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Effect of Calcium Chloride and Calcium Nitrate on Potato (*Solanum tuberosum L.*) Growth and Yield

Yewubnesh Wendimu Seifu* and Shiferaw Deneke
Department of Plant Sciences, Collage of Agriculture and Environmental Sciences, Arsi University, Assela, Ethiopia

Abstract

In potato production calcium nutrients can be applied in the form of calcium chloride or calcium nitrate. In this regard, application of calcium nutrients during growth of potato plants can be considered as an alternative method to improve plant growth and yield. The objective of this study was to determine the effect of calcium chloride and calcium nitrate on potato growth, tuber yield and assess whether these calcium nutrients differentially affected potato plant growth and tuber yield. Pot experiment was conducted in lat-house under natural sun light condition. The study was conducted in randomized complete block design with four replications. The treatments were consisted of a factorial combination of two potato varieties (shenkola and gera) and three types of calcium nutrients: calcium chloride alone, calcium nitrate alone and calcium chloride mixed with calcium nitrate (1:1) each at three levels (5 g, 10 g and 15 g per liter per plant) and the control treatment (0 g of Ca nutrients). In comparison to the control treatment, application of either calcium nitrate alone or combined application of calcium chloride mixed with calcium nitrate has significantly increased plant height and tuber yield both in shenkola and in gera potato varieties. In contrast, plant height and tuber yield was not significantly differed in both potato varieties sprayed with all levels of calcium chloride alone. Hence it can be concluded that application of calcium chloride and calcium nitrate differentially affected potato plant growth and tuber yield.

Keywords: Potato tuber yield; Plant growth; Number of tuber; $CaCl_2$; $CaNO_3$

Introduction

Potato (*Solanum tuberosum* L.) is an important source of food worldwide. The tuber is rich in carbohydrates and certain groups of vitamins, trace elements and minerals. Like in any other country, potato is very important food and cash crops especially on the highland and mid altitude areas of Ethiopia [1]. The crop is used as a source of food and creates job opportunity to generate income for more than 2.3 million Ethiopian households in different areas of the country [2]. Ethiopia's potato area has grown to 160,000 ha, with average yields around 9 tons/ha [3]. Even though production area is increased yield obtained per hectare is not as high as production area coverage and farmers get low yield because of sub-optimal fertilization.

Plant nutrition is an important factor determining growth and production of specific crop. Therefore, optimizing nutritional status of a crop with mineral elements, specifically with calcium nutrients could be a feasible way to increase crop productivity. Pre-harvest application of calcium nutrients increases the content of calcium in the plant tissue. The higher calcium level in the cell prevents losses of phospholipids and proteins which enhance functionality of membrane [4]. In deed calcium have also great role to strengthen cell wall structure [5] and facilitate uptake of other nutrients. In addition, application of calcium nutrients during growth period increases yields [6]. Furthermore, application of calcium nutrients increases potato tuber marketable yield, storage life, tuber weight, tuber size [5,7], reduces input of fungicide and lowers cost of production has been reported [8].

In potato production calcium nutrients can be applied in the form of calcium chloride [6] or calcium nitrate [7]. In this regard, application of calcium nutrients during growth of potato plants can be considered as an alternative method to improve yield. The objective of this study was to determine the effect of calcium chloride and calcium nitrate on potato growth, tuber yield and assess whether calcium chloride and calcium nitrate differentially affected potato plant growth and tuber yield. In this regard, the output of this study can be used to amend calcium nutrients in potato nutrition specifically in Ethiopia, where use of calcium nutrients in potato production is less recognized.

Materials and Methods

Pot experiment was conducted at Arsi University, Assela, Ethiopia. The study was carried out during rainy of June-September 2016.

Plant materials

Seed tuber of two potato varieties (Gera and shenkola) was obtained from Adet Agricultural Research Center, West Gojam, and Ethiopia and used as plant material. Seed tubers were selected for uniformity of tuber size and number of buds. Single seed tuber (40 g) was planted at the center of each pot in the experimental units.

Growth substrate

Mixture of arable soil, sand and compost (2:1:1 ratio by volume) was used as growth substrate. Growth substrate was mixed efficiently and then filled into bottom sealed ten liters pots to a total weight of eight kg per pot. At the beginning of the experiment the pots was watered with 2 L of sterilized water until saturation level. Later on, water supply was carried out together with Ca fertilizer nutrients. All agronomic practices and cultural managements were kept uniform.

Experimental design and treatments

The study was conducted in Randomized Complete Block Design (RCBD) with four replications. The treatments were consisted of a factorial combination of two potato varieties and three types of calcium nutrients: $CaCl_2$ alone, $CaNO_3$ alone and $CaCl_2$ mixed with $CaNO_3$

***Corresponding author:** Yewubnesh Wendimu Seifu, Department of Plant Sciences, Collage of Agriculture and Environmental Sciences, Arsi University, Assela, Ethiopia, Tel: +251966740770; E-mail: yewub27@gmail.com

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(1:1) each at three levels (5 g, 10 g and 15 g per liter per plant) and the control treatment (0 g of Ca nutrients). Totally, 20 treatments and 80 experimental units were included in the study. Calcium nutrients were applied through foliar application starting at one month after planting and with ten days interval, till 2 months old. The plants in the control treatments were sprayed with tap water alone.

Data collection

Tuber yield: Total tuber yield was measured through destructive measurements, at 90 days after sowing. Tubers were harvested by washing the root system under running water. Total harvested yield (g) was measured and followed by sorting of the diseased and poor quality tubers. Healthy tubers with no defects were considered as marketable yield (g). Changes in yield due to application of calcium fertilizer were calculated from differences between the treatments.

Plant height, number of branches and number of tubers: At three months after planting, plant height was measured from the main stem. The measurement was carried out by using ruler (cm) starting from the soil surface (basal end of stem) to the top of the plant (shoot apex). Number of branches was counted at the same day of measuring plant height. Number of tubers was counted after harvesting tubers at 90 days after sowing.

Tuber tissue analysis for determination of calcium content: Tuber tissue analysis for determination of calcium content was carried through atomic absorption on spectrophotometer using methodology described by Hamdi et al. [7].

Data analysis

Statistical evaluations of the results were carried out through General Linear Model on IBM SPSS Statistics version 22. The effect of calcium fertilizers was considered as significant if $P<0.05$. Significant mean comparison was done using LSD test ($\alpha=0.05$).

Results and Discussion

Tuber yield

The interaction between potato varieties and calcium nutrients was found significant ($P=0.028$) for average tuber yield. In comparison to the control treatment, application of $CaNO_3$ alone and combination of $CaCl_2$ and $CaNO_3$ has significantly increased potato tuber yield both in shenkola and in gera potato varieties. However the highest average tuber yield was obtained with application of $CaNO_3$ at 15 g per pot and average tuber yield has increased by 77% in both potato varieties (Figure 1A). Similarly the increased average yield in potato plants sprayed with combination of $CaCl_2$ and $CaNO_3$ was ranged from 32-44% and 37-60% in shenkola and in gera potato varieties respectively (Figure 1C). In contrast, potato tuber weight was not significantly differed in both potato varieties sprayed with all levels of $CaCl_2$ alone (Figure 1B). This finding is in agreement with Ozgen and Palta, suggesting that application of calcium either from calcium chloride or calcium nitrate during bulking increased tuber weight [9]. Furthermore application of calcium fertilizers increasing potato tuber marketable yield, storage life, tuber weight, tuber size and quality has been reported [5,7]. The increased tuber yield in potato plants supplied with calcium nutrient can be because of the higher calcium accumulation in the tuber tissue enhances tuberization, as positive correlation was found between tuber yield and tuber calcium content (Figure 2A-2C). Similarly, El-Beltagy et al. has suggested that potato tuber yield increases with increasing calcium nutrients to the medium levels [10]. In fact calcium concentration influence tuber formation through alteration of biochemical processes such as by changing hormonal balance at the stolon tip. In contrast to the current result Hirschi has been reported that tuber weight/yield is not affected by application of calcium nutrient, and this dis-agreement might be because of differences in calcium nutrient application forms as foliar application was used in the current study [11].

Plant height

Pre-harvest application of calcium nutrients has significantly ($P<0.05$) affected potato plant height. In comparison to potato plants grown without calcium nutrients (the control treatment), all types of calcium nutrients increases plant height. However significantly higher plant height was noticed in both potato varieties supplied with combined application of $CaNO_3$ with $CaCl_2$ at all applied levels. The increased plant height was varied between 47-87% in shenkola and 45-50% in gera potato variety (Figure 3A-3C).

Number of branches and number of tubers

Number of branch was significantly affected by potato variety alone ($P<0.05$). This suggests that total number of branch may depend on total number of buds produced per tuber. Therefore calcium application may not re-generate buds, but enhance growth of buds. Number of tuber was not significantly affected by pre-harvest application of calcium nutrients ($P>0.05$) (Table 1). In contrast, Ozgen and Palta has been

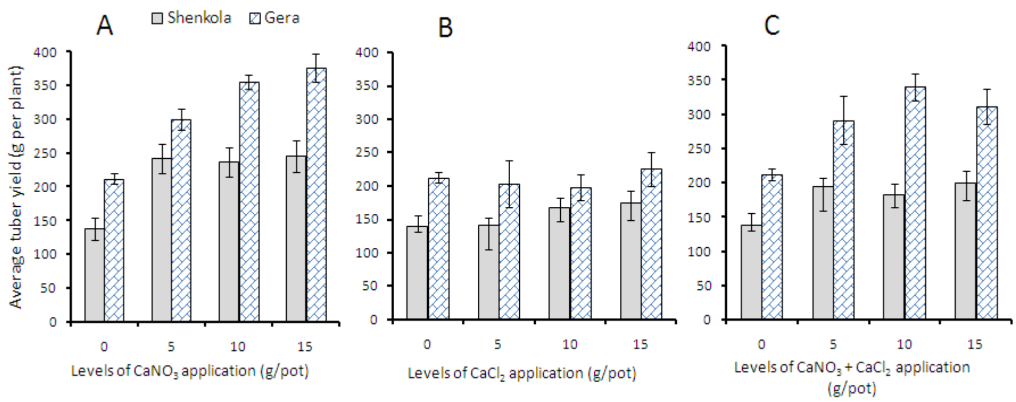

Figure 1: Effects of pre-harvest application of $CaNO_3$, $CaCl_2$ and combined application of $CaNO_3$ and $CaCl_2$ on tuber yield of two potato varieties (Shenkola and gera).

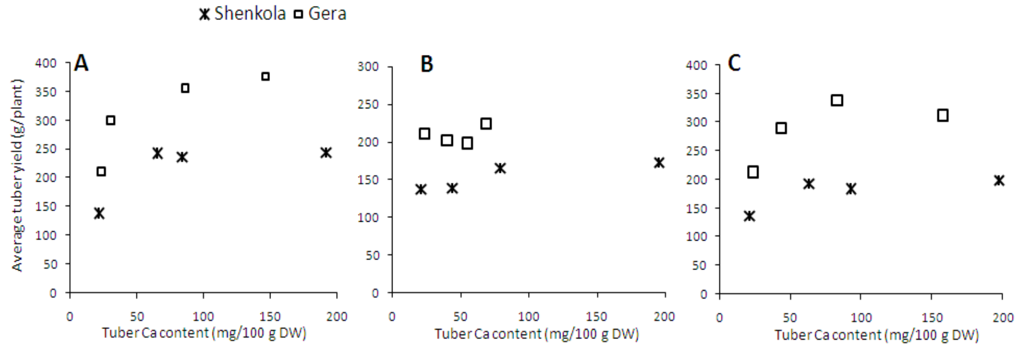

Figure 2: Correlation between $CaNO_3$ and average tuber yield (A), $CaCl_2$ and average tuber yield (B) and combined application of $CaNO_3$ with $CaCl_2$ and average tuber yield (C) in two potato varieties (shenkola and gera).

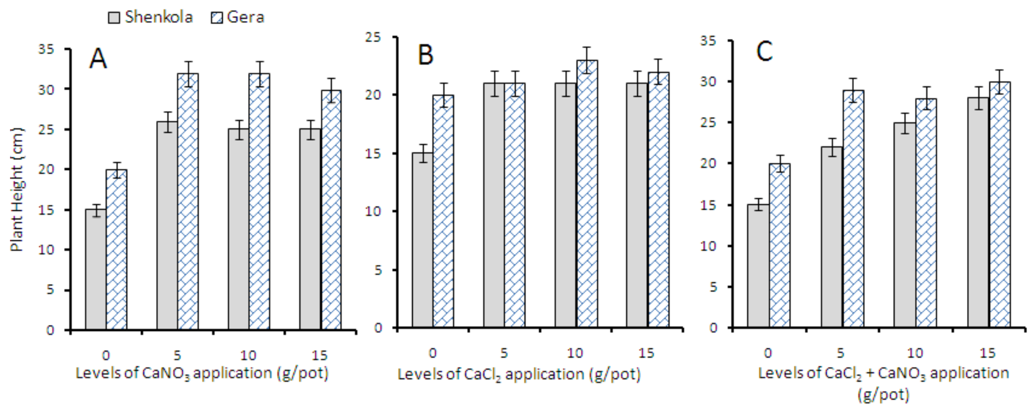

Figure 3: Effects of pre-harvest application of $CaNO_3$, $CaCl_2$ and combination of $CaNO_3$ and $CaCl_2$ on plant height of two potato varieties (Shenkola and gera).

Ca nutrients (treatments)	Potato varieties	No. of tubers	No. of branch
Control_0g	Shenkola	16	16
	Gera	15	15
CaNO3_5g	Shenkola	13	13
	Gera	17	17
CaNO3_10g	Shenkola	17	17
	Gera	16	16
CaNO3_15g	Shenkola	17	17
	Gera	13	13
CaCl2_5g	Shenkola	14	14
	Gera	15	15
CaCl2_10g	Shenkola	17	17
	Gera	14	14
CaCl2_15g	Shenkola	17	17
	Gera	15	15
CaNO3+CaCl2_5g	Shenkola	15	15
	Gera	16	16
CaNO3+CaCl2_10g	Shenkola	14	14
	Gera	17	17
CaNO3+CaCl2_15g	Shenkola	17	17
	Gera	13	13

Table 1: Effects of pre-harvest application of $CaNO_3$, $CaCl_2$ and combination of $CaNO_3$ and $CaCl_2$ on number of tubers and number of branches of two potato varieties (Shenkola and gera).

reported that total number of tubers per plant was significantly affected by application of calcium and provide evidence that application of calcium to the soil can alter tuberization and reduces number of tuber produced per plant [9].

Conclusion

Pre-harvest application of either calcium nitrate alone or combined application of calcium nitrate together with calcium chloride enhances potato plant growth and in turn improves tuber yield. These results suggest that application of calcium chloride and calcium nitrate differentially affected potato plant growth and tuber yield. Hence according to the current study foliar application of calcium nitrate was found efficient than application of calcium chloride. Indeed, further research is needed to compare different mode of application such as drip irrigation.

Acknowledgements

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