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Effect of Lime and Potassium on Potato Yield in Acid Soil

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Abstract: A study was conducted in strongly acidic sandy loam soil at the Potato Breeder Seed Production farm, BARI, Debigonge, Panchogar, to investigate the effect of lime and potassium on tuber yield. The tested factors were application rates of lime (0, 0.5, 1.0 and 2.0 t ha^{-1}) and potassium (0, 60, 80 and 100 K, kg ha^{-1}). The treatment combinations were allocated to experimental plots in Randomized Complete Block Design. Lime and potassium significantly increased tuber yield. Highest increased yield was recorded about 86.54% over control. The optimum rate of lime and potassium in acidic sandy-loam soils could be recommended for potato cultivation at 2 t ha^{-1} and 100 kg ha^{-1}, respectively.

Key words: Lime, potassium, potato, yield, acid soil

INTRODUCTION

In Bangladesh there are different types of problem soils that are not good enough in health. These soils restrict the growth of plants and make crop production difficult and sometimes impossible. Acid soil in Bangladesh is one of these problem soils. The characteristics of strongly acidic soil is low in pH, deficiencies of organic matter, less content of Ca, Mg, P, K and high content of Fe, Al, Mn. The potential of acid soil for crop production is limited due to less availability of phosphorus and high content (toxicity) of aluminium[1].

The soil of Northwest part of Bangladesh is acidic in nature. The topsoil is strongly acidic and subsoil is moderately acidic. Potato is one of the most important vegetable crops in this region and in Bangladesh as well. It may play a vital role to minimize food shortage. Total production of potato in the country is about 1.6 million tons[2]. The annual average growth rate of potato production was 3.7% from 1987 to 1997[3]. But actual yield is quite low, 11.3 t ha^{-1}, compared to other countries like Republic of Korea (22 t ha^{-1}), Iran (19.7 t ha^{-1}), India (16.88 t ha^{-1}) and China (13.05 t ha^{-1})[3].

In our country, it is quite common to find soils used for potato production with pH values as low as 5.0. Crop yield on these soils increases with the increase in pH[4]. Optimum range of soil pH for potato production is 5.2 to 6.5[5,6]. It is also found that K bearing minerals in these soils are low. Lime and potassium increase the yield of potato and improve the size of tuber (170-370 g)[7]. Liming on acid soils also increases resistance to bacterial soft rot and decreases the severity of internal brown spot[7]. This practice also makes phosphorus more available, reduce the aluminum toxicity, increases availability of nitrogen, potassium, calcium, magnesium and micronutrients, renders iron and manganese insoluble and harmless, increases fertilizer effectiveness and decreases plant diseases[8].

Continued use of acid forming fertilizers is leading to a decrease of pH with an accompanying decrease in crop yields. Very few studies have been conducted on liming on potato and their interaction with potassium in acid soil. A study is needed to determine the effect of lime and potassium and their interaction on acid soil to optimize their level for satisfactory yield of potato.

MATERIALS AND METHODS

The experiment was conducted at the experimental field of Bangladesh Agricultural Research Station, Debigonj, Ponchagor, Bangladesh. The soil of the experimental site is very acidic, sandy loam and very poor in terms of nutrient availability.

The experiment was conducted in 4x4 factorial design (RCBD) with three replicates for each of sixteen treatment combinations. The tested factors were application rates of lime (0.0.5, 1.0 and 2.0 t ha^{-1}) and potassium (0, 60, 80 and 100 kg ha^{-1}). Each level of lime was applied with 4 level of potassium.

Lime was applied in the form of $Ca(OH)_2$ as commercial grade before 15 days of planting of crops to allow it reacts with soil properly. Other fertilizers were applied at the rate of 260, 250, 100, 10, 100 and 10 kg ha^{-1} urea, triple super phosphate, gypsum, zinc sulphate,

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magnesium sulphate and boric acid, respectively. Potassium in the form of muraite of potash was applied for each plot as per treatments. Half of urea and all other mineral fertilizers were applied in two bands on each side of the tuber. Remaining half of urea was applied at the time of earthing up of potato. The variety "Cardinal" was selected for planting.

Harvesting was done after 90 days of planting. Data was recorded from the selected 3rd row of each plot to avoid the boarder side effect and tuber yield was calculated from (3x3 m) of unit plot area and converted into t ha^{-1}. Potato was harvested manually at the time of physiological maturity.

To find out the effect of each treatment on the yield and compare the yields among the treatments statistical analysis was done. Data was analysed by using SPSS and MSTAT standard package (Excel). Treatment means for different parameter was separated using Duncan's multiple range tests (DMRT) at 95% confidence level. Regression analysis was done for related parameter.

RESULTS AND DISCUSSION

Growth characteristics of potato

Percent germination: The percent emergence of potato was not significantly influenced either by lime or by potassium (Table 1). Percent germination was observed 25 days after planting of tuber. Germination of tuber was observed 95 to 98%.

Percent foliage coverage: Percent foliage coverage was observed at 60 days after planting whereas the total duration of potato was 90 days only. It was found that percent foliage coverage increased with increasing level of lime and potassium. Both lime and potassium was statistically significant at 5% level of significance (Table 2). Increased foliage coverage due to lime might be attributed to higher pH. Interaction of lime and potassium had no effect on percent foliage coverage.

Plant height: From the Table 3, it is evident that application of lime and potassium significantly increased plant height as well as their interaction. Application of lime and potassium increased plant height from 47.40 cm to 53.42 and 45.29 to 54.76 cm, respectively at 60 days after planting.

Yield components and yield of potato

Stems per hill: The number of stems per hill increased significantly with increasing level of lime and potassium from 3.60 to 3.87 and 3.57 to 3.85, respectively (Table 4). But there was no difference among the treatments of lime and potassium.

Number of tuber per hill: The number of tuber per hill was not significantly affected either by lime or by potassium (Table 5). However, number of tuber per hill increased from 9.33 to 10.02 and 9.19 to 9.30 with different level of lime and potassium application, at 60 days after planting.

Tuber yield: Application of lime and potassium and their interaction significantly increased tuber yield at 5% level of significance. Tuber yield was increased from 22.06 to 29.65 t ha^{-1} and 23.15 to 30.14 t ha^{-1} with application of lime and potassium, respectively (Table 6). The lowest yield was obtained from control 17.98 t ha^{-1} and highest was 33.54 t ha^{-1} i.e. 86.54% higher than control with higher level of lime and potassium application.

The significant effect on tuber yield due to potassium application was might be attributed by higher availability of applied potassium. Potassium is known to play an important role in starch synthesis and translocation of photosynthates from leaves to tubers[9]. Combination of phosphorus and potassium significantly improves tuber weight[10]. Significant effect due to liming was attributed by increased availability of calcium, magnesium, sulphur, phosphorus, organic matter and other micronutrients and decreased the availability of iron and manganese in soil. Application of lime increased calcium uptake as well as tuber formation. Field research on potato has documented that calcium application to low CEC in sandy soil can improve the yield of tuber and grade, as well as increase resistance to bacterial soft rot[11].

Tuber grade: Application of lime and potassium was significantly effective on tuber grade. Percent tuber grade (28-55 mm dia.) was increased with increasing level of lime and potassium as well as their interaction. Percent tuber grade was increased from average 56.15 to 66.93% and 60.80 to 66.95% due to application of lime and potassium, respectively where as the control was 47.26% (Table 7). The result agreed with previous findings by other researchers[7].

Sahota and Singh[10] observed that a combination of phosphorus and potassium favored the uptake of P, K and N as well and increased the yield through the increase in size (wt) of individual tubers. Similar result was found by Reddy[9]. In sandy soil liming increased the tuber yield and size of tubers (170-370 g) as observed by Collier *et al.*[11]. Highest grade (72.22%) was obtained from 2 t ha^{-1} lime and 100 kg ha^{-1} potassium.

Table 1: Effect of lime and potassium on percent germination of potato

Lime t ha^{-1}	0	0.5	1	2	Mean	CV%
K kg ha^{-1} 0	96.33±1.15	96.78±1.67	98.89±0.96	96.78±1.68	97.19±1.37a	
60	97.89±0.77	97.22±1.92	97.78±2.54	97.22±1.92	97.53±1.79a	1.78
80	97.22±1.92	97.22±2.92	98.11±1.64	96.22±1.83	97.19±2.08a	
100	98.89±0.96	97.89±1.96	98.44±1.50	97.78±2.54	98.25±1.74a	
Mean	97.58±1.2a	97.28±2.11a	98.03±1.66a	97.00±1.99a		
Lime	ns	Potassium	ns	Lime x Potassium	ns	

Table 2: Effect of lime and potassium on % of foliage coverage at 60 DAP of tubers

Lime t ha^{-1}	0	0.5	1	2	Mean	CV%
K kg ha^{-1} 0	50.00±2.00	56.67±5.77	58.33±5.78	65.00±8.66	57.50±5.05b	
60	68.33±10.40	70.00±10.00	81.67±2.88	81.67±5.76	75.42±7.26a	8.84
80	71.67±2.88	73.33±11.54	83.33±4.68	91.67±7.63	80.00±6.95a	
100	76.67±11.50	80.00±3.54	86.00±2.78	95.00±2.53	84.42±4.33a	
Mean	66.67±6.20b	70.00±6.83ab	77.22±4.90ab	83.33±5.51a		
Statistically significant at 0.05 probability*						
Lime	*	Potassium	*	Lime x Potassium	ns	

Table 3: Effect of lime and potassium on plant height at 60 DAP

Lime t ha^{-1}	0	0.5	1	2	Mean	CV%
K kg ha^{-1} 0	40.41±1.3f	44.21±1.6e	47.61±0.53c	48.93±1.72d	45.29±1.29c	
60	45.27±1.3d	46.61±1.0de	50.06±0.7bc	53.47±0.83c	48.85±0.98b	
80	51.46±1.2c	52.32±1.2c	55.80±0.20a	55.13±.61ab	53.68±0.98a	2.18
100	52.46±1.0c	53.52±1.4b	56.92±0.23a	56.13±0.72a	54.76±0.84a	
Mean	47.4±1.18c	49.17±1.32b	52.60±0.43a	53.42±0.97a		
Statistically significant at 0.05 probability						
Lime	*	Potassium	*	Lime x Potassium	*	

Table 4: Effect of lime and potassium on number of stem/hill at 60 DAP

Lime t ha^{-1}	0	0.5	1	2	Mean	CV%
K kg ha^{-1} 0	3.40±0.20	3.33±0.58	3.67±0.23	3.87±0.31	3.57±0.33a	
60	3.61±0.46	3.67±0.12	3.73±0.12	3.87±0.31	3.73±0.25a	6.64
80	3.67±0.10	3.80±0.23	3.93±0.23	3.87±0.12	3.80±0.15a	
100	3.73±0.23	3.73±0.42	4.07±0.13	3.87±0.31	3.85±0.27a	
Mean	3.60±0.22a	3.63±0.34a	3.85±0.18a	3.87±0.26a		
Statistically significant at 0.05 probability *						
Lime	*	Potassium	*	Lime x Potassium	ns	

Table 5: Effect of lime and potassium on tuber/hill at 60 days after planting of tuber

Lime t ha^{-1}	0	0.5	1	2	Mean	CV%
K kg ha^{-1} 0	9.00±0.78	8.71±1.79	9.59±0.47	9.46±0.44	9.19±1.12a	
60	9.49±0.75	9.38±1.48	9.46±0.80	10.21±1.00	9.64±1.00a	11.0
80	9.29±1.04	9.13±0.54	10.13±1.30	9.96±0.75	9.63±0.91a	
100	9.54±1.12	8.31±0.52	8.91±0.81	10.46±1.58	9.3±1.01a	
Mean	9.33±0.92a	8.88±1.08a	9.52±1.09a	10.02±0.94a		
Lime	ns	Potassium	ns	Lime x Potassium	ns	

Table 6: Effect of lime and potassium on tuber yield (t ha^{-1}) of potato

Lime t ha^{-1}	0	0.5	1	2	Mean	CV%
K kg ha^{-1} 0	17.98±.89 j	24.4±.25gh	25.84±1.5g	24.36±.65h	23.15±0.84d	
60	20.74±.81i	24.8±1.99gh	28.54±.76f	28.8±2.07ef	25.72±1.41c	9.22
80	24.09±.54h	28.18±1.54f	30.35±.32cd	31.91±0.44b	28.63±0.71b	
100	25.37±.79gh	30.02±1.23de	31.64±1.0bc	33.54±1.42a	30.14±1.16a	
Mean	22.06±0.80c	26.85±1.25b	29.09±0.90a	29.65±1.15a		
Statistically significant at 0.05 probability *						
Lime	*	Potassium	*	Lime x Potassium	*	

Table 7: Effect of lime and potassium on % tuber grade of potato

Lime t ha^{-1}	0	0.5	1	2	Mean	CV%
K kg ha^{-1} 0	47.26±1.8h	55.08±1.8f	60.29±2.2d	61.9±2.31bc	60.8±2.05c	
60	52.72±1.1g	57.31±0.8e	61.76±1.4bc	64.27±1.97b	62.45±1.34b	3.39
80	62.79±2.4c	63.25±2.1c	63.62±1.44c	69.15±0.95a	61.68±1.72b	
100	63.29±2.8c	64.86±1.9cb	67.43±1.62b	72.22±2.01a	66.95±1.96a	
Mean	56.15±2.04d	59.02±1.66c	64.70±1.68b	66.93±1.81a		
Statistically significant at 0.05 probability *						
Lime	*	Potassium	*	Lime* Potassium	ns	

Table 8: Effect of lime and K on total dry matter yield (haulms+ tuber) (t ha^{-1}) of potato

Lime t ha^{-1}	0	0.5	1	2	Mean	CV%
K kg ha^{-1} 0	4.18±0.20	5.35±0.31	6.09±0.14	5.43±0.23	5.26±0.22c	
60	4.63±0.036	5.80±0.47	6.41±0.08	6.48±0.19	5.83±0.19b	
80	5.50±0.10	6.39±0.23	6.76±0.27	7.03±0.37	6.42±0.24a	8.45
100	5.69±0.09	6.65±0.24	7.43±0.41	7.36±0.20	6.79±0.23a	
Mean	5.01±0.11c	6.05±0.31b	6.67±0.22a	6.58±0.25a		
Statistically significant at 0.05 probability *						
Lime	*	Potassium	*	Lime x Potassium	ns	

Total dry matter yield: Total dry matter yield was significantly increased with the level of lime and potassium application (Table 8). Dry matter yield was increased adversely from 5.0 to 6.58 t ha^{-1} and 5.26 to 6.79 t ha^{-1} with highest level of lime and potassium application. Interaction of lime and potassium had no effect on total dry matter yield. However, the lowest mean total dry matter was obtained from control plot (4.18 t ha^{-1}).

Application of lime and potassium significantly increased total dry matter yield as well as total uptake by plant. Total dry matter was increased from 4.18 to 7.43 t ha^{-1} due to the application of lime and potassium. Lime and potassium significantly increased the tuber yield of potato. Lime at 2 t ha^{-1} and potassium at 100 kg ha^{-1} (L_3K_3) gave highest yield (33.54 t ha^{-1}) followed by lime at 2 t ha^{-1} and K 80 kg ha^{-1} (31.91 t ha^{-1}) and Lime 1t ha^{-1} and K 100 kg ha^{-1} (31.64 t ha^{-1}), respectively. Lowest yield was obtained from the control 17.98 t ha^{-1}. Optimum requirement of lime and potassium on potato in acidic sandy loam soils are 2 t ha^{-1} and 100 kg ha^{-1}, respectively.

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