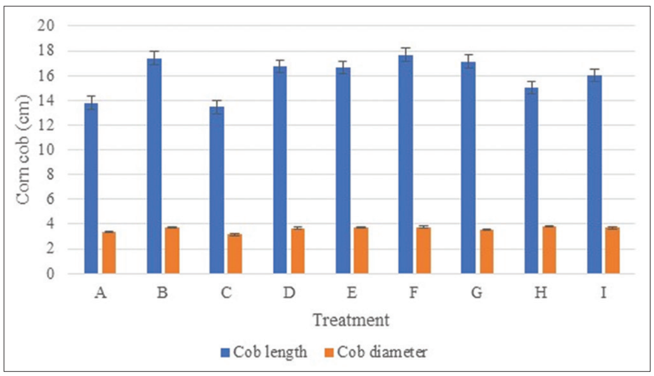

Figure 2: Cob length and cob diameter of corn plants

directly by the roots for plant growth. Nutrient availability is improved through fertilization. Various fertilizer ratios were applied to see the condition of soil nutrients and their uptake in plants. The results showed that the ratio of N.P.K.Ca.Mg significantly affected soil N, P, and K nutrients (Table 3) and plant leaves (Table 4). This is because the increased NPK content in the root zone will increase the concentration of nutrients in the leaves (Erel *et al.*, 2008). These results align with the research of Sulaeman *et al.* (2017), which states that NPK fertilizers have water-soluble properties so that they easily dissolve in soil solution, which causes total soil N P and K to increase.

Similar results were observed for soil and leaf Ca and Mg, which were significantly affected by fertilizer application. Applying Ca and Mg fertilizers increases the amount of Ca and Mg accumulation in the soil, which increases the effect on nutrient levels in the leaf. This result is in line with Nirmalayanti *et al.* (2017) that NPK quickly provides nutrients because it has a relatively high solubility, and the application of CaMg contributes Ca and Mg elements to the soil followed by an increase in soil pH so that nutrient absorption becomes optimal. Weng *et al.* (2022) said that the rate of Ca accumulation in each leaf increases gradually with increasing doses of Ca ions because plants can directly absorb the nutrients contained in fertilizers, so the availability of nutrients in the soil is increased by fertilization. However, fertilizers' efficiency depends on the fertilizers' dissolution rate in the soil (Zhang *et al.*, 2022).

Tables 3 and 4 illustrate that the application of N.P.K.Ca.Mg fertilizer with not too high NPK doses at a ratio of 0.5: 0.5: 0.5: 1: 1 (D) increased nutrient levels in soil and plants, which tended not to differ from 1: 1: 1: 1: 1 (F). This can occur because nutrients are sufficiently available in the soil in sufficient quantities, so reducing fertilizer doses can supply nutrients to plants. In line with research conducted by Sitohang *et al.* (2021) on cacao plants, the application of N.P.K.Ca.Mg fertilizer at a dose that is not too high provides sufficient nutrients for plants manifested by the best results in Terrell and fruit stock, while the application of fertilizer at high doses reduces the plant's response to the number of flushes, flowers, cherries, and fruit stock.

Corn growth

The benchmark in knowing the response of fertilization to plant vegetative growth can be seen from plant height, stem diameter, and number of leaves (Sudding *et al.*, 2021). NPK fertilizer is needed to increase plant height during growth, enlarge stem diameter, and form roots to support the plant to stand upright (Hasan *et al.*, 2020).

The analysis showed that the fertilizer balance of N.P.K.Ca.Mg had a significant effect on plant height, stem diameter, and number of leaves (Table 5). This is because these fertilizers contain nutrients plants need to strengthen plant structure and produce enough chlorophyll for photosynthesis to increase growth. This aligns with research conducted by Sitanggang *et al.* (2018) that shows that using NPK and dolomite fertilizers (Ca and Mg) resulted in higher vegetative growth in rice. As Marschner (2012), K plays an important role in cell elongation, Ca plays a role in cell wall formation and membrane stabilization, and Mg is a component of chlorophyll needed in the process of photosynthesis and protein synthesis, so the addition of these nutrients will increase plant growth.

N.P.K.Ca.Mg fertilizer balance of 0.5: 0.5: 0.5: 1: 1 (D) gave growth that was not significantly different from 1: 1: 1: 1: 1 (F) and 1: 1: 1: 0: 0 (B) with stem diameter at the ratio of 0.5: 0.5: 0.5: 1: 1 (D) was the largest. This is because the treatment of 0.5: 0.5: 0.5: 1: 1 (D) supplies a high Ca element, where Ca contributes to cell enlargement. As Sukkaew *et al.* (2022) state, calcium in the stem strengthens the plant structure and affects stem growth. This shows that the application of not too-high doses of NPK fertilizer with the addition of Ca Mg gives similar growth results to the maximum NPK application, so it can be said that the ratio of N.P.K.Ca.Mg is 0.5: 0.5: 0.5: 1: 1 (D) effectively increases the growth of corn plants.

The correlation results stated that plant height was positively correlated with leaf N (r=0.627**) and leaf K (r=0.762**), stem diameter was positively correlated with leaf Ca (r=0.669**), and the number of leaves was positively correlated with leaf Mg (r=0.400*). This is related to the role of Ca and Mg in plants, where calcium plays a role in the process of cell division (Martias, 2004), and magnesium acts as a constituent of chlorophyll (Larasati *et al.*, 2017). As Heruwanto and Supriono (2016), the element calcium is found in the stem for cell elongation, cell division, and stem hardening, while the element Mg is found in the leaves. Mg deficiency can inhibit chlorophyll production, producing low photosynthetic capacity and affecting new leaf growth. A positive correlation was also shown in the number of leaves to plant height (r = 0.544**). The more leaves, the greater the photosynthetic area, so the assimilated production increases. If the assimilate produced is high, the energy used for growth is also high, so an increase follows in plant height in the number of leaves. As Suntoro *et al*. (2017) state, plants with many leaves grow faster than plants with few leaves because many-leafed plants can produce higher photosynthates.

Corn yield

The analysis showed that N.P.K.Ca.Mg fertilizer balance significantly affected cob weight with husk, cob weight without husk, cob length, and cob diameter. As Bojtor *et al*. (2022) state, nitrogen and phosphorus are the nutrients most plants need during the seed-filling stage, while nitrogen and calcium provide maximum effects during the yield formation stage. In their research, Sitohang *et al*. (2019) said that applying N.P.K.Ca. Mg fertilizer increased brown growth manifested in higher leaf size, number of flowers, number of cherelle, and number of pods compared to no fertilization.

N.P.K.Ca.Mg fertilizer balance in the ratio of 0.5: 0.5: 0.5: 1: 1 (D) gave high levels of available P (Table 3), P leaf (Table 4), and corn yield (Figures 1 & 2) because the application of P fertilizer increases P accumulation in the soil and plant P uptake which affects crop yield (Jiang *et al*., 2021). The reduction of NPK dosage in the application of N.P.K.Ca.Mg in the ratio of 0.5: 0.5: 0.5: 1: 1(D) decreased the weight of the cob with husk and the weight of the cob without husk which was not significantly different from 1: 1: 1: 1: 1 (F) or 1: 1: 1: 0: 0 (B), while cob length and cob diameter were not different. This happens because the P supply from fertilizer helps form corn cobs. Edy and Ibrahim (2022) stated that the element P influences maximum cob formation. This result aligns with research conducted by Bojtor *et al.* (2021) that shows that N and P elements have beneficial effects during the cob formation stage of corn, such as increasing dry matter production, grain yield, and its components.

Correlation revealed that leaf N was positively correlated with cob weight with husk (r=0.549**), cob weight without husk (r=0.524**), and cob length (r=0.442*). Increased N fertilization doses can directly improve the protein content and corn production (Arifin, 2019). Leaf P was positively correlated with cob weight with husk (r=0.379*), cob weight without husk (r=0.454**), cob length (r=0.506**), and cob diameter (r=0.353*). As Sudding *et al*. (2021) stated, N and P elements are absorbed mainly by plants in the generative phase and seed filling, where seed density is closely related to cob length and diameter. Fruit formation is influenced by N and P but not K (Erel *et al*., 2008).

CONCLUSION

Based on the above data and analysis, it can be concluded that the N.P.K.Ca.Mg ratio is 0.5: 0.5: 0.5: 1: 1 (D) is the best ratio because a decrease in NPK dosage efficiently increases nutrient status and uptake which is significantly different from 1: 1: 1: 0: 0 (B) and control (A) and gave corn growth and yield that tended to be not significantly different from 1: 1: 1: 0: 0 (B) and significantly different from the control (A).

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