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Full Length Article

Response of Irish Potato (*Solanum tuberosum*) to the Application of Potassium at Acidic Soils of Chencha, Southern Ethiopia

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ABSTRACT

An experiment was conducted at at acidic soil of Chencha, Southern Ethiopia to investigate the effect of different levels of potassium (K) fertilizer on the tuber yield of potato for two years (2007-2008). The treatments were 0, 30, 60, 90, 120, 150, 180, 210, 240, 270 and 300 kg ha^{-1} K. Potato varity CIP392618-511 was planted in a plot size of 3.75 x 3.9 m with inter and intra row spacing of 70 cm and 30 cm, respectivelly. The experiment was laid out in RCB design with three replications. The resut revealed that application of K has significantly increased the tuber yield of potato compared with the control in both years. There was a steady increase in the tuber yield of potato for K levels from 30 kg ha^{-1} up to 150 kg ha^{-1} in both years. There was also an increase in yield for K levels beyond 150 kg ha^{-1}, but the increase was with decreasing trend. Combined analysis of the two years data showed that still the highest yield was obtained at K level applied at of 150 kg ha^{-1}. It increased the total tuber yield from 18 tha^{-1} in the control to 53 tha^{-1} (190%). The relationship between K levels and yield is best expressed with quadratic equation of $y = -0.000x^2 + 0.0.301x + 16.0$ with a significant $R^2 = 0.904$. The partial budget analysis data showed that the highets net benefit and marigenal rate of return (10755%) was obtained from K applied at 150 kg ha^{-1}. It is concluded that there is a significant and positive response of potato to applied K and the highest biological and economic yield was obtained at K level of 150 kg ha^{-1} suggesting that soils of Chencha area are deficient in K. Thus it is recommended that K fertilizer should be imported and applied in acidic soils of Chencha area to mitigate K deficiency for enhanced potato yield.

Key Word: Potasium (K); Potato; Soil acidity

INTRODUCTION

Potassium (K) is one the essential elements required by plants for their growth and development. It plays very important role in activation of enzymes, photosysnthesis, starch sysnthesis, nitrate reduction and suger degradation (Askegaard *et al*., 2004). Potassium is particularly important in helpling plants adapt to environmental stress such as drought, improved winter hardiness and confer plants tolernace to frost, diseases and insect pests (Brady & Weil, 2002). Thus, its deficiency in soil causes serious reduction in crop yield and crops encountered with K deficiency become easily succeptible to disease and pests, damge by frost and have poor yield and quality (Umar & Moinuddin, 2001). In most cases, K deficiency is associated with soil acidity in areas where there is high rainfall and crop production has gone for many years. In such situation, most of the cations including K are leached and mined as a result deficiency of such essential elements could occur (Potash Institute, 1979; Getachew, 2009).

In Ethiopia, so far there was a general understaning that Ethiopian soils are rich in K and there was no need for its application based on the research conclusion of Murphy (968) some 40 years ago. However, with time it is likely that in some soils deficiency of K could occurr due to continous mining, leaching loss, soil erosin so on. In some highlands of southern Ethiopia such as Chencha and Hagereselam areas of southern Ethiopia, soil acidity is a serious problem to crop production and in most cases soil acidity is associated with K deficiency. The results of soil chemiclal analysis data of samples from subcentes of these location showed that they have available K content of 11.2 and 19 mg/L, respectively which is quite low for plant growth and develpment (Jones, 2001). The possible causes for the occurnce of K deficiencies in some highland areas of southern Ethiopia and possibly in other similar areas of Ethiopia could be soil erosion caused by torrential rainfall alog, which K is removed, deforestation, continous ming of K through crop export, leaching of cataions including K and other possible reasons (Wassie *et al*., 2009). Similar to this, Schneider *et.al*. (1994) reported that Nepalse soils used to rich in available K due to high content of silt, but continous cropping of heavy feeder crops have exhausted nutrients including K and farmers do not replenish the harvested nutrients leading to nutrient deficiency and ultimately resulting in reduced yields of crops. A Sudy conducted in Pakistan revealed that combined application of farm yard manure and potasium has significantly improved the yield

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of potato (Pervez *et al*., 2000). In an other study conducted at eight agro ecology zones the K levels required for optimum potato production varies from 110-120 kg ha^{-1} as K_2O with the yield response ranging from 5100-5700 kg ha^{-1} (Grewal *et al*., 1991). In Ethiopiar, previous study conducted at Chencha location of Southern region comparing NP with NPK application on potato revealed that the tuber yield of potat was increased from 11.77 tha^{-1} in the NP treatments to 34.93 tha^{-1} in the NPK treatments, which means NPK application increased the tuber yield by 197% over the NP treatments sucgessting that K is critically deficient in the area (Wassie & Shiferaw, 2009). However, there only limited studies conducted so far in Ethiopia to investigate the effect of K application on the yield of potato.

Based on such facts and informations an experiment was conducted to investigate the response of Irish potato to the application of different levels K fertilizers at Chencha for two years. Thus, the finding of this investigation is presented in this paper.

MATERIALS AND METHODS

The experiment was conducted at Chencha subcenter Awassa agricultural research center. It is located at 37°.60' E and 6°.13' N. It has an altitude ranging from 3005mabsl and a mean annual rainfall of 1800 mm. The soil is caly loam with pH 4.8, 0.308% N, 3.2 mg/L P, 11.2 mg/L K and 2.4% OC. The treatments were various levels of Potassium (K) that is 0, 30, 60, 90, 120, 150, 180, 210 and 240, 270 and 300 kg ha^{-1} of K applied as muriate of potash (KCl). The experiment was laid out in RCB desighn with 3 replications. The test potato variety CIP392618-511 was planted in a plot size of 3.75 X 3.9 m with intra and inter row spacing of 30 and 70 cm, respectivelly. The seed rate was 2 tha^{-1}. The experiment was conducted for tow searsons (2007 & 2008). N and P were applied at 110 and 40 kg ha^{-1} as urea and TSP, respectivelly un-iformly to all plots. Urea was applied as split application that half of at planting and the remaining half was applied at planting. Data on tuber yield was collected and analysed statistically to detect variation using SAS sftware version 9.0 (SAS, 2000). Partial budget or economic analysis treatments or K-levels were calculated to determine or recommend K level that give biologically and economically feasible yield of potato. In doinig economic analysis, the mean yield data of potato produced over two years were used.

Partial budget analysis of selected treatments was done according to CIMMYT (1998). The tuber yield data was adjusted down by 10% t to minimize plot management effect by the research or to reflect the actual farm level performance. The markatable mean tuber yield data produced by each treatments analyzed over the two years have been used in calculating the partial budget.

The field price of 1 kg of potato that farmers receive for sale of the crop was taken as 2 ETB (Ethiopian Birr) kg^{-1}. Potassium was applied as KCL and the price used was 8.60 ETB. The price of lime 100 ETBQ^{-1}. Gross benefit was calculated as average adjusted grain yield (kg/ha) X field price that farmers receive for the sale of the crop (2 ETBkg^{-1}).

1 ETB = 0.074USD

Total variable cost (TVC) was calculated as the sum of all cost that is variable or specific to specific treatment in this case the cost of KCl was used. Net benefit was calculated by subtracting total variable cost from the gross benefit.

Marginal rate of return (MRR) was calculated as the ratio of differences between net benefits of successive treatments to the difference between total variable costs of successive treatments. Treatments with high variable cost and with lower net benefit than the previous treatment are indicated as dominated (D).

RESULTS

The effect of potassium application on the tuber yiled of Irish potato at acidic soils of Chencha is for 2007 and 2008 growing seasons presented in Table I. Potassium application has significantly increased the tuber yield of potato compared with the control. Increasing level of K application has successively increased the tuber yield up to K level of 150 kg ha^{-1}. Application of K at a rate of 150 kg ha^{-1} increased the total tuber yield from 15.6 tha^{-1} in the contol to 57.2 tha^{-1} in 2007 and the corresponding increase in 2008 ranged from from 24.5 to 50.3 tha^{-1}. The Percentage yield increase over the control ranged from 39 to 267 in the year, 2007 and it ranged from 13 to 95% in 2008. The lowest percent increase (30%) obtained from K level of 30 kha^{-1} and the highest percent yield incraese (267%) was obtained from K level of 150 kg ha^{-1} in 2007. In 2008 the lowest and highe yield increase over the control was obtained from K applications of 30 and 150 kg ha^{-1}, respectivelly.

Seasons have significantly affected the tuber yield. Accordingly, higher total tuber yield (48.8 tha^{-1}) was obtained in 2007 than in the year 2008 (34.5 tha^{-1}). Year by K-fertilizer levels interactoions were not siginficant.

The result of combimed analysis of K response data over two years and the relationship is presented in Fig. 1. There was a significant yield increase for increasing levels of K and the highest tuber yield was obtained from K level of 150 kg ha^{-1}. Over two years appication of K at 150 kg ha^{-1} increased the markatable tuber yield of potato by 192% over the control. Application of K levels beyond 150 k ha^{-1} increased the tuber yield with decreasing levels. The relationship of K levels with yield was best expressed with quadratic equation of $y = -0.000x^2 + 0.0.301x + 16.0$ with a significant $R^2 = 0.904$.

The results of partial budget analysis data of selected treatments is shown in Table II. It was found that the highest net benefit and mariginal rate of rate of return (MRR) was

Table I: The effect of different potasium levels on the tuber yield of Irish potato at acidic soil of Chencha, southern Ethiopia

Potassium levels (kgha^{-1})	Tuber Yield (tha^{-1})			
	2007		2008	
	Total Yield	Marketable Yield	Total Yield	Marketable Yield
0	15.6d	13.4d	24.5c	21.3d
30	21.7d	19.7d	25.7bc	22.8cd
60	38.0c	34.63c	29.7c	26.5cd
90	40.0c	36.9c	35.7abc	32.9abcd
120	50.8ab	41.8ab	36.5abc	34.6abcd
150	57.2a	55.9a	50.3a	49.2a
180	49.3abc	47.5ab	42.8bc	41.4abc
210	54.8a	51.8a	45.2ab	42.7ab
240	52.3ab	49.7a	44.9abc	42.6ab
270	51.4ab	48.8a	33.3abc	31.6abcd
300	51.3ab	48.5ab	44.1abc	41.6abc
LSD (0.05)	12.3	11.7	20.3	19.2
CV (%)	16.0	16.7	32	32.3

Table II: Partial budget analysis data of selected K levels

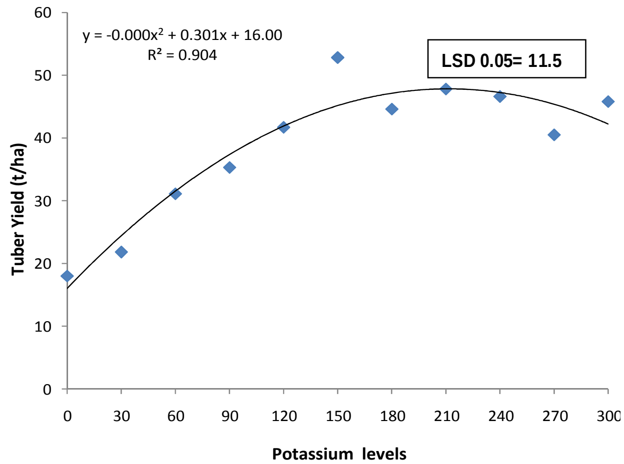
Partial budget	*K levels (kgha^{-1})						
	Control	30	60	90	120	150	180
Total yield (Qha^{-1})	180	218	311	353	417	526	446
Adj. yield (Qha^{-1})	162	196.2	279.9	317.7	375.3	473.4	401.4
Gross benefit birrha^{-1}	32400	39240	55980	63540	75060	94680	80280
TVC	0	180.75	361.5	542.5	723	903.75	1084.5
Net benefit birr/ha	32400	39059.25	55618.5	62997.5	74337	93776.25	79195.5
MRR	-	3684	9161	4076	6282	10755	D

obtained from K level applied at 150 kg ha^{-1}. The next highest MRR was obtained from K applied at 60 kg ha^{-1}.

DISCUSSION

Potasium (K) is one of the major element required by plants for their healthy growth and development. The main souce of K for crops is the soil reserve and according to Jones (2001) Soil K level > 100 mg/L (Mehlich No. 3 Method) (Jones, 2001) is adequate for normal plant growth and that below 50 mg/L is vey low. In the study area of this experiment the soil has 11.2 mg/L, which is quite vey low for plant growth according to this category K levels by Jones (2001). The result of this study has shown that there was an ample response of potato to applied K levels and response is expected from application of K in situations, where there is very low levels of available soil K conten as that happend in this study. In a similar study, Umar and Moinuddin (2001) found in their study at Masoori in Uttar Pradesh in 1999 and 2000 that the yield of potato was appreciably increased due to application of K with intial soil available K level of 75 mg/L. There are also a number of literature evidnces showing the a positive responbse of various crops to applied K (Umar & Moinuddin, 2001; Shao-wen *et al.*, 2004). Adhikary and Karki (2006) reported that Potassium applied at 50 kg ha^{-1} at planting bassally and

Fig. 1: The effect of applications of different levels of K fertilizer on the marketable tuber yield of potato over tow years



50 kg ha^{-1} top dressed produced the tallest plant height and the highest tiller numbers and biomass of potatro. It has also produced the heighest tuber yield (24.75 tha^{-1}) compared with absolute control that produced 6.63 tha^{-1}. In a similar study, Panique *et al.* (1997) reported a significant tuber yield increase up to 332 kg K ha^{-1} in five sites having soil K content ranging from 75-110 mg/L. According to the same authors, there was no response to K application in seven sites with high soil content (125-180 mg/L). The current finding show there is an enourmous increase in the tuber yield of potato indicating deficiency of K in acidic soil of Chencha is agianst the conclusion by Murphy (1968) some 40 years ago, who reported that Ethiopian soils were considered to be rich in potassium (K) and hence there was no need for application of K fertilizers. Thus, the current finding is inagreement with these reports and further strengthen the previous report by Wassie and Shiferaw (2009), whose finding disproved the long standing conclusion by Murphey (1986) that Ethiopian soil are rich in potassium. However, at Murphy (1968) time Ethiopian soils were rich in K, population was very low, forest cover was enormous, there was low incidence of erosion and nutrient mining.

In this study, there was a significant difference between years in the yields of potato produced. Such yield difference between years could be attributed to weather difference between the years besides other probable causes. This may due to the waether difference between the two seasons in terms of rainfall, temperature so on. The K treatment by season interactions were not significant in this study sggesting that the change in season did not affect the pattern of response of potato to different K levels.

CONCLUSION

Application of potassium has significantly and positivelly increased the tuber yield of of potato at Chencha suggesting low level of soil K and there is a need for application of K fertilizer. This finding further disproves the report by Murphy (1968) that Ethiopian soils are rich in Potassium. The highest biological and economic optimum tuber yield was obtained from the application of Potassium (K) at 150 kg ha^{-1}. Therefore it is recommended that there is a need for verification and demonstration of K at 150 kg ha^{-1} for potato production in Chencha area of Southern Ethiopia.

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