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Response of Cowpea Genotypes to Low Soil Phosphorus Conditions in Africa

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Introduction

Cowpea is used as a grain crop in semi-arid areas of Sub-Saharan Africa because of its high protein content (20% to 25%) and as nutritional supplement to cereals for human consumption which is economical than animal protein for smallholder farmers and rural dwellers (Inaizumi et al., 1999). The crop plays an important role in nitrogen fixation, by fixing considerable amounts of nitrogen (N) biologically ranging between 3-254 kg N ha^{-1} per year (Sanginga et al., 2000), with subsequent residual effect of nitrogen on succeeding crops.

One of the constraints to high productivity of cowpea is poor soil fertility, notably the low level of available phosphorus which is widely spread (Sanginga et al., 2000).

In order to cut down phosphate further usage in the near future and to save costs for small-scale farmers, exploring the genetic resource of crops is an alternative way to utilize the small amounts of less available P in soils more efficiently (Gweyi-onyango et al,. 2011). The high cost of these soluble phosphate fertilizers has resulted in considerable increase in the use of the rocks phosphate (RP) in developing countries. This study seeks to identify cowpea genotypes that maintain high yields, high P use-efficiency and uptake under low soil P condition and positively respond to rock P application.

Material and Methods

The study was conducted in a greenhouse at the International Institute of Tropical Agriculture (IITA), Ibadan-Nigeria between (March –July, 2014). Mean daily temperature in the green house during the study period was 30.4 °C and average relative humidity was 70.7 %.Top soil of 0–30 cm depth collected from a highly weathered, acidic Alfisol was used for the pot experiment. The soil samples were analyzed for chemical and physical properties of Soil pH, Total N, available P and K and organic C content. Fifteen (15) cowpea lines were used for the pot experiment and were selected from the Legume Breeding Program of IITA, based on a previous evaluation of their ability to acquire P from less available sources.

A strip plot design was used with two factors. The first factor comprised 15 cowpea genotypes and the second factor was P fertilizer application with seven treatment levels of phosphorus, three treatment levels of mono potassium phosphate (30 , 60 , 90 mg P kg soil^{-1}) ,three treatment levels Togo rock phosphate (60, 90, 120 mg P kg soil^{-1}) and the control treatment. All pots received basal dressing of 2.78g (H_3BO_3) ,0.94g ($MnSO_4$ H_2O) ,0.21g ($ZnSO_4$ $7H_2O$), 5.12g (Na_2MoO_4 $2H_2O$), 3.00g ($FeCl_3$) , 0.0043g ($CoSO_4$ $7H_2O$) , and 60 mg P kg soil^{-1} (KCl) (Vincent 1970). Three seeds of each line were sown in each pot and thinned to two plants per pot two weeks after emergence. No N fertilizer, mycorrhizal fungi or rhizobia inoculums were applied. Insecticides were sprayed third and fifth weeks to control insect pests. Harvesting of plant samples was done 70 days after planting and oven- dried at 60°C-65°C for 72 hrs to estimate the dry matter content. P and N in the shoot and grain were analyzed. Data was analyzed using SAS version 9.3.Treatment means were separated by least significant differences (LSD) at $p < 0.05$.

Results and Discussion

Grain yield response of cowpea genotypes to low soil P under no P fertilization

Danilla and IT89KD-288 produced the highest grain yield ranging from 6.8g to7.2 representing 64% increase in grain yield compared to TVU7778, IT00K-1263 and IT97K-390-2 produced the lowest grain yield of 4 to 5 g pot^{-1}(Fig 1). A similar trend was observed by Saidou *et al.,* (2012) where Danilla was identified as good performer under no or minimal external P application. This implies Danilla has the ability to utilize inherent soil P more efficiently than the other genotypes engaged in this study. This reason may account for Danilla’s ability to produce higher yields under low soil P conditions. The observed differential performance of the cowpea lines under no P application provides vital information to identify potential high-yielding genotypes for P-deficient soils.

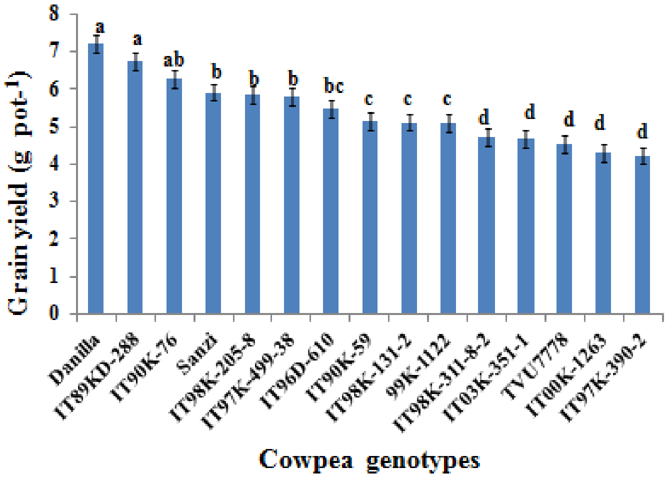

Fig. 1: Grain yield, at harvest of fifteen cowpea genotypes without P-fertilizer application in an acidic low P soil. Vertical bars represent ±S.E. of the mean (n=3). Different letters above the column indicate significant differences at P (≤ 0.05)

Effect of different P fertilizer treatments on cowpea grain yield

Genotypes responded highest at fertilizer level 60 mg P kg^{-1} soil as MP with up to 42% increase compared to the control (Fig 2). There were no significant differences between fertilizer treatment levels at 60 mg P kg^{-1} soil as RP, 90 mg P kg^{-1} soil as RP and the control treatment in grain yield production. It was observed that 120 mg P kg^{-1} soil of RP recorded the lowest grain yield with 19% reduction. Genotypes responded poorly to the highest P-concentrations (90 mg P kg^{-1} soil of MP and 120 mg P kg^{-1} soil of RP). This may imply that cowpea genotypes have a threshold at which they utilize fertilizer. Decrease in grain yield at 90 mg P kg^{-1} soil of MP maybe attributed to P toxicity but this phenomenon may be excluded in the case of rock phosphate because of its slow dissolution. The decline in growth and productivity of cowpea genotypes that received high RP (120 mg of RP kg^{-1} soil) may also be attributed to the inhibitory effects of heavy metals (mercury, lead, cadmium etc) present in Togo PR.

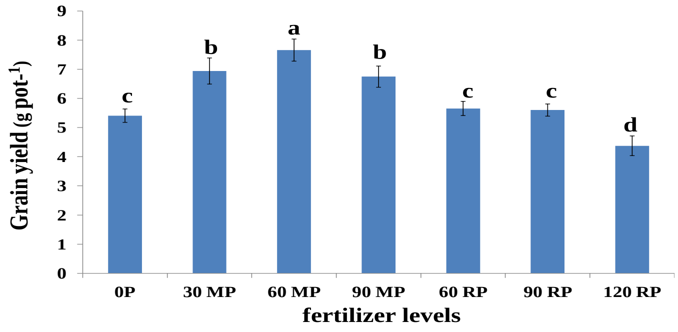

Fig. 2: Effect of P-fertilizer treatments on grain yield of cowpea genotypes at harvest. Vertical bars represent ±S.E. of the mean (n=45). Different letters above the column indicate statistical significance at the $P \leq 0.05$ levels.

Classification of cowpea genotypes on the basis of their response of grain yield production to Togo rock phosphate

Five genotypes were responsive to RP (Table 1) and these were Sanzi, IT96D-610, IT99-1122 and IT00K-1263. This observation is very promising given that RP has low solubility rate and is usually not available for short season plant but has residual effect in succeeding crops. Legumes mostly acidify their rhizospheres more than non-legumes and absorb its dissolution products because of their demand for Ca and the acidifying effect of nitrogen (N) fixation in the soil near the root system (rhizosphere). This implies legumes are usually more effective than non-legumes at using RP (Kamh et al., 1999). Such scenario may apparently explain the underlying mechanism driving responsiveness of some genotypes to RP as observed in the current study. IT90K-76 showed the strongest responses at a rate of 60 mg P kg^{-1} soil as RP having the highest grain yield of 7.63 g pot^{-1}. While genotype IT96D-610 showed the strongest responses at P fertilization rate of 90 mg kg^{-1} soil RP. At 120 mg P kg^{-1} soil as RP all genotypes had lower or same grain yield compared to the control.

Table 1: Classification (clustering) of cowpea genotypes based on their response to Togo rock phosphate in terms of grain yield production at harvest

Responsive Genotypes	P application (mg P kg soil^{-1})				Non-responsive Genotypes	P application (mg P kg soil^{-1})			
	0P	60RP	90RP	120RP		0P	60RP	90RP	120RP
IT90K-76	6.27	7.63	6.33	6.32	IT89KD-288	6.75	6.94	6.61	4.01
Sanzi	5.92	6.88	6.53	6.00	IT98K-205-8	5.84	6.13	6.33	5.72
IT96D-610	5.47	6.39	6.47	5.13	IT97K-499-38	5.82	5.95	4.58	5.03
IT99-1122	5.10	5.40	5.98	5.01	IT98K-131-2	5.12	5.09	5.14	5.27
IT00K-1263	4.29	4.93	6.26	3.27	IT03K-311-8-2	4.71	4.68	4.54	4.81
					IT90K-59	5.16	4.94	4.87	2.70
					IT97K-390-2	4.23	4.67	4.61	3.93
					TVU7778	4.55	5.04	5.01	2.20
					Danilla	7.21	5.12	5.87	2.83
					IT03K-351-1	4.66	5.04	4.87	3.11
LSD	0.74								

Conclusions and Outlook

Substantial genotypic variability exists among cowpea genotypes to utilize soil P or P applied as fertilizer on acidic tropical soils. We identified Danilla and IT89KD-288 as promising genotypes for acidic soils under no or minimal external P application. Cowpea genotypes responded best to P fertilizer level of 60 mg P kg^{-1} soil of mono potassium phosphate. Five genotypes were identified as responsive to RP.

Investigating further into the genotypes that exhibited significant responses to rock phosphate application will be worthwhile with emphasis on their performance at different locations and rock phosphate types

Acknowledgement

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