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Growth and Yield of Maize by Nitrogen and Potassium Inorganic Fertilizers Application to Fluventic Eutrudepts

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Abstract. Maize production requires nutrients so that the soil becomes fertile and makes it easier for plants to grow well. It has been known that potassium nutrient enhances the carbon cycle in plant to maintain the development of plant and so on the yield quantity. This test was carried out from November 2022 to March 2023 on Fluventic Eutrudepts Located in Jatinangor. This test was carried out using a Randomized Block Design (RBD), which consisted of seven combinations of inorganic compound fertilizer nitrogen and potassium (NK) dose treatments. Each treatment was repeated three times. The test results showed that a dose of 1 ¾ NK accompanied by 1 dose of single nitrogen and phosphor (NP) could significantly increase maize yields compared to the control or without the addition of solid inorganic fertilizer NK inorganic fertilizer. The effect of giving solid inorganic fertilizer NK 1 ¾ dose of inorganic fertilizer significantly increase the yield of corn plants compared to the control treatment (without NK).

1 Introduction

The global population increased in each year as it is predicted that it will reach 9.9 billion by 2050 [1]. This mean the food demand will be raised up and has to be fulfilled. Maize is one of staple food that is common to be consumed in some countries, included in Indonesia. There is a greater need for food due to the growing population, thus maize can meet those needs while also providing human nutrition and a number of health advantages. Numerous health advantages of maize exist. Maize (Zea mays, L.) has B-complex vitamins that are benefit for healthy derma and digestive system. The beneficial nutrition in maize such as vitamins A, C, and K, beta-carotene, and selenium are also presented in maize. One important component in maize that has diuretic characteristics is potassium [2]. The cultivation of maize is one of the priorities of government since it is always monitored by National Statistic Agency up until 2021. One of obstacles that has to be faces to support the production of this commodity is soil nutrition management.

One of the most prevalent forms of agricultural soil in Indonesia, Inceptisols cover 70.52 million ha (37.5%) [3]. Because there is less than 20% organic matter in this soil, it has a light texture and a substantial amount of clay, most of which is the mineral kaolinite clay (1:1). the soil reacting in an acidic to slightly acidic manner due to the existence of a sulfuric horizon and an oxide layer that are difficult for water to penetrate. Several edaphic (plant-related) elements, including the amount of clay and organic matter, affect how productive Inceptisols are. The management of this soil requires nitrogen input because it is a young soil type and the parent rock has not yet undergone extensive weathering [4].

Nitrogen and Potassium play major role in maize growth. This nutrition supports the growth primary grain crop component in maize, starts to form at the three-leaf stage (BBCH 13) and continues up until the five-leaf stage (BBCH 15) [5]. Realistic harvest potential requires to ensure the plant growth is at its best, included the nutrition fulfillment. Naturally, maize has a great capability for absorbing minerals that are consumed often. Amounts of mineral fertilizers, including nitrogen, should be satisfied [6]. Potassium (K) is the second most absorbed nutrient by maize (Zea mays L.) [7], and it is crucial for enzymatic activation and osmotic adjustment [8]. Potassium fertilization should be added to support the maize growth due to its high mobility in soil [9] especially in tropical soil with high leaching process. It has been known that fertilizing maize with urea and both potassium mineral fertilizers without causing any harm to the micronutrient content of the maize biomass [10].

This research aims to experiment the combination compound inorganic fertilizer nitrogen and potassium (NK) 7:50 ratio with common nutrition Nitrogen (Urea 46%) and Phospor (SP-36 36% of P_2O_5) to check the difference of growth and yield of Maize.

2 Methodology

The experiment has been carried out in field trials at the Soil Chemistry and Plant Nutrition Field Test, Sumedang Regency, West Java with altitude of 725 meters above sea level. The tests were carried out from November 2022 to March 2023. The materials used in the experiment consisted of: Sweet corn seeds of the Secada variety, compound inorganic fertilizer (NK) containing 7-50, Urea Fertilizer (46% of N), SP-36 (36% P_2O_5), Cow manure as basic fertilizer at a dose of 5 tons per hectare. The tools used in the experiment consisted of technical scales, scissors, ruler, cloth meter, plastic rope, stationery and observation diaries, laboratory equipment for soil analysis, one computer unit as a tool for data processing and reporting.

This test was accomplished using the Randomized Block Design (RBD) consisted of nine treatments (seven doses of compound inorganic fertilizers, one dose of recommended fertilizer doses and one control treatment (without fertilizer) for corn plants as a comparison). Each treatment was repeated three times so that a total of 27 experimental plots were plots. The soil used is Fluventics eutrudepts from Jatinangor, which has been made into plots according to the treatment to be applied. The pH of the soil is 6,09 with Total N was 0.20% (low) and K_2O at 63,16%. Soil processing was done by turning it back and forth to 20 cm depth from the soil surface. The next step was making beds for each treatment and planting holes with a spacing of 75 cm x 25 cm. Each bed was given compost as a basic fertilizer for the planting medium. Prior to fertilization, all manure as basic fertilizer is mixed evenly and incubated for 14 days. inorganic fertilizers, Urea, SP-36, and NK were given according to treatment. The dose of inorganic fertilizer is given at 25 DAP as a complementary fertilizer. The dose of Urea fertilizer is given 1/4 of the dose at 7 DAP and 21 DAP. At the age of 35 DAP Urea was given by ½ dose. SP-36 and NK fertilizers were all given at the age of 7 DAP on the side of the plant hole with a distance of 5 cm.

Maize was planted with 75 cm x 25 cm space between plants. The planting hole was made using a stick of wood with a depth of +3 cm, 3 g of Furadan (3% carbofuran) was sown into the hole, then a seed was added to each planting hole and covered by soil. The maintenance carried out in this test refers to standard cultivation carried out in plant cultivation. Maintenance carried out in the field includes: irrigation, replanting, thinning, wild plant removal, and also pests and diseases controlling. Watering is done every day if there is no rain, especially in the morning or evening which aims to prevent the plants from drying out and to maintain soil moisture. Watering was done until the conditions of the planting medium are moist. Wild plants around the main plants were removed by pulling the weeds that grow around the plants, then destroying them and re-burying them in the soil so that the nutrients absorbed by the weeds are not lost. Pest and disease control is carried out both physically and chemically. Physical pest control is by taking pests directly that are visible at the test site, while chemical control is by spraying insecticides with the active ingredient profenofos 500 EC on plants affected by insect attack in the experimental field.

Observations to plants were included measuring height (cm), stem diameter (mm), and leaves number on 14, 28, 42, 56 Day After Planting (DAP). Observation of height were occurred from the soil surface to the tip of the highest leaf. Observation of stem diameter was carried out by measuring the stem of the plant transversely using a caliper. The results of each treatment were harvested after 87 days after planting. The yield was measured by scale by two types; the weight of the maize with husk and the weight of maize without husk. Length and diameter of the cob were also measured. Yields are expressed in fresh cob weight per plot then converted to yield per hectare Observations and experimental data analysis was performed using IBM SPSS 25 software.

3 Result and Discussion

3.1 Growth Of Maize Due to Nitrogen and Potassium Fertilizer

Plant height shows one of the characteristics of plant growth related to other growth factors and components. High growth according to genetic characteristics is very relevant to the productivity of these plants. The development of plant height based on observational data can be seen in Table 1. The combination application of standard NP doses with NK inorganic fertilizer was had a significant effect on plant height. Plant height on 14 DAP before fertilizer application showed a significantly different effect on the control treatment. After fertilizer application, the ¾ to 1 ½ doses of NK plus NP treatment showed significantly different results compared to the control treatment and standard NP at 28 and 42 DAP. Furthermore, at 56 DAP observations, the combination treatment of 1 to 1 ¼ doses of NK (treatment F, G) and 1 ¾ doses of NK (treatment I) showed plant height equivalent to standard NPK and was significant to the control treatment. The combination treatment of 1 ½ NK accompanied by NP showed the best plant height at the end of the vegetative stage of 193.31 cm.

Table 1. Plant Height at 14, 28, 42 DAP and Maximum Vegetative Time (56 DAP)

Treatment	Height (cm)			
	14 DAP	28 DAP	42 DAP	56 DAP
A=Control without Fertilizer	22.97^{a}	79.92^{a}	121.33^{a}	179.45^{a}
B=N, P, K	26.66^{bc}	85.26^{b}	127.34^{bc}	186.84^{cd}
C=¼ NK + NP	25.11^{b}	84.76^{b}	126.00^{b}	182.47^{ab}
D=½ NK + NP	26.28^{bc}	86.87^{bc}	126.32^{b}	185.24^{bc}
E=¾ NK + NP	26.53^{bc}	88.65^{cd}	127.84^{bc}	189.21^{d}
F=1 NK + NP	26.18^{bc}	87.13^{bcd}	129.55^{cd}	187.93^{cd}
G=1 ¼ NK + NP	26.02^{bc}	87.36^{bcd}	126.63^{b}	187.49^{cd}
H=1 ½ NK + NP	27.04^{c}	89.91^{d}	130.82^{d}	193.31^{e}
I=1 ¾ NK + NP	26.80^{c}	87.08^{bcd}	126.09^{b}	187.43^{cd}

Note: Numbers followed by the same letter are not significantly different according to Duncan's multiple range test at the 5% level.

Observations at 28 DAP began to show significant differences in plant height compared to 14 DAP, there was a difference between the application of standard NPK fertilizer and those given a combination of NK inorganic fertilizers compared to no fertilizer application (control). This was because of nutrient fulfillment by each treatment was different. Two sources of nitrogen in this experiment were affecting the plant height. 1 ½ doses of NK with 1 dose of NP gave the highest result for plant height parameter. It has been known that crops got benefit from nitrogen's ability to enhance vegetative development [11]. The positive correlation of nitrogen and plant growth also showed in some research [12, 13]. The productivity of hybrid maize and the day of emergence were both affected by increasing N fertilizer doses [14].

The effect of NK inorganic fertilizer treatment on stem was observed at the same time with height measuement. From the experimental results it could be seen that high dose of NK fertilizer helps the stem to enlarge their diameter as treatment F to I (Table 2). The largest diameter found in H treatment (1 ½ NK + NP). This treatment has a little bit different in size with F, G, or I and B treatment.

Table 2. Stem Diameter of Plants at 14, 28, 42 DAP and Maximum Vegetative Time (56 DAP)

Treatment	Stem Diameter (mm)			
	14 DAP	28 DAP	42 DAP	56 DAP
A=Control without Fertilizer	4.24^{a}	11.71^{a}	22.57^{a}	28.79^{a}
B=N, P, K	5.01^{c}	15.26^{c}	27.35^{cde}	31.01^{bc}
C=¼ NK + NP	4.47^{b}	14.08^{b}	25.14^{b}	29.99^{ab}
D=½ NK + NP	4.95^{c}	15.58^{cd}	27.68^{cde}	30.90^{b}
E=¾ NK + NP	5.04^{c}	16.62^{d}	27.86^{cde}	31.23^{bc}
F=1 NK + NP	5.10^{c}	15.97^{cd}	28.30^{de}	31.09^{bc}
G=1 ¼ NK + NP	4.95^{c}	15.91^{cd}	26.61^{c}	31.13^{bc}
H=1 ½ NK + NP	5.18^{c}	16.62^{d}	28.70^{e}	32.80^{c}
I=1 ¾ NK + NP	4.97^{c}	15.73^{cd}	26.80^{cd}	31.17^{bc}

Note: Numbers followed by the same letter are not significantly different according to Duncan's multiple range test at the 5% level.

Treatment of a dose of NP and 1 ½ NK showed a significant value at 42 DAP and 56 DAP. This value was not significantly different from the standard NPK treatment or the combination of NP with ¾ to 1 ¾ doses of NK, but it was significantly different from the control treatment. This is in accordance with the statement that N fertilizer is needed to stimulate stem diameter enlargement [14]. It was also stated that during the growing season, the effects of potassium and nitrogen on the maize stem were at their greatest [16].

Treatments that were not given NK and NP inorganic fertilizers showed a slower development of stem diameter compared to other treatments. This is because fertilizers, especially macro-nutrient fertilizers, are needed for plant growth, especially in stimulating the formation of plant height and enlargement of stem diameter. The organic fertilizers also have a role in supporting plant vegetative growth applied in early stage of preparation. The diameter of the stem usually produces a large cob and vice versa. Stem diameter also affects the stem weight and plant height, the greater the stem diameter, the heavier the stem weight and the higher the plant.

The treatment without NK and NP inorganic fertilizers showed a slower growth in the number of leaves compared to other treatments. At the beginning of growth stage, there was a significant difference in leaf growth. Compared to the generative growth stages, potassium was accumulated 2-3 times greater during vegetative period of the observation

[17]. This shows that the combination of NK and NP inorganic fertilizers can accelerate leaf multiplication. However, at 42 and 56 DAP the number of leaves in all treatments had similarity due to the maximum vegetative growth.

The range of the number of leaves at 42 DAP was uniform between 8 to 10 leaves. The number of leaves increased at 56 DAP with a value of 10 to 13 leaves per plant. The presence of nitrogen which functions as an essential element in enzymes and chlorophyll molecules, potassium as an activator for various enzymes for carbohydrate metabolism and protein synthesis, also phosphorus plays an active role in transferring energy in plant cells.

Table 3. Number of Plant Leaves at 14, 28, 42 DAP and Maximum Vegetative Time (56 DAP)

Treatment	Sum of Leaves			
	14 DAP	28 DAP	42 DAP	56 DAP
A=Control without Fertilizer	4.60^{a}	5.90^{a}	8.45^{a}	10.28^{a}
B=N, P, K	5.03^{abc}	7.03^{b}	10.35^{cd}	12.51^{bc}
C=¼ NK + NP	4.72^{a}	6.72^{b}	9.48^{b}	10.91^{a}
D=½ NK + NP	5.28^{c}	6.94^{b}	9.69^{b}	12.26^{bc}
E=¾ NK + NP	4.94^{abc}	6.94^{b}	10.79^{d}	12.60^{bc}
F=1 NK + NP	4.74^{ab}	7.21^{b}	9.93^{bc}	12.41^{bc}
G=1 ¼ NK + NP	5.00^{abc}	7.11^{b}	10.68^{d}	12.14^{b}
H=1 ½ NK + NP	5.16^{bc}	7.30^{b}	10.86^{d}	13.05^{c}
I=1 ¾ NK + NP	4.76^{ab}	6.89^{b}	10.94^{d}	12.56^{bc}

Note: Numbers followed by the same letter are not significantly different according to Duncan's multiple range test at the 5% level.

3.2 Yield Of Maize Due to Nitrogen and Potassium Fertilizer

The yield was observed included cob weight, husked cob weight. The results of statistical calculations show that there are differences in the effect of treatment on the yield components of the sweet corn plant (Figure 1). Treatment of 1 ½ doses of NK with NP (treatment H) showed high cob and husked cob weight of 445.51 g and 367.93 g.

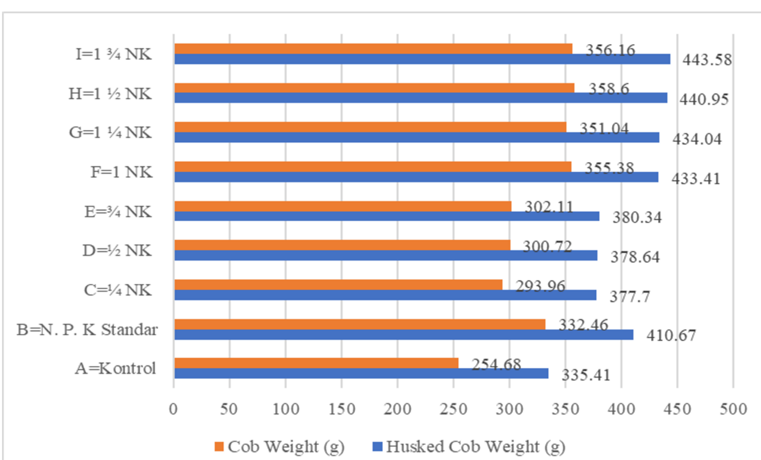

Fig. 1. differences in the effect of treatment on the yield components of the sweet corn plant

The treatment of 1 ¼ dose of NK with NP (G treatment) showed the largest cob diameter compared to the control treatment of 54.99 mm. Meanwhile, the most significant cob length was found in the 1 ¾ NK treatment (treatment I), which was 21.41 cm. Effect of treatment on cob weight, cob weight, cob length and cob diameter were components of corn yields that affected the overall yield.

Table 4. Yield Components of Maize Based on NP and NK Fertilizing Treatment

Treatment	Components			
	Husked Cob Weight (g)	Cob Weight (g)	Cob Diameter (mm)	Cob Length (cm)
A=Control without Fertilizer	334.66^{a}	257.18^{a}	46.90^{a}	16.54^{a}
B=N, P, K	413.54^{c}	331.88^{c}	52.15^{bcd}	20.67^{c}
C=¼ NK + NP	377.85^{b}	296.34^{b}	49.63^{abc}	17.64^{ab}
D=½ NK + NP	380.34^{b}	299.31^{b}	49.58^{abc}	18.66^{b}
E=¾ NK + NP	381.27^{b}	298.48^{b}	50.06^{abc}	18.70^{b}
F=1 NK + NP	433.58^{d}	350.17^{d}	48.87^{ab}	20.19^{c}
G=1 ¼ NK + NP	440.85^{de}	357.59^{de}	54.99^{d}	20.18^{c}
H=1 ½ NK + NP	445.51^{e}	367.93^{f}	52.77^{cd}	20.46^{c}
I=1 ¾ NK + NP	435.58^{de}	363.42^{ef}	51.99^{bcd}	21.41^{c}

One dose of NP and 1½ dose of NK is suspected as the best dose in this experiment since the higher dose resulted lower yield component. Potassium nutrition is important to help the growth of maize since it might aid establish high-quality crop production as well as plant tolerance under conditions of drought [18]. The accumulation of nutrition was not measured but based on study, Nitrogen and phosphorus were accumulated mostly in grain (68–83%), whereas potassium was observed more in stover (64–77%) [19]. In another research, most trace elements in the aerial portions of maize had greater concentration as a result of potassium fertilization. Raised of manganese and iron content and decreased cadmium, lead, nickel, and cobalt content were the results of nitrogen fertilization. Fe:Zn and Fe:Mn ratios in maize were also raised [20]. This statement will be considered in the next research to manage the nutrition of potassium and nitrogen wisely.

4 Conclusions

One dose of NP and 1½ dose of NK gave the best result in growth and yield component. This dose will be recommended to be applied in Fluventics eutrudepts that has same condition with the cultivation area to raise up the growth and yield component of maize.

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