GROWTH AND TUBER YIELD OF POTATO (*Solanum tuberosum L.*) UNDER DIFFERENT LEVELS OF PHOSPHORUS AND FARM YARD MANURE

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Abstract

Low soil fertility is a major constraint to potato production in most Parts of Kenya. To enhance growth and yield of potato field research was carried on potato (Asante variety) for 2 seasons at NARC – Kitale and on farm Psigirio in 2002 and 2003. The experimental design was Randomized Complete Block (RCB), with three replications. Nine treatments of phosphorus rates (0, 52.2 and 100.4 kg ha^{-1}and farmyard manure 0, 10 and 20t ha^{-1}) either singly or in combination were used. Data were recorded on tuber dry weight; shoot dry weight and total yield of potatoes. Phosphorus and FYM had a significant ($p \leq 0.05$) influence on tuber dry weight; shoot dry weight and total yield depending on the season and year. A combination of P at100.4 kg ha^{-1} and FYM at 20t ha^{-1} resulted in an increase of 82% tuber dry weight and 62% of fresh tuber yield compared to the control. Tuber number and shoot dry weight were also affected by the application of P and FYM. Potato yield can therefore be improved through application of phosphorus and farm yard manure

Key words: *Solanum tuberosum,* soil fertility, farmyard manure, phosphorus, yield.

INTRODUCTION

Potato is an important horticultural crop worldwide used as human food as well as animal feed. However, in Kenya, potato ranks the highest horticultural crop in terms of hectarage accounting for 108,516 ha, yielding 670,303 MT (MOA & RD, 2000). The tubers are boiled or steamed, baked, roasted, or used as chips.

Low soil fertility common with repeated planting in some sites is a major constraint to potato production in most parts of the country such as West Pokot District (SMP, 1995), besides insect pests and diseases. Potato yields about 8 t ha^{-1} (MOA & RD, 2000), which is much less than 30 to 40 t ha^{-1} realized in Kenya with the application of fertilizer 15N-15P-10K (Nandasaba et al., 1999).

Soil organic manure can be met from four sources; crop residue, farmyard manure, legumes and commercial fertilizers (Brady, 1990). Organic manures improve soil structure (Cook 1967; Roy et al., 1981; Aggarwal et al., 1995) and supply plant nutrients (Brady, 1990; Palm et al., 2000). In addition to nitrogen and phosphorus, farmyard manure (FYM) also provides potassium in the soil (Cook, 1967; Roy, 1981; Porter et al., 1999). Ahn (1993) reported that animal manures are mostly used in maintaining fertility of cultivated soils in areas where both livestock and arable farming are being practiced. Studies by Porter et al. (1999) showed that soil amended with 45 MT ha^{-1} FYM increased in potato yield by 23% compared to the yields from non-amended soils. However, Irungu et al. (2000) reported reduced potato yields where FYM was used alone.

Many commercial farmers do use inorganic fertilizers such as phosphorus because they have the highest concentration of nutrients and are easily dissolved into available forms upon application (Woomer, et al., 1999). Sikka (1982) reported that nitrogen stimulates haulm development; increases leaf production and potato tuber yields. The author also observed increased leaf expansion and enhanced tuber maturity when phosphorus was used at planting.

The main objective of the current study was to assess the potential of producing vigorously growing potato with high yields through the use of farmyard manure together with reduced quantities of phosphorus.

MATERIALS AND METHODS

The study was carried out in 2002 and 2003 at two sites; Kitale and Psigirio in West Pokot District, Rift Valley province of Kenya) NARC-Kitale site at National Agricultural Research Centre (NARC) Kitale, which lies at longitude of 35^{o} 7.5'E, latitude 1^{o} N and an altitude of 1890 m above the sea level. The area receives an average rainfall of 1182-mm per annum. The soil type is rhodic ferrasols which are well-drained, friable clay, with a pH of 6.8. The mean maximum temperature is 25^{o}C, mean temperature of 18.3^{o}C, and mean minimum temperature of 11.5^{o}C. Psigirio site West Pokot District, lies at longitude of 35^{o} 15' E, latitude 1^{o} 15' N and an altitude of 2000 m above the sea level. The area receives an average rainfall of 1289-mm per annum The soil type is humic cambisols and humic acrisols which are well drained, dark reddish brown, friable sandy clay loam to clay, with a pH of 6.8. The mean maximum temperature is 23.4^{o}C, mean temperature of 16.3^{o}C, and mean minimum temperature of 9.3^{o}C.

The experimental design was Randomized Complete Block (RCB), with three replications. Nine treatments

of phosphorus and farmyard manure either singly or in combinations were used. The P rates were 0, 52.2 and 100.4 kg ha^{-1} while the FYM rates included 0, 10 and 20t ha^{-1}. The treatments were: Control, 10t FYM ha^{-1}, 20t FYM ha^{-1}, 50.2 kg P ha^{-1}, 50.2 kg P ha^{-1}+ 10t FYM ha^{-1}
50.2 kg P ha^{-1} + 20t FYM ha^{-1}, 100.4 kg P ha^{-1}, 100.4 kg P ha^{-1}+ 10t FYM ha^{-1}, 100.4 kg P ha^{-1} + 20t FYM ha^{-1}. The plot size was 10m x 10m separated by 1m paths. The potato variety used in this trial was Asante, the most preferred variety in West Pokot district (Nandasaba et al., 1999). Potatoes were planted at a spacing of 75cm x 30cm.

The FYM used was well-decomposed manure from the livestock shed, which was analyzed to determine the mean NPK content before application. The manure was spread to their respective plots immediately after ploughing, and then incorporated into the soil. Phosphorus was applied in form of triple superphosphate by drilling along the furrows and mixed well with the soil.

Standard cultural practices such as weeding, pest and disease control were carried out uniformly in all plots. Weeding commenced after the potatoes had sprouted (3 weeks after planting) to avoid uprooting the seed tubers. To enhance vegetative growth, nitrogen was applied as CAN at the rate of 75 $kgha^{-1}N$ uniformly to all plots, five weeks after emergence. Earthing up (ridging) along the rows was done twice before the plants fully covered the spaces between the rows (8 weeks after planting), after which no more weeding or earthing up was done to avoid destruction of haulms.

Dry mass of shoots (all parts above the ground level) and tubers (roots, stolon and tubers) were determined 70 days after planting (when tubers had reached maturity) by digging out three hills at random from the inner rows. The plant parts were oven dried at 70^{o}C until constant weights were attained. Tubers were harvested from an area of 2.25 m^2 (10 hills) at the center of each plot and counted before sorting them into ware and seed tubers.

RESULTS AND DISCUSSION

Effects of Phosphorus and Farmyard Manure on Plant Height

Neither P nor FYM and their combinations had a significant effect on plant height in 2002 at the Kitale site (Table 1). However, in 2003 at both sites, phosphorus and FYM increased plant height depending on the site and the level of the treatments applied.

At the Kitale site in 2003, 100.4 kg ha^{-1}P increased potato stem height by 25% over the control, which had the shortest plants (37.8 cm) (Table 1). However, there was no significant difference in plant height when P was applied at low rate of 50.2 $kgha^{-1}$ or at the high rate of 100.4 $kgha^{-1}$ singly or in combination with FYM (Table 1). At the Psigirio, the combined application of 100.4 kg P ha^{-1} + 20 t FYM ha^{-1} resulted in the tallest plants (30%) over those in the control plots (Table 1). The height differences observed in 2002 and 2003 might be attributed to high soil fertility in the experimental area that resulted to vigorous growth even where there was no fertilizer application. However, Sikka, (1982) attributed this observation to early retardation in the growth of potato due to phosphorus deficiency.

Effect of Phosphorus and Farmyard Manure on Tuber and Shoot Dry Weight

The high tuber and shoot dry weights in potato were observed at the Kitale site in 2002 even where there was no fertilizer application (Table 2). This could be attributed to high soil fertility in the experimental area. However, in 2003 at both sites, various levels of phosphorus application significantly ($p \leq 0.05$) affected tuber and shoot dry weight (Table 2). At both sites, 100.4-kg ha^{-1}P increased tuber dry weigh by 48% and shoot dry weight by between 72% and 75% over the control (Table 2). Increased tuber and shoot dry weights were also observed in the plots where combined P and FYM was applied. The P and FYM effects observed might be due to the fact that in 2003 the plots were sited where the previous crop was (as often practised by the farmers). The first crop had already utilized some of the soil nutrients since potato is a heavy feeder (Sikka, 1982).

The current results agree with these of Mugambi, (1979) who found that the application of both phosphorus and nitrogen promoted leaf growth during early stages of development. The increase in root and shoot dry weight with increase in phosphorus and FYM application can be attributed to increased root length and density and Leaf Area Index (LAI) which positively correlates with potato tuber yield (Opena and Porter, 1999). Application of FYM increases P availability (Ranganathan and Selvaseelan 1997), and hence increase in tuber and shoot dry weight with increase in FYM application (Mwania, 1983).

Effects of Phosphorus and Farmyard Manure on Tuber Yield

Phosphorus and FYM combination had no effect on total tuber yield at the Kitale site in 2002 (Table 3). However, in 2003, at both sites P and FYM treatments affected total tuber yield. Yield increases of between 7% to 65% was observed in amended plots compared to yields from plots where no P or FYM was applied. The highest yield of 27t ha^{-1} (65% over the control) resulted at Psigirio site and was realized in plots receiving 100.4 kg P ha^{-1} + 20 t FYM ha^{-1}. Plots with no P, FYM or combination of both as well as those with lower rates had the lowest yield ($p \leq 0.05$) (Table 3). The current results agree with those of Mugambi (1979), which showed that the application of N, P, and K increases tuber yield. These results also agree with work done by Sud (1996), who reported significant responses of potato tuber yield to P and S at application rate of 22 kg ha^{-1}.

There was no significant ($p \geq 0.05$) difference between the application of 0, 10, 20 t ha^{-1} FYM. However there was an increase in potato yield with increasing FYM. Implying that the application of FYM in combination with phosphorus resulted in the reinforcement of FYM by P applied (Ahn, (1993). Thus the yield of potatoes was proportional to the amount of P applied. FYM application increases root length density and LAI, which results to increase in tuber yield (Opena and Porter, 1999). FYM also increases the uptake of N, Fe, Zn and P (Ranganathan and Selvaseelan, 1997). Nitrogen and phosphorus uptake by plants increase with increase in FYM level (Minhas and Sood, 1994). This might explain why tuber yields increase with increasing FYM at any given level of P application.

Effect of Phosphorus and Farmyard Manure on Total Tuber Number of Potato

Phosphorus and FYM at all levels did not influence the total number of potato tuber at the Kitale site in 2002. However, in 2003 increased total tuber number attributed to the application of P and FYM was observed both in Kitale and Psigirio sites (Table 4). The largest number of tubers (330,000 ha^{-1}) was realized at Psigirio sites in plots which received 100.4 kg P ha^{-1} + 20t FYM ha^{-1}, while the lowest tubers (120,000 ha^{-1}) were harvested from plots with no P or FYM amendments. At any given level of P application, the total number of potatoes, increased with increase in FYM application. The observation might be attributed to soil mineralization from the soil due the available carbon for microbial respiration, provision of nitrogen and phosphorus (Nyamangara et al., 2000). The availed nitrogen in the soil is important in tuber initiation and tuber enlargement (Sikka, 1982).

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Tab. 1.: The effects of Phosphorus and FYM on plant height (cm) at Kitale (2002 and 2003) and Psigirio, (2003)

	Kitale		
Treatments	2002	2003	Psigirio (2003)
Control	40.3	37.8c*	25.7c
10 FYM (t ha^{-1})	41.0	38.5bc	29.9bc
20 FYM (t ha^{-1})	42.8	39.8bc	32.7ab
50.2 kg P ha^{-1}	39.6	46.2abc	31.8ab
50.2 kg P ha^{-1}+ 10 FYM (t ha^{-1})	39.2	47.2ab	34.5ab
50.2 kg P ha^{-1}+ 20 FYM (t ha^{-1})	43.8	46.4abc	35.6a
100.4 kg P ha^{-1}	45.1	49.7a	33.6ab
100.4 kg P ha^{-1}+ 10 FYM (t ha^{-1})	41.1	50.1a	36.5a
100.2 kg P ha^{-1}+ 20 FYM (t ha^{-1})	43.4	51.5	36.6a
LSD ($p \leq 0.05$)	ns	9.2	5.0
C.V.(%)	18.2	10.8	8.0

*Means followed by the same letter in the same column are not significantly different according to DMRT ($p \leq 0.05$)
ns=no significance

Tab. 2.: Dependence of Potato Tuber and Shoot Dry weight (t/ha) on Farm Yard Manure and Phosphorus on the 70 DAP at Kitale and Psigirio, 2003

	Tuber dry Wt. (t ha^{-1})		Shoot dry Wt. (t ha^{-1})	
Treatment	Kitale	Psigirio	Kitale	Psigirio
Control	3.9c*	1.2e	1.8b	0.2e
10t FYM ha^{-1}	4.1c	2.0d	1.9b	0.4de
20t FYM ha^{-1}	4.2c	2.6d	1.9b	0.5d
50.2 kg P ha^{-1}	6.3b	3.8c	1.9b	0.8c
50.2 kg P ha^{-1} +10 t FYM ha^{-1}	6.3b	4.1bc	2.0ab	0.8c
50.2 kg P ha^{-1} + 20t FYM ha^{-1}	6.6b	4.2bc	1.98ab	0.8c
100.4 kg P ha^{-1}	7.6a	4.8ab	2.3ab	0.9bc
100.4 kg P ha^{-1} + 10t FYM ha^{-1}	8.2a	5.0a	2.4ab	1.0ab
100.4 kg P ha^{-1} + 20t FYM ha^{-1}	8.1a	5.4a	2.5a	1.1a
LSD ($p \leq 0.05$)	0.8	0.7	0.2	0.2
CV (%)	7.25	10.37	5.90	11.52

* Means followed by the same letter in the same column are not significantly different according to DRMT ($p \leq 0.05$)

Tab. 3.: The effects of farmyard manure and phosphorus on potato tuber yield (t ha^{-1}), Kitale (2002 and 2003) and Psigirio (2003)

	Kitale		
Treatments	2002	2003	Psigirio, 2003
Control	26.8	9.0c	9.4d
10t FYM ha^{-1}	31.9	14.0bc	14.6bcd
20t FYM ha^{-1}	25.7	13.3bc	17.1bcd
50.2 kg P ha^{-1}	30.1	20.3ab	13.3cd
50.2 kg P ha^{-1}+ 10t FYM ha^{-1}	29.0	18.5ab	17.3bcd
50.2 kg P ha^{-1} + 20t FYM ha^{-1}	28.5	18.6ab	22.1ab
100.4 kg P ha^{-1}	32.7	22.3a	19.0bc
100.4 kg P ha^{-1}+ 10t FYM ha^{-1}	28.3	24.6a	21.3ab
100.2 kg P ha^{-1} + 20t FYM ha^{-1}	28.9	25.3a	26.9a
LSD (($p \leq 0.05$)	ns	9.8	7.9
CV (%)	9.3	8.2	9.3

*Means followed by the same letter in the same column are not significantly different according to DMRT ($p \leq 0.05$)
ns=no significance

Tab. 4.: The effects of farmyard manure and phosphorus on total tuber number ($x10^5$) Kitale (2002 and 2003) Psigirio, 2003

	Total tuber number		
	Kitale		
Treatments	2002	2003	Psigirio, 2003
Control	1.7	1.2f	1.9f
10t FYM ha^{-1}	2.2	1.2f	2.4e
20t FYM ha^{-1}	1.6	1.8e	2.7cd
50.2 kg P ha^{-1}	2.0	2.5b	2.3e
50.2 kg P ha^{-1}+ 10t FYM ha^{-1}	1.9	1.8e	2.6d
50.2 kg P ha^{-1} + 20t FYM ha^{-1}	2.0	2.0d	3.1 b
100.4 kg P ha^{-1}	2.2	2.4bc	3.1b
100.4 kg P ha^{-1}+ 10t FYM ha^{-1}	2.1	2.4c	2.8 c
100.2 kg P ha^{-1} + 20t FYM ha^{-1}	1.9	3.0a	3.3a
LSD ($p \leq 0.05$)	ns	0.1	0.1
CV (%)	2.6	2.9	1.4

*Means followed by the same letter in the same column are not significantly different according to DMRT ($p \leq 0.05$)
ns =no significance

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