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Eco-farming in Managing Global Change

Department of Agrotechnology
Universitas Muhammadiyah Yogyakarta

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Growth and Yield of Potato (*Solanum tuberosum* L.) cv. Granola as Response to Calcium Supplementation

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ABSTRACT

A number of studies have provided evidence that calcium (Ca) involved in tuberization process of potato (*Solanum tuberosum* L.). The purpose of the present study was to determine the effect of calcium application on several growth variables and tubers yield of potato grown in field. Seed of potato var Granola were raised at three different Ca levels that equivalent to the rate of 40, 80, and 160 kg.ha^{-1}, which were supplied from two different Ca sources, $CaSO_4.2H_20$ (gypsum) and $MgCO_3.CaCO_3$ (dolomite). Each treatment consisted of two replications. The calcium was applied as basal treatment, and all plots received the same amount of N, P and K. The experiment was conducted during August and October 2016 at Horticulture Seed Station of Karo District, Kabanjahe, North Sumatera, where soil type is sandy loam, with the pH of 5.2 and exchangeable soil calcium level of 0,83 meq.100g^{-1}. In general, plants subjected to calcium supplementation, either from gypsum or dolomite, out-performed the control and exhibited significantly higher plant and wider plant canopy, whereas no difference on the number of mainstem. Tuber yield reduction, however, were observed among the calcium fertilization though it was not apparently statistically significant.

Keywords: Calcium nutrition, Growth response, Granola, Potato yield, *Solanum tuberosum*

INTRODUCTION

Calcium is essential for normal growth and development in plants, and plays an important role in regulating many physiological functions (Hepler and Wayne 1985). Calcium is also involved in the interlinked network of pectic molecules that form 'egg-box', which influences the cell wall structure and membrane integrity (Jarvis *et al.*, 2003).

Certainly calcium is needed along the growing of plants, but it seems that the greatest need happens during tubers initiation to mid bulking. As have been proposed by many researchers, Ca uptake occurs by direct up take across the periderm or via stolon and tubers roots. Few studies that have been conducted on Ca uptake into tubers have concluded that there was little transfer of calcium from basal root, and it has been proposed that Ca uptake occurs by direct uptake across the periderm or via stolon and at the base of the tubers buds, and not via the main roots that are located at the base of the stem (Bamberg *et al.*, 1998; Busse and Palta, 2006; Habib and Donnelly, 2002; Kratzke and Palta, 1986).

Application of calcium (Ca) fertilizer has increased over the past several years to achieve higher yield and with benefit to a variety of improvements in storage quality and processing quality. The calcium fertilizer was applied more widely, and was not only related to its role on preventing internal brown spot and sub-apical necrosis of sprouts (Tzeng *et al.*, 1986), but also to mitigate potato skin disorder and to enhance tubers resistance to bacterial soft rot (Ginzberg *et al*, 2012). Further more, calcium nutrition on potato can reduce impact of environment stress (Kleinheinz and Palta 2002).

There have been number of studies investigated the effect of calcium-application on yield and calcium content of the tuber. Although tuberization in potato was known to be under complex biochemical control involving hormones (Palta, 2010), however Ozgen and Palta (2005), in their study showed that supplemental Ca application could suppress the tuberization signal. It was reported that small increase until a significant increase in total yield related to calcium application on potato (Simmon *et al.*, 1988; Forsmann *et al.*, 2000). Result of study on calcium application as calcium chloride showed that calcium in moderate promoted some morphological parameter and also tubers yield, but resulted in a contrary effect when higher concentration was applied (El-Beltagy *et al.*, 2002). Numerous studies related to calcium and supplement on potato have been performed, and the result have differed depending on the location, variety, genotypes, applying methods, type of fertilizer and amount of given fertilizer.

MATERIALS AND METHODS

The experiment was conducted during August and October 2016 at Horticulture Seed Station of Karo District, at Kutagadung - Kabanjahe, North Sumatera. The location was situated at 1.350m above sea level. At this research location, soil type is sandy loam, with the pH of 5.2 and exchangeable soil calcium level of 0,83 meq.100g^{-1}.

Table 1. Some physical and chemical properties of experimental soil

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	C-org (%)	N-tot (%)	C/N	P-avl (ppm)	K-exch. (meq /100)	Na-exch. (meq /100)	Ca-exch. (meq /100)	Mg-exch. (meq /100)	P_2O_5 %	K_2O %
0-10	72.2	17.2	10.6	3.58	0.19	18.85	14.53	0.51	0.37	0.83	0.37	0.02	0.04

Appearently desease free, uniform (20-30 g) sized and well sprouted F0 seeds of *Solanum tuberosum* L. var Granola were selected as planting materials. Each experimental plot was 12 m^2 consisted of five rows with 3.0 m in length. Seeds were planted 30 cm apart within the row and rows were 80 cm apart. All treatments received equal amount of N, P and K, equivalent to A-B-C kg ha^{-1} respectively. About 80% of N-P-K fertilizer was applied as basal while the remaining was top dressed at 30 days after planting. The calcium was applied in single application as basal treatment. Potato plant were raised in the field at three different Ca levels that equivalent to the rate of 40, 80, and 160 kg.ha^{-1}, which were supplied from two different Ca sources, i.e. $CaSO_4.2H_2O$ (gypsum) and $MgCO_3.CaCO_3$ (dolomite). A randomized block design non factorial with seven nutrient treatments and two replications per treatment was used. The scheme of the experiment were: K0 = 0 kg.ha^{-1} Ca, K1 = 40 kg.ha^{-1} Ca (dolomite), K2 = 80 kg.ha^{-1} Ca (dolomite), K3 = 160 kg.ha^{-1} Ca (dolomite), K4 = 40 kg.ha^{-1} Ca (gypsum), K5 = 80 kg.ha^{-1} Ca (gypsum), K6 = 160 kg.ha^{-1} Ca (gypsum). Intercultural operational such as weeding and earthing up were done manually. Data were collected on plant canopy and yield. Under canopy attribute, parameter data were collected on plant height, canopy width and number of main stems. Five plants were measured from each of plots at each day of 40, 55, 70, 85 after planting. Tubers were harvested at 92 days after planting (DAP). At harvest, tubers from ten plants from each experiment plot were collected, rinsed free of soil, and weighed. Analysis of variance (ANOVA) were performed to test treatments effects on plant height, canopy, number of main stems and total tuber yield.

RESULTS AND DISCUSSION

In general, application of calcium either from dolomite or gypsum significantly affected the vegetative growth of potato (Table 2).

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Table 2. Analysis of variance (ANOVA) for treatment effects

Variable	40 DAP		55 DAP		70 DAP		85 DAP	
	F_{value}	P	F_{value}	P	F_{value}	P	F_{value}	P
Mean plant height	3.92	0.0817	4.84	0.0083	5.08	0.0069	25.77	1.67E-06
Mean canopy width	0.81	0,5810	2.77	0.0584	12.86	8.34E-05	20.23	6.83E-06
Mean number of main stem	0.46	0.8260	1.88	0.1604	2.20	0.1096	5.64	0.0044

Plants subjected to calcium supplementation, either from gypsum or dolomite, outperformed the plants with no calcium supplement (control) and exhibited significantly higher plant (Fig. 1). The result indicated that plant height of potato was significantly affected by different level of calcium application. At 40 days after planting, average plant height was 4.25-5.75 cm and 5.75-6.25 cm for the dolomite and gypsum treatment respectively as compare to 2.75 cm for untreated plant. No significant different of plant height between untreated and lower level of calcium (40 and 80 kg.ha^{-1}) given in form of dolomite.

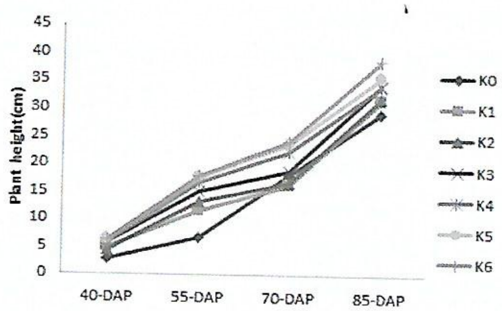

Figure 1. Potato plant height at different level of calcium fertilization

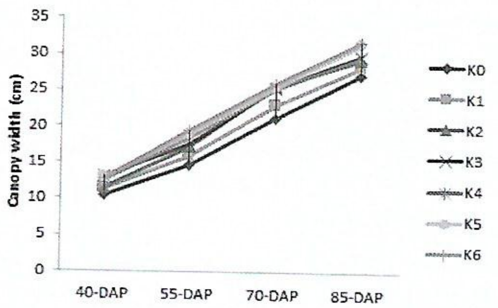

Figure 2. Canopy width at different level of calcium fertilization

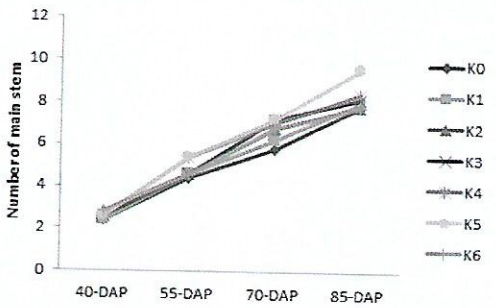

Figure 3. Number of main stem at different level of calcium fertilization

Plant received higher calcium (160 kg.ha^{-1}) in form of dolomite, and gypsum at all investigated calcium level was significantly taller than untreated and low level dolomite treated plants. This trend continued until a week before harvest time, where untreated plant average height was 29.25

cm. At the same time the average height for dolomite and gypsum treated plants were 31.60-34.15 cm and 33.90-38.75 cm respectively.

Overall width of plant canopy was significantly influenced by calcium application (Fig. 2). The effect was not observed, however, until 55 days after planting. Starting at 70 days after planting, plant received 40-160 $kg.ha^{-1}$ calcium in form of dolomite showed significant wider of canopy (23.1-25.6 cm) compared to 21.2 cm for the untreated with calcium. The same effect was also found in plant received gypsum at all calcium levels where average width of canopy range from 23.1 to 26.1 cm. At 70 days after planting no difference effect was found among the level of gypsum. By a week before harvesting, the average canopy width reached 28.25-29.9 cm and 29.65-31.85 cm for dolomite and gypsum treated plants respectively, while canopy of untreated plant was 27.25 cm.

Number of main stem of potato plant was not affected by application of calcium supplement (Fig.3), either applied in gypsum or dolomite form. Potato plant had 3 main stems in average by 40 days after planting, and was increased to 9 main stems by 85 days after planting.

This study provides evidence that supplemental calcium application can boost plant growth, in line with previous study of El-Beltagy *et al.*, (2002) which showed that calcium in moderate promoted some morphological parameter but the contrary effect was found when higher concentration was applied. Meanwhile, Banerjee *et al.*, 2014 found that potato plant received 180 $kg.ha^{-1}$ calcium showed higher values of biometrical parameters. This research suggests that potato plant showed a positive response to addition of calcium nutrient, up to 160 $kg.ha^{-1}$, to soil when applied at single application as basal treatment, as indicated by plant height and width of canopy but not on number of main stem.

Significant different effect was also found between gypsum and dolomite, in which lower calcium in form of dolomite has no significant effect while higher level of 180 $kg.ha^{-1}$ showed similar effect to calcium in form of gypsum at all level. Plants receiving dolomite, $MgCO_3$. $CaCO_3$, at the same time received magnesium, which function actually very important in plants physiological process, mainly as a co-factor in almost all enzymes activating phosphorylation processes. Mondy *et al.* (1987) reported, however, a clear indication of a competitive ion effect between Mg^{2+} and Ca^{2+} which supported evidence that application of calcium on potato plant suppressed the magnesium uptake. Therefore, it seems reasonable to suspect that only at higher level of dolomite, the negative effects of application of calcium could be accomplished by the magnesium presence in dolomite.

Although vegetative growth of potato tuber was positively affected by calcium, in this experiment the data on tuber yield apparently showed no significant effect (F_{value}=0.58; P=0,7403) as shown on Fig. 4.

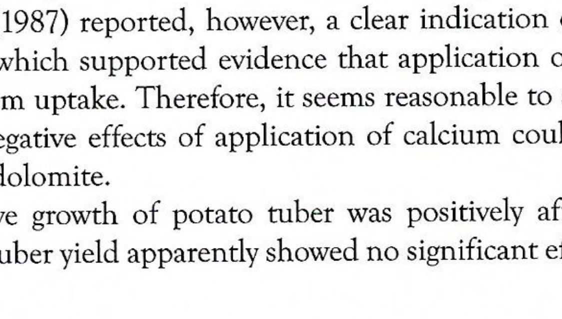

Figure 4. Tubers yield at different level of calcium fertilization

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Yield variations are influenced by nutrient. Mean tuber yield were lower, i.e. 10 and 20 ton.ha^{-1} for plant received dolomit and gypsum respectively, compared to 20 ton.ha^{-1} for untreated plants. Although tuber yield reduction were observed, it was not apparently statistically significant. No difference affect was found among the calcium level used in this experiment. Banerjee *et al.* (2014), has proved that calcium increased potato tuber yield planted in sandy loam soil. However, the result of our study are consistent with the previous study of Ozgen *et al.* (2006) that application of calcium nitrate, calcium chloride and N-Plus either alone or in combination has no effect on yield of potato cv Russet Burbank in two consecutive planting seasons.

In the present work, Ca was applied as a basal treatment. Calcium was taken up and transported via xylem to upper part of potato plant force driven by transpiration (Busse and Palta, 2006; Palta, 2010). Thus, this could be the reason for taller plant and wider canopy of potato plant compared to untreated plants. In another hand, the effect of calcium was not observed on tuber yield. It can be assumed that the tuber initiation and development stage may be negatively affected by calcium supplementation. This in line with previous study of Ozgen and Palta (2005) that showed that supplemental Ca application could suppress the tuberization, although tuberization in potato was known to be under complex biochemical control involving hormones (Palta, 2010). Moreover, El-Beltagy *et al.*, (2002) found that calcium in moderate level promoted tubers yield, but higher level resulted in a contrary effect.

Certainly calcium is needed along the growing of plants, but it seems that the greatest need happens during tubers initiation to mid bulking. Splitting calcium application, in which part of the calcium be applied during tuberization may be able to see more effect on yield.

CONCLUSIONS AND SUGGESTION

Plants subjected to calcium supplementation at the rate of 40-160 kg.ha^{-1} applied in this study, either applied in from of gypsum or dolomit, out-performed the untreated plants and exhibited significantly higher plants and wider plants canopy, whereas no difference on the number of main stem. Calcium at all rate between 40 to160 kg.ha^{-1} which applied in this study, has no significant different efect on tuber yield. Further studies are needed to improve of fertilization method, in which splitting calcium application where part of the calcium should be applied during tuberization is highly recommended.

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