POTENTIAL OF SODIUM AS A SUBSTITUTE FOR POTASSIUM IN MAIZE GROWTH

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Abstract. Sodium has the potential to replace the function of potassium in plant metabolic processes. Several studies have shown a role for sodium in stimulating plant growth. The purpose of this study was to obtain the proportion of sodium in replacing potassium in the growth of corn plants. This research was conducted in April - July 2019 at the Greenhouse and Plant Laboratory of the Politeknik Lamandau. This research was arranged using a completely randomized design with a fertilization treatment consisting of 100 kg. ha^{-1} KCl (K100), 75 kg. ha^{-1} KCl + 25 kg. ha^{-1} NaCl (K75 + Na25), and 50 kg. ha^{-1} KCl + 50 kg. ha^{-1} NaCl (K50 + Na50) with six replications. The results showed that sodium was able to partially replace the role of potassium in the growth of maize plants. Fertilization of Potassium 50% + 50% sodium was able to show the same growth with K100% fertilizer in forming canopy and root dry weight in the vegetative period of maize.

Keywords: The proportion of sodium, fertilizer, corn growth

INTRODUCTION

Potassium (K) is essential nutrients for corn, comprising a significant proportion of total fertilizer expenditures, and can be yield limiting in many major crop production especially corn in the world (Pi et al., 2014; Putra et al., 2019). K nutrients are even absorbed by plants in greater amounts than other nutrients,that are able to absorb 20-40% of K (Clark, 1990), but are only able to arrange 1.70-2.70% of leaf dry matter in the plants (Mas'ud, 1992), and it is also known that a large proportion (90-98%) of the total K of land is still in an unavailable form (Wakeel et al., 2010). Potassium is essential for all plant life, and in most terrestrial plants K^+ is the major cationic inorganic nutrient. The roles of K^+ in plants can be summarized as the following: (1) activation of enzymatic reactions, (2) charge balancing, and (3) osmoregulation (Wakeel et al., 2011).

In Indonesia, the used of K fertilizer must still rely on imports, so the price of fertilizer is relatively expensive. Meanwhile, many research results show that some K functions in plants can be replaced by Sodium (Marschner, 1995; Ismail, 1998; Benito et al., 2014). Therefore, research of the use of NaCl as an alternative to potassium substitutes is needed on growth of corn in Indonesia.

Sodium is approximately 2.8% of earth's crust as compared to 2.6% of K^+. Sodium (Na) has been seen as an essential nutrient for groups of halophyte plants such as *Atriplex vesicaria* and C4 group plants that have a pathway of dicarboxylic photosynthesis (Tisdale et al., 1990; Adam and Shin, 2014). The role of Na^+ in plants and its status as an essential element is still being debated. Plants may be divided into two categories based on Na^+ nutrition, natrophilic and natrophobic, depending upon their growth response to Na^+ and its translocation to shoots (Wakeel et al., 2009).

Based on several phenomena and the results of the study, the potential for replacement of K by Na needs to be taken into account in carrying out fertilizing actions, especially in plants that are adaptive to drought/salinity (natrophilic), so this study aims to examine how much chance sodium can substitute potassium on corn cultivation technology, through observing plant growth.

MATERIAL AND METHODS

This research was conducted in April-July 2020 in the greenhouse and plantation laboratory, Politeknik Lamandau . The materials used in this study were corn seeds and 200 kg. ha^{-1} Urea, 100 kg. ha^{-1} SP-36 and KCl fertilizer based on the specified treatment. This research was arranged using a completely randomized design with fertilization treatment consisting of 100 kg. ha^{-1} KCl (K100), 75 kg. ha^{-1} KCl + 25 kg. ha^{-1} NaCl (K75 + Na25), and 50 kg. ha^{-1} KCl + 50 kg. ha^{-1} NaCl (K50 + Na50) with six replications. This research used a polybag so that the calculation of fertilizer dosage requirements for each polybag based on the layer by soil 20 cm with bulk density of soil 1.3 g. cc^{-1}. Urea and KCl or NaCl fertilizers are given twice, namely 1/3 part at planting and 2/3 part at 14 days after planting, while SP-36 fertilizer is given once at planting.

The observational data obtained were further analyzed using analysis of variance (ANOVA) based on a complete randomized design using ms. Excel macro add-ins (DSAASTAT version 1.101) at an error rate of 5% and will be further tested with Tukey Test if the results of analysis of variance show significant differences (Onofri and Pannacci, 2014).

RESULTS AND DISCUSSION

Based on the results of the maize plant height variance, it can be seen that the 100% KCl fertilizer treatment gave a better response (Table 1). Partial replacement of Potassium causes a decrease in maize plant height. Meanwhile, based on the results of the variance of the maize leaf area, it showed that the partial replacement of potassium did not have a significant effect (Table 1). The treatments that were not significantly different showed that Na + was able to partially replace the function of potassium in root growth, namely the formation of leaf area of maize plants.

Table 1

Leaf area and leaf area of maize

Treatment	Plant Height (cm)	Leaf Area (cm^2)
K100%	127.00 a	6,769.96 a
K75% + Na25%	109.93 b	7,323.44 a
K50% + Na50%	108.70 b	6,112.82 a
CV (%)	5.37	32.09

Note: The numbers in the column followed by the same letter are not significantly different according to Tukey HSD at the 95% level.

Based on the results of the variance of total root length and root surface area of maize plants, it was shown that the treatment had no significant effect on the total root length and root surface area (Table 2). The unrealistic treatment showed that Na^+ was able to partially replace the function of potassium in root growth, namely the growth of total root length and root surface area. Based on the results of the shoot dry weight and root dry weight, it shows that the partial treatment of K substitution with Na does not have a significant effect (Table 3).

Table 2

Root length and root surface area of plants

Treatment	Root length (cm)	Root surface area (cm^2)
K100%	99.62 a	1,590.33 a
K75% + Na25%	108.99 a	1,523.51 a
K50% + Na50%	93.88 a	1,541.98 a
CV (%)	34.92	6.44

Note: The numbers in the column followed by the same letter are not significantly different according to Tukey HSD at the 95% level.

Tabel 3

Shoot dry weight and root dry weight of Maize

Treatment	Shoot dry weight (g)	Root dry weight (g)
K100%	11.91 a	3.29 a
K75% + Na25%	10.65 a	3.54 a
K50% + Na50%	10.66 a	3.24 a
CV (%)	20.42	30.52

Note: The numbers in the column followed by the same letter are not significantly different according to Tukey HSD at the 95% level.

The study of partial replacement of K with Na showed no significant impact on the growth of maize for all treatments. It can explain that Na has a role in plant growth such as leaf area, root length, root surface area, and shoot and root dry weight. The absence of significant differences between treatments indicated that Na was able to replace K in the metabolic process of the maize so that it was able to form good dry matter even in low K conditions.

Sodium can replace the function of K even though it is not specific, especially in plants that can absorb, translocate, and group Na in vacuoles which can replace the function of K in maintaining turgor cells (Gattward *et al.*, 2012). In soils that have low K nutrient content, Na can function as ion balance control, control osmotic pressure, protein synthesis, increase water balance in regulating stomatal conductance (Gattward *et al.*, 2012). Several studies have reported that Na can minimize the impact of K deficiency on plant growth processes in sugarcane, lettuce, cotton, spinach, tomatoes (Mundy, 1983; Marschner, 1995; Tahal *et al.*, 2000; Idowu and Aduayi, 2007; Pi *et al.*, 2014), and barley (Ma *et al.*, 2011). Krishnasamy *et al.* (2014) explained that giving Na was able to stimulate root growth, especially root dry weight in K nutrient deficiency conditions. The application of Na also stimulated the formation of the shoot to increase the rate of photosynthesis. The increase in the rate of photosynthesis will be followed by the formation of assimilates to support plant growth.

Atriplex vesicaria L. plants given 1.20 mM Na^{+} were able to give better dry weight results than plants that were not given Na treatment. Sodium is not included in a macronutrient, but several studies have shown that the addition of sodium nutrients indicates an increase in plant dry weight (Marschner, 1985). Research on the substitution of potassium with sodium in sugar beets shows that sodium is translocated to the canopy, thereby increasing the dry weight of the plant (Wakeel et al. 2011).

The substitution of potassium with sodium has a good effect on the cytoplasm because when sodium is present in the cytoplasm, the cytoplasmic structure becomes better (Marschner, 1995). Besides, the presence of sodium in the plant body can activate the starch synthase enzyme better than potassium. With the help of sodium in the activation of the starch synthase enzyme, it causes a decrease in the starch content in plants but the dissolved carbohydrate content of the sucrose part becomes larger, so this can increase plant dry matter (Marschner, 1985).

CONCLUSIONS

Sodium can partially replace the role of potassium in the growth of corn plants. Fertilization of potassium 50% + 50% sodium can show the same growth with K100% fertilizer, especially the formation of shoot and root dry weight in the vegetative period of maize.

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