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Effect of phosphorus on the agronomic performance of two Crotalaria species in Kenya

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Abstract

Crotalaria brevidens Benth. and *Crotalaria ochroleuca G. Don*. are two promising indigenous vegetables grown and consumed in Kenya. Yields of 2 to 3 ton ha $^{-1}$ have been reported without application of fertilizers compared with a potential of 10 -12 tons ha^{-1}. Phosphorus is one of the most limiting nutrients in many tropical soils causing low production of food crops including African indigenous vegetables. A greenhouse experiment was set to evaluate the effect of different phosphorus levels on growth of two *Crotalaria* species. Seeds of two *Crotalaria* species were sown in 2kg plastic pots filled with a mixture red soil and sand in the ratio of 5:1. Eight equivalent levels of phosphorous; 0, 15, 30, 45, 60, 75, 90,105 kg P_2O_5 ha^{-1} were applied at planting in form of Triple super phosphate. The experiment was laid out in completely randomized design replicated four times. Data on plant height, number of leaves, branches and pods, 1000 seed weight were recorded and analyzed using SAS 9.1.3 Software. Analysis of variance and significant means were separated using Student Newman Keuls test at $p \leq 0.05$.There was significant interaction ($p \leq 0.0001$) between phosphorous levels and species in mean plant height, number of branches and number of leaves. Number of leaves increased as phosphorus levels increased for both varieties. There was clear species difference in their response to different phosphorus levels .This research work is relevant to farmers growing slender leaf without addition of fertilizers to realize that additional of higher levels of phosphorus will enhance various parameters of its production.

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Introduction

Slender leaf is a legume in the family Fabaceae. The family contains 600 species that grow wild in the tropical and subtropical areas (Abukutsa-Oyango, 2004). The genus *Crotalaria* has 500 species of herbs and shrubs found in Africa. It originated from Northern Nigeria then spread to Ethiopia and Southern Tanzania. Among the slender leaf species growing in Africa, *Crotalaria brevidens* and *Crotalaria ochroleuca* are used as vegetables (Abukutsa- Onyango, 2007) . They are commonly cultivated and consumed throughout East Africa and to a limited extent in West Africa (Abukutsa-Onyango, 2004). The young leaves and shoots that are consumed have been reported to be a good dietary source of provitamin A, carotenoids, vitamin C, iron, calcium and proteins (Abukutsa-Onyango, 2004). The species have also been reported to have medicinal applications (Uiso and Johns**,** 1996).

Although slender leaf is commercially produced in Kenya, only 2-4 tons per hectare have been harvested, yet it has potential of producing 10-12 tons per hectare (Abukutsa- Onyango, 2007). The major constraints in slender leaf production have been poor quality seed, lack of technical production and utilization packages .(Abukutsa- Onyango, 2007). Continuous cropping of land with little return of nutrients leads to low soil fertility characterized by low amounts of soil organic carbon, nitrogen, and phosphorus (Okalebo *et al.*, 1990). Both phosphorus and nitrogen (N) deficiencies are extensive in sub-Saharan African agricultural soils and this causes low crop productivity, especially in smallholder agriculture (Buresh *et al.*, 1997). Phosphorus fertilization stimulates growth (Singh and Sale, 2000) and is required for photosynthesis (Freeden *et al.*, 1989). It also increases hydraulic conductibility of roots (Radin and Eidenbock, 1984). Crops require great amounts of phosphorous for the development of meristematic tissues, which divide and grow rapidly as observed by Brady and Weil, 2000. Application of 26.4 kg phosphorus ha^{-1} improved seed yield, nitrogenase activity and nodulation in pea (*Pisum sativum* L.) (Kasturi, 1995). In mung bean (*Vigna radiate L)*, application of 26 kg P ha^{-1} increased the nodulation and yield (Sarkar and Banik, 1991). Shenoy and Kalagudi, 2005 observed yields reduction of 10-15% due to phosphorous deficiency in the production of sunflower (*Helianthus annuus L).*

The effect of nitrogen levels between 0-100 kg ha^{-1} on the growth, leaf and seed yield has been investigated in slender leaf (Abukutsa-Onyango, 2007). However, the effect of phosphorus on the growth of slender leaf has not been investigated in Kenya. The objective of this study was therefore to evaluate the effect of phosphorus on the growth of two varieties of slender leaf.

Materials and methods

Experimental site

The study was carried out at Jomo Kenyatta University of Agriculture and Technology (JKUAT) demonstration farm situated 36 km North-East of Nairobi along the Thika-Nairobi highway. Juja is in the Upper midland zone 4 which is semi-humid to semi-arid, situated at 1530 meters above sea level. The area receives an annual rainfall of 1074 mm with annual mean temperature of 20.5˚C (Batjes, 2006).

Experimental design and materials

A composite sample of red soil (Humic nitisols) and sand mixture in the ratio of 5:1 was taken to the laboratory for analysis of nitrogen, phosphorus and potassium (NPK) using the procedures described by Okalebo , 1986.The soil mixture was then put in 2kg plastic pots which were set up in a greenhouse at Jomo Kenyatta University of Agriculture and Technology (JKUAT) in the month of January-May 2013. These were then arranged in complete randomized design (CRD) and replicated four times. Seeds of *C. brevidens* and *C. ochroleuca,* obtained from Indigenous vegetable multiplication center at JKUAT were sown in 2 kg plastic containers consisting analyzed soil. The seeds germinated in five days. Eight equivalent levels of 0, 15, 30, 45, 60, 75, 90 and 105kg of Triple super phosphate fertilizer

(TSP) supplied the required phosphorus and was applied at planting. The plants were kept weed free and watering was done three times per week. Data on plant height, number of branches, number of leaves and number of pods was collected from the second week after germination up to maturity at the 15th week. 1000 seed weight was collected was collected after the seed had dried at the 17th week.. Data was analyzed using SAS 9.1.3. Software. Analysis of variance (ANOVA) was done and means were separated using student Newman Keuls (SNK) test at $p \leq 0.05$.

Results and discussion

The analysis of soil mixture used in the study showed that the phosphorus level was 0.0001%. At phosphorus level below 0.2% plants show phosphorus deficiency (Mills and Jones, 1995). The phosphorus level in the study soil was far below the phosphorus deficiency level in plants of 0.2 % and could not sustain the growth of the slender leaf as shown in Table 1.

Table 1. Soil composition before addition of phosphorous.

Chemical	Amount
Nitrogen	0.05%
Potassium	0.4%
Phosphorus	0.0001%(1ppm)
EC	0.09 ds/m
pH	5.69

Plant height

There was significant interaction between phosphorus levels and *Crotalaria* species on the plant height $p \leq 0.0001$ (Table 2). *Crotalaria ochroleuca* recorded the highest mean plant height of 70.8 cm at 15 kg P_2O_5 ha^{-1} while the lowest plant height 56.1cm was recorded at 60 kg P_2O_5 ha^{-1}. *Crotalaria brevidens* recorded highest mean plant height of 37.5cm after application of 60 kg P_2O_5 ha^{-1} with lowest mean plant height 28.4cm obtained in the control with zero phosphorus. The optimum fertilizer level for *C.ochroleuca* was 15 kg P_2O_5 ha^{-1} for enhanced plant height above which there was no more increase. For *C.brevidens* the optimum phosphorus level for plant height was 60 kg P_2O_5 ha^{-1} above which the plant height would not increase. This different response to different phosphorus levels for the two *Crotalaria* species could probably be due to their species difference. These results differed from those of Pramanik *et al.*, 2009 who found phosphorus fertilization did not have significant effect when applied in the growth of seven green manure crops that included *Crotalaria juncea*. However, the effects of phosphorus fertilization on stem height in beans was found significant by Rahini *et al.*, 2012 with highest height achieved after application of 96 kg P_2O_5 ha^{-1}.

Number of leaves

The mean numbers of leaves per plant at different phosphorus levels were significantly different ($p \leq 0.0001$), with the number of leaves increasing with increase in phosphorus levels (Table 2). *Crotalaria brevidens* had a higher mean number of leaves 115.9 leaves per plant than *C. ochroleuca* with 49.7 mean number of leaves during the twelve weeks of growth. The highest mean number of leaves was obtained at 105kg P_2O_5 ha-1 for both species. Lowest number of leaves was found when no phosphorus was applied for both *Crotalaria* species. Observations from this study show that higher levels of phosphorus are required for production of higher number of leaves resulting in a larger leaf area for photosynthesis. When the nutrient supply is suboptimal leaf growth is limited as the net photosynthesis becomes low resulting to less number of leaves. Different results were reported by Oyewale, 2013 which showed that the leaves of snake plant (*Trichosanthes cucumerina* L.) increased between 15-30 kg P_2O_5 ha^{-1} beyond which there was reduction.

Phosphorus plays a major role in photosynthesis without it photosynthesis is almost totally inhibited as earlier reported by Heber *et al.*, 1989.

Number of branches

The highest mean number of branches 11.3 was attained at 90kg P_2O_5 ha^{-1} for *C. brevidens*, while the lowest mean number of branches 8.0.was attained at zero phosphorus level at the twelve week. Similarly the highest number of branches for *C. ochroleuca* was 12.3 while the lowest number of branches 7.1 was attained at zero phosphorus level (Table 2).

Table 2. Effect of phosphorus levels on some growth parameters of the two slender leaf species.

	Crotalaria brevidens			Crotalaria ochroleuca		
P Levels (kg/ha)	plant height(cm)	Number of leaves	Number of branches	plant height(cm)	Number of leaves	Number of branches
0	28.4±3.6^{c}	71.3 ±2.3^{c}	8.0 ± 1.0^{e}	63.6 ± 9.2^{abc}	27.9 ± 5.1^{d}	7.1 ± 1.0^{c}
15	34.0 ±4.3^{ab}	84.5 ±3.3^{c}	8.9± 1.0^{d}	70.8 ± 9.2^{a}	40.1 ± 7.7^{c}	9.8 ± 1.2^{b}
30	31.0 ±3.7^{bc}	106.5±7.2^{b}	9.8 ±1.0^{bcd}	59.7± 7.9^{bc}	49.0 ± 9.1^{b}	9.7 ± 1.1b
45	31.3±3.8^{bc}	122.3±19.7^{b}	9.6 ± 1.0^{cd}	59.5±7.8^{bc}	45.4 ± 7.6^{bc}	9.7± 1.1^{b}
60	37.5 ± 4.2^{a}	135.2±20.6^{a}	10.3±1.1^{bc}	56.1 ± 6.7^{c}	60.1 ± 10.5^{a}	12.0 ± 1.2^{a}
75	31.2±3.7^{bc}	127.9±21.4^{b}	9.4± 1.0^{cd}	56.6 ± 6.7^{bc}	52.0 ± 9.3^{a}	11.9 ± 1.3^{a}
90	35.4 ± 3.9^{a}	137.5±23.5^{a}	11.3 ±1.2^{a}	66.4 ± 7.8^{ab}	58.8 ± 9.8^{a}	11.7 ± 1.2^{a}
105	35.1 ± 4.0^{a}	141.9±25.1^{a}	10.8±1.2^{ab}	58.4 ±6.8^{bc}	64.3 ± 11.8^{a}	12.3 ± 1.1^{a}

Mean numbers followed by same letter are not significantly different p≤0.05 by SNK.

There was significant interaction between phosphorus and *Crotalaria* species on the mean number of branches per plant (p≤0.0001). The results of this study show that there was species difference in their response to different phosphorus levels. The optimal phosphorus level for branch production was 90 kg P_2O_5 ha^{-1} for *C. brevidens* and 105 kg P_2O_5 ha^{-1} for *C. ochroleuca* although there is no significant difference between the two levels. Lowest number of branches was attained at zero phosphorus indicating the importance of phosphorus in enhancing growth. Both *Crotalaria* species had a higher affinity for phosphorus for branch production Different results were observed by Awomi *et al.*, 2012 who found maximum mean number of branches per plant in Mung bean (*Vigna radiata L*) were obtained after application of 60 kg P_2O_5 ha^{-1}.

Table 3. Effect of phosphorus on number of pods and seed weight.

Treatment	Number of pods		Seed weight (g/1000 seeds)	
P_2O_5kg/ha	Crotalaria brevidens	Crotalaria ochroleuca	Crotalaria brevidens	Crotalaria ochroleuca
0	13.2± 6.0^{ab}	1.9± 1.37^{b}	4.3 ± 0.1^{b}	5.9 ± 0.1^{ab}
15	11.6± 5.2^{ab}	5.9± 2.71^{ab}	5.0 ± 0.4^{ab}	5.9 ± 0.1^{ab}
30	10.9± 5.3^{ab}	6.7± 2.4^{ab}	4.5 ± 0.2^{ab}	6.9 ± 0.3^{a}
45	18.4± 5.6^{a}	11.0± 4.1^{ab}	5.1 ± 0.3^{ab}	6.2 ± 0.3^{ab}
60	8.1± 4.6^{b}	6.6± 2.8^{ab}	5.4 ± 0.3^{ab}	5.7 ± 0.5^{ab}
75	16.2± 6.5^{ab}	8.6± 3^{ab}	5.7 ± 0.6^{ab}	6.6 ± 0.1^{ab}
90	14.6± 6.9^{ab}	18.3± 5.6^{a}	6.4 ± 0.6a	5.1 ± 0.8^{b}
105	12.1± 5.2^{ab}	18.9± 7.6^{a}	5.4 ± 0.3^{ab}	6 ± 0.1^{ab}

Mean numbers followed by same letter are not significantly different at p≤0.05 by SNK.

Number of pods

Application of 45 kg.P_2O_5 ha^{-1} gave the highest mean number of pods 18.4 for *C. brevidens* and this was significantly different from other levels while the least mean pod number was 7.4 attained after application of 60 kg P_2O_5 ha^{-1} at maturity. This response was different for *C. ochroleuca* where the highest number of pods 18.9 was attained at 105 kg P_2O_5 ha^{-1} (Table 3). The increment in number of pods at highest phosphorus level confirms the role of phosphorus in promoting formation of nodes and pods in legumes. However, the two *Crotalaria* species responded differently to phosphorus application probably due to their genetic potential. These results differ from those of Basu *et al.*, 2003 where maximum number of pods was achieved at application of 60 kg P_2O_5 ha^{-1} in ground nut (*Arachis hypogea*). 45 kg P_2O_5 $ha^{-1}$was optimum in forming pods for *C. brevidens* while *C. ochloreuca* produced highest number of pods at application of 105 kg P_2O_5 ha^{-1}.

Thousand Seed weight

For *C. brevidens* seed weight at zero phosphorus was significantly different from 90 kg P_2O_5 Ha^{-1}but not different from other levels (Table 3).The highest seed weight 6.04 g/1000 was found at 90 kg P_2O_5 ha^{-1} while the lowest 4.3 g/1000 was obtained without phosphorus. These results were different from those of *C. ochroleuca* where highest thousand seed weight of 6.9 g was obtained at 30 kg P_2O_5 ha^{-1} and the lowest 5.1g, at 90 kg P_2O_5 ha^{-1}. The results for *C. brevidens* were similar to those obtained by Turuko and Mohammed, 2014 who found the highest 1000 seed weight at 90 kg P_2O_5 ha^{-1} in common bean (*Phaseolus vulgaris*).

Conclusion

The results of this experiment showed that there was significant interaction between phosphorus and the two *Crotalaria* species. Phosphorus had significant effect on plant height, leave number, branch number, pod numbers and 1000 seed weight of the two *Crotalaria* species showing that the two slender leaf species required different levels of phosphorous for optimal performance in respect to the different parameters.

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References

Abukutsa-Oyango M. *Crotalaria Brevidens Benth* and *Crotalaria ochroleuca G Don*.In: Grubben GJH and Denton OA **Eds** Plant Resources of Tropical African Vegetables 2. PROTA Foundation, Wageningen, /Backhuys Publishers, Leiden, Netherlands/CTA, Wageningen, Netherland, 221-231 P.

Abukutsa.-Onyango M. 2005 Effect of nitrogen rates on germination of stored seed of slender leaf (*Crotalaria brevidens*) In Wesonga JM (Eds) Proceedings of the fourth workshop on Sustainable Horticultural production in the tropics.6TH-9THDecember 2005 Moi University, Eldoret Kenya, 188-195 P.

Abukutsa-Oyango MO. 2003. Unexploited potential of indigenous African vegetables in Western Kenya. Maseno Journal of Education, Arts and Science **4(2),** 103-122.

Awomi TA, Singh AK 2003.. Effect of Phosphorus, Molybdenum and Cobalt Nutrition on Yield and Quality of Mungbean (Vigna radiata L.) in Acidic Soil of Northeast India. Indian Journal of Hill Farming**, 25(2)** 22-26 P.

Abdul BK, Jabbar HS. 2012. Effects of phosphorus on biological nitrogen fixation in soybean under irrigation using saline water. Global Journal of Science Frontier Research Agriculture & Biology Volume **12(1),** 1.

Batjes N. 2006 World Bank Climate Change Portal 2.0

Basu MP. 2003.. Effect of cobalt, Rhizobium and Phosphobacterium inoculations on growth attributes of summer groundnut (*Arachis hypogaea* Linn.). Environmental Ecolology **21,** 813-816 P.

Buresh RJ, Sanchez PA. 1997. Building soil phosphorus capital in Africa. In: Replenishing Soil Fertility in Africa . Buresh RJ, Sanchez PA *Eds*,. SSSA and ASA, Madison, WI, USA ,111–149 P.

Freeden AR. 1989 . Influence of phosphorus nutrition on growth and carbon partitioning in Glycine max . Plant Physiology **89,** 225-230 P.

Jabbar HS, Abdul BK. 2012. Effects of phosphorus on biological nitrogen fixation in soybean (Glycine max L.) under irrigation using saline water. Global Journal of Science Frontier Research Agriculture & Biology **12(1),** 1.

Kasturi K. 1995. Response of Pea (*Pisum sativum* L.) to moisture stress and application of P, S and Zn fertilizers. Ph.D. thesis, Indian Agricultural Research Institute, New Delhi,India, 75-80.

Mills HA, Benton JJ. 1995 Plant analysis Handbook **11,** 17.

Pramanik M, Sarka MA. 2009. Effect of phosphorus rate on growth, nodulation and biomass yield of green manure crops. Mymensingh 2202, Bangladesh: Department of Agronomy,Bangladesh Agricultural University **7(1),** 22-28.

Okalebo JR, Othieno C. 1990. Phosphorus status of cropland soils in the semi-arid areas of Machakos and Kitui Districts,Kenya.In:A search for strategies for sustainable cropping in Eastern Kenya. ACIAR proceedings Dec10-11,2005. Nairobi, Kenya.

Okalebo R, Gathua W. 1986. Laboratory methods of Soil and plant analysis.A working manual ,Second edition **29(36),** 61-62.

Uiso FC, Johns T. 1996. Consumption patterns and nutritional contribution of *Crotalaria brevidens* (mitoo) in Tarime District, Tanzania. Ecology of Food and Nutrition **35(1),** 59-69.

Oyewale RO, Idowu GA. 2013. Effect of phosphorus application on the growth,yield and yield components of snake plant (*Trichosanthes cucumerina.L*). World Journal of Agricultural Sciences **1,** 088-093.

Radin JA. 1984. – Hydraulic conductance as a factor limiting leaf expansion of phosphorus–deficit cotton plants. Journal of Plant Physiology **75,** 372-377.

Rahimi AI, Panahi K. 2012. Effects of different rates of nitrogen and phosphorus on morphological traits of beans (*Phaseolus vulgaris L.*) in Yasouj region :International Journal of AgriScience **2(2),** 161-166.

Shenoy VA. 2005. Enhancing plant phosphorus use efficiency for sustainable cropping. Biotechnology. Advances **23,** 501-513 P..

Singh DA. 2000. Growth and potentially conductivity of white clover roots in dry soil with increasing phosphorus supply and defoliation frequency., -Agronomy Journal. **92,** 868-874.

Turuko M, Mohammed A. 2014. Effect of Different Phosphorus Fertilizer Rates on Growth , Dry Matter Yield and Yield Components of Common Bean (*Phaseolus vulgaris* L .) **2(3),** 88–92. http://dx.doi.org/10.12691/wjar-2-3-1