RESPONSE OF SLENDER LEAF SPECIES *CROTALARIA BREVIDENS* AND *CROTALARIA OCHROLEUCA* TO DIFFERENT PHOSPHORUS LEVELS

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Abstract
Nearly 30% of Kenyan's children are classified as undernourished and have micronutrient deficiencies, a problem that can be alleviated by consumption of African indigenous vegetables such as slender leaf (*Crotalaria* spp). Slender leaf is rich in Vitamins A, C iron and protein. Although slender leaf has been commercially produced in Kenya, only 2-4 tons per hectare have been achieved and yet it has potential of producing 10-12 tons per hectare. Declining soil fertility in the tropical soils and low phosphorus levels are among the major causes of its low productivity. The objective of this study was to evaluate the effects of different phosphorus application rates on growth and yield of *Crotalaria brevidens* and *Crotalaria ochroleuca* species grown under greenhouse conditions. A greenhouse pot experiment was conducted between January 2013-June2013,in a complete randomized design with sixteen treatment combinations of two factors that were eight phosphorus fertilizer rates,0,15,30,45,60,75,90 and 105kg$P_2O_5$$ha^{-1}$ and two slender leaf species *Crotalaria brevidens* and *Crotalaria ochroleuca* replicated four times. Growth parameters observed weekly included plant height, branch number, leaf number, flower number, pod number, thousand seed weight and seed yield taken from two weeks after germination up to 15 weeks when the seeds were harvested. Results showed that phosphorus had significant effect ($p \leq 0.05$) on leaf number with the highest leaf number achieved after application of 105kg P_20_5 ha^{-1} for both varieties. *Crotalaria brevidens* achieved highest number of leaves (100.25±10.16) and while the highest number of leaves for *Crotalaria ochroleuca* was (50.5 ±4.28). Effect of phosphorus on branch number was significant ($p \leq 0.05$) at application of 90kg P_20_5 ha^{-1} for both varieties. Phosphorus application significantly affected flower numbers ($p \leq 0.05$) with the highest flowers recorded at application of 75kg P_20_5 ha^{-1} for *Crotalaria brevidens* (96.8±10.8) and application of 105kg P_20_5 ha^{-1} for *Crotalaria ochroleuca* (54.5±10.11). Phosphorus had a significant effect ($p \leq 0.05$) on seed weight with the highest weight per plant recorded at application of 75kg P_20_5 ha^{-} for both varieties. We conclude that phosphorus application can significantly improve yield of slender leaf species in *Rhodic Ferrasols* of Kenya.

Key words: Micronutrient deficiencies, Indigenous vegetables, soil fertility, leaf number, seed weight.

1.0 Introduction

Crotalaria spp is commonly known as slender leaf, rattle pea or Ethiopian rattlebox. In international trade it is referred to as a vegetable of small-scale production (Onyango, 2004). Slender leaf is one of the most promising indigenous vegetables in East and Central Africa that has been grown and consumed for a long time. The young leaves and shoots are consumed with 100g fresh weight contributing, 100% of the daily dietary requirement for vitamin A, vitamin C, iron, calcium and 40% of proteins (Onyango, 2003). Slender leaf has been reported to have medicinal applications such as treating stomach related ailments, swellings and Malaria (Olembo *et al.,* 1995; Onyango, 2004). Crotalaria species are used as a source of fibers, silage, and green manure (Cook and White, 1996; Ramos *et al*., 2001; Onyango 2004).

Although slender leaf has high germination percentage of over 90% that occurs within 5 days (Onyango, 2005), its production is still low ranging from 2-4 tons per hectare of leaves while it has a potential of producing 10-12 tons (Mukurasi, 1986 ; Onyango, 2004). Slender leaf is mainly grown for domestic market. And the area under production in Kenya was 451, 504 and 446 ha from the year 2009 to 2011 respectively. The production was 2381, 2814 and 2481 metric tons of leaf yield in the same period. Slender leaf contribution to total domestic value of horticulture was 0.03%, 0.07%, and 1.8% respectively in 2011(HCDA, 2011).

Continuous cropping of relatively impoverished land with a small return of nutrient contributes to the decline in soil fertility characterized by low amounts of soil organic carbon, nitrogen, and phosphorus (Okalebo et al. 1990, 1993; Swift et al,1994).Application of phosphorus to the legumes improves the seed yield considerably (Hussain, 1983). *Solanum nigrum* has been found to require phosphorus at the rate of 40kg/ha for optimum production (Merinyo and Shang' a 1996; Chweya, 1997). Both P and N deficiencies are extensive in sub-Saharan African agricultural soils and are the main causes of low crop productivity, especially in smallholder agriculture (Buresh *et al*., 1997; Sanchez *et al.,* 1997; Haileslassie *et al*., 2006). Nutrient depletion in East Africa ranges from high to very high with alarming figures in countries such as Kenya, Ethiopia and Rwanda, where annual depletion rates exceeded 40kgNha^{-1}16.6 kg P ha^{-1}and 33.2kg K ha^{-1}(Smaling *et al.,* 1997).

2.0 Materials and Methods

The pot experiment was carried out at Juja, Jomo Kenyatta University of Agriculture and Technology demonstration farm situated 36km 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 1074mm with annual mean temperature of 20.5˚C (Batjes, 2006).

Red soil and sand mixture at the ratio of 5:1 was thoroughly mixed and this was filled in 2kg plastic pots and put in a greenhouse. A sample of the soil mixture was taken to the lab for analysis of nitrogen, phosphorus and potassium (NPK).A greenhouse pot experiment was set with eight fertilizer rates consisting of 0, 15, 30, 45, 60, and 75, 90 & 105kg$P_2 0_5$ha^{-1}. These were arranged in complete randomized design (CRD) for the two species and replicated four times. Slender leaf seeds obtained from Indigenous vegetable multiplication center in JKUAT were sown in 2kg plastic containers consisting of *Rhodic ferralsols* obtained from, Nikanini farm 1km from JKUAT Juja campus. The study was carried out in the month of January 2013 to May 2013. Seeds germinated in five days. Triple super phosphate fertilizer was applied as a basal fertilizer with each plant receiving 0,0.28g,0.56g,0.84,1.13g,1.41g,1.69g,1.97g TSP for each treatment and this was replicated four times. The plants were kept weed free and watering was done three times per week. Data on plant height, branch, leaf number, flower and pod number, biological seed yield, and thousand seed weight was collected. Data was analyzed using Genstat version 14.

3.0 Results and Discussion

3.1 Soil Analysis

After thorough mixing of red soil sand mixture 500g was taken for soil analysis. The soil sample was air dried and soil pH, electrical conductivity, total nitrogen, available phosphorus, exchangeable potassium were analyzed using(Mehlich,1953;NAL,1986)method. Extraction was done using double acid method for available Phosphorus. Results of the soil analysis showed that the pH was 5.69, electrical conductivity of 0.09 mS/cm, nitrogen was 0.05percent, potassium was 0.4 percent while available phosphorus level was1part per million. Data on plant height, branch and leaf number was taken from two weeks after germination up to maturity time. Watering was done three times per week the plants were weed free.

3.2 Effect of Phosphorus on Plant Growth Parameters

The results of phosphorus on growth are shown in Table 1.

Table 1: Mean comparison for Crotalaria brevidens and Crotalaria ochroleuca for the different growth parameters

	Crotalaria brevidens			*Crotalaria ochroleuca*		
	Vegetative	Reproductive	Maturity	Vegetative	Reproductive	Maturity
Leaf number	0.255	0.001*	0.001*	0.166	0.001*	0.001*
Branch number	0.155	0.072	0.001*		0.001	0.001*
Flower number	-	-	0.498	-	-	0.039*
Pod number	-	-	0.141	-	-	0.039*
Plant height	0.164	0.161	0.224	0.155	0.107	0.135
Seed weight			0.009*			0.009*

*significance at P<0.05

The effect of phosphorus was different for the slender leaf species. The effect of phosphorus on leaf number was not significant for both varieties during the vegetative stage but was significant ($P \leq 0.001$) during reproductive and maturity stage for both varieties. The highest leaf number was achieved after application of 105kg P_20_5 for both species *Crotalaria brevidens* had 131.5±10.16 leaves and *Crotalaria. ochroleuca* had highest number of leaves 50.5±4.28. Phosphorus significantly affected branch number ($p \leq 0.001$) for. *C.ochroleuca* but this was not significant for *C.brevidens*. The effect of phosphorus on flower and pod was only significant ($p<0.05$) for *C. ochroleuca* but not for *C. brevidens* (Table 1). Different phosphorus levels did not significantly affect plant height for both *Crotalaria* species unlike the results of Tomar *et al.*, (2004) who showed that increased levels of phosphorus had positive effects on plant height with the maximum height recorded after application of 60 kg/haP_20_5. This result agrees with the previous findings by Singh and Hiremath (1990) and Mandal and Sikder (1999) on phosphorus effects on Mung bean (*Vigna radiata* L.). The application of P at 60 kg/ha gave the maximum number of pods/plant, number of grains per pod with zero showing the poorest response.

3.3 Effect of Phosphorus on Seed Yield

Phosphorus application significantly affected seed yield in both varieties of slender leaf,

Table 2. *Table 2: Effect of fertilizer on seed yields of Crotalaria brevidens and Crotalaria ochroleuca (g/plant)*

Phosphorus(P_20_5) (kg/ha^{-1})	Crotalaria ochroleuca		Crotalaria brevidens	
0	12.01	ab	9.17	a
15	10.94	a	9.56	ab
30	14.85	abc	13.17	abc
45	16.17	bc	15.11	cd
60	18.5	cd	14.25	bcd
75	19.2	cd	18.55	d
90	22.34	d	14.57	cd
105	18.7	cd	15.84	cd

Means values within a column followed by the same letter are not significantly different by Fitchers protected Lsd($p \leq 0.05$)

Application of 45-105kg$P_20_5ha^{-1}$ for Crotalaria brevidens was not significantly different although the highest yields were achieved at application of 75kg$P_2O_5ha^{-1}$. Application of 0-15kgP205$ha^{-1}$was not significantly different from application of 30kg$P_20_5ha^{-1-}$Different treatment effects were observed in Crotalaria ochroleuca, where application of 90kg$P_20_5ha^{-1}$produced the highest yields. This was not significantly different from application of 60, 75 and 105kg$P_20_5ha^{-1}$. However, the lowest yields resulted from application of 0-15kg$P_20_5ha^{-1}$ (Table 2). Deshbratar et al (2010) found that phosphorus significantly affected grain yield, number of pods and number of grains per pod in the growth of pigeon peas (*Cajanus cajan*).Other significant results on the effect of phosphorus on yield and grain of Mung (*Vigna radiata* L) bean were shown by Awomi et al (2012) after application of 60kg of phosphorus.

3.4 Effect of Phosphorus on Thousand Seed Weight of Crotalaria Brevidens and Crotalaria Ochroleuca

The effect of phosphorus on thousand seed weight was significant ($p \leq 0.009$) for both species of slender leaf, Figure 1.

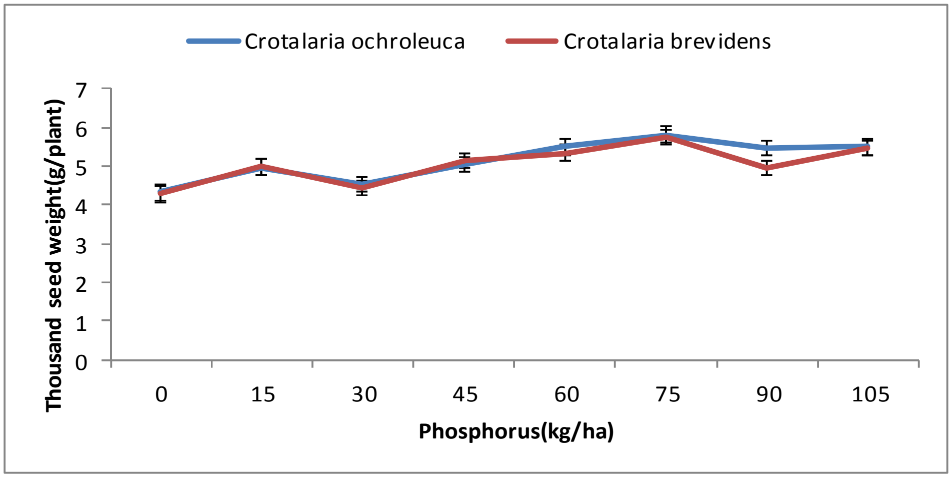

Figure 1: Effect of phosphorus on thousand seed weight of Crotalaria ochroleuca and Crotalaria brevidens.

The effect of phosphorus on the two varieties of slender leaf was similar for 0-45kgP_2O_5ha$^{-1.}$ Maximum 1000-seed weight was attained by application of 75kgP_2O_5ha^{-1} for both *Crotolaria* species. Different results were observed by Hakoomat *et al.,* (2004) on the seed weight of Chick pea where maximum seed weight was obtained at application of 90kg P_2O_5ha^{-1} followed by 120kg P_2O_5ha$^{-1.}$The effect of phosphorus fertilizer on 1000-grain weight of barley was significant with maximum 1000-grain weight of observed after application of 60 kg haP_2O_5 as reported by Mehrvarz *et al*., (2008).

4.0 Conclusions

On the basis of this study, phosphorus was found to have significant effects on the yield of the two slender leaf species grown in *Rhodic ferralsols* of Kenya. Further research should be done in order to find an alternative source of phosphorus that is cheaper and affordable to most rural populations. Production of slender leaf and its consumption will go a long way in reduction of malnutrition especially in children and lactating mothers who suffer from serious micronutrient deficiencies in Kenya. This is in line with Vision 2030's goals of provision of a healthy and economically empowered population.

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