Effect of phosphorus (P) application on nutrient uptake, biomass, pod and seed formation in cowpea [*Vigna unguiculata* (L.) Walp]

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Introduction

- Phosphorous (P) deficiency is a serious problem which limits the productivity of cowpea in sub-Saharan Africa.
- P deficiency affects negatively the formation of nodule (1, 2) and the symbiotic fixation of N_2 by limiting growth and survival of rhizobia (1, 3) in legume crops.
- According to our previous study, P and N uptake in cowpea are significantly correlated ($r = 0.817$, $P < 0.01$) (4), that is, P uptake affects N uptake strongly.
- Field experiment was conducted to elucidate the effects of P application on P and N uptake, growth status, and yield of cowpea genotypes.

Materials and Methods

Field experiment was conducted under low P soil environment (Photo 1 and Table 1) in 2014 and 2015 at Fashola (N07°53'718'',E003°45'773''), Nigeria.

- Two tested lines for low P tolerance were Iron bean and IT97K-499-38.
- Two tested P sensitive lines were Sanzi and TVu 7778 .
- P applications were 0 and 30 kg P ha^{-1} using single super phosphate (SSP).
- SSP was broadcasted on the soil surface uniformly in 30 kg P ha^{-1} treatment.
- Cultivation was conducted under the rainfed condition (Figure 1).

Table 1. Characters of the soil from Fashola village

Parameters	Range	Mean
pH - H_2O (1:1 water :soil)	6.6-7.3	6.9
Clay (%)	8.0-14.0	12.5
Silt (%)	10.0-20.0	13.0
Sand (%)	72.0-76.0	74.5
Organic carbon (%)	0.68-0.86	0.80
Total nitrogen (%)	0.057-0.080	0.070
Available Phosphorus (mg kg^{-1})	0.88-1.49	1.06
Exchangeable bases (cmol$_c$ kg^{-1})		
Ca	1.79-1.91	1.86
Mg	0.97-1.31	1.20
K	0.07-0.11	0.10
Na	0.06-0.08	0.07
Exchangeable A l (cmol$_c$ kg^{-1})	0.00	0.00
Effective cation exchange capacity (cmol$_c$ kg^{-1})	2.94-3.36	3.23
Other micronutrients (mg kg^{-1})		
Zn	15.54-23.60	19.2
Cu	1.46-3.58	2.82
Mn	67.00-115.00	92.75
Fe	137.00-168.00	148.75

Photo 1 Soil in Fashola

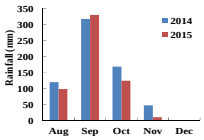

Figure 1 Amount of rainfall during cowpea cultivation in Fashola

Results

- Rainfall in 2014 was sufficient for allowing plants to mature, while rainfall in 2015 was inadequate for plants to attain maturity (Figure 1).
- Under enough rainfall condition, the effects of P application appeared more strongly on seed weight per pod compared to pod length, pod weight, and seed number per pod (Figure 4).

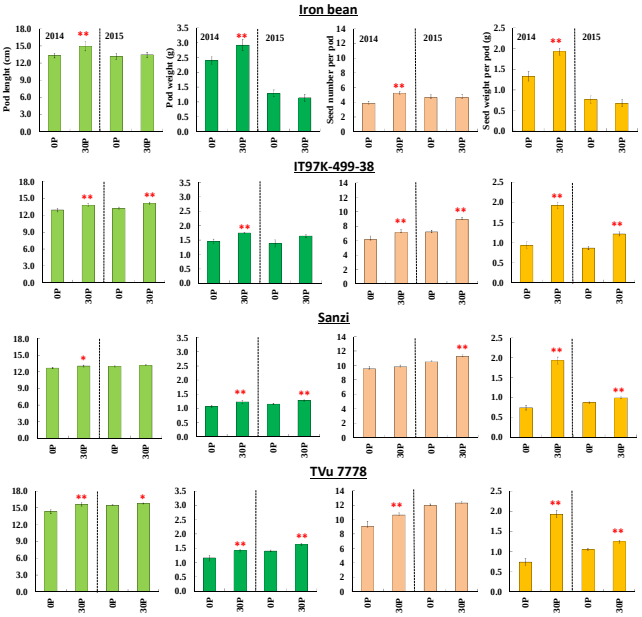

Figure 4 Pod length, pod weight, seed number per pod, and seed weight per pod for 4 tested lines under the applications of zero P (0P) and 30 kg P ha^{-1} (30P) in 2014 and 2015

The numbers of pods studied were 150 pods from each treatment, totally, 300 pods per line in 2014. In 2015, the numbers of Iron bean pods studied were 44 pods from 0P and 38 pods from 30P. For IT97K-499-38, 130 and 140 pods were used respectively from 0P and 30P. Sanzi and TVu 7778 were researched 300 pods as 2014.
Two asterisks represent the significant differences at $P < 0.01$, and one asterisk represents the significant differences at $P < 0.05$ by Tukey's method, compared to 0P in each line at each WAS. Vertical bar represents standard error.

Results

- Under 0 (0P) and 30 kg P ha^{-1} (30P), P and N uptake ranged between 0.01 and 0.06 g per plant and between 0.07 and 0.44 g per plant respectively in all lines at 5 weeks after seeding (WAS) (Figure 2).
- P (approx. 73-89 %) and N uptake (approx. 75-86 %) and shoot dry weight (approx. 71-79 %) increased at 7 WAS in 30P compared to 5 WAS, except for IT97K-499-38, in 2014 (Figure 2 and 3).
- IT97K-499-38 had comparatively smaller biomass at 7 WAS in both year (Figure 2 and 3). However, it showed biomass increase of approx. 60 % at 8 WAS in 2015 (Figure 3).

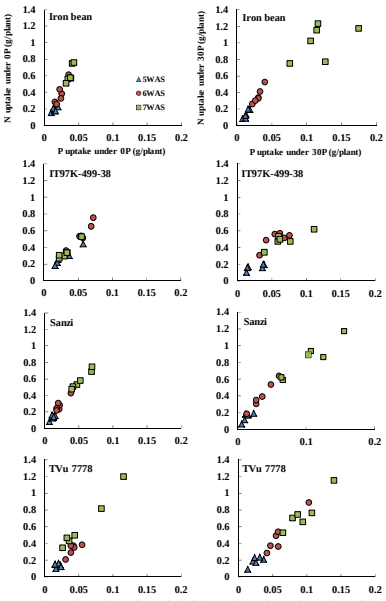

Figure 2 P and N uptake in 4 cowpea genotypes at 5, 6, and 7 weeks after seeding (WAS) under the application of 0 (0P) and 30 kg P ha^{-1} (30P) in 2014.

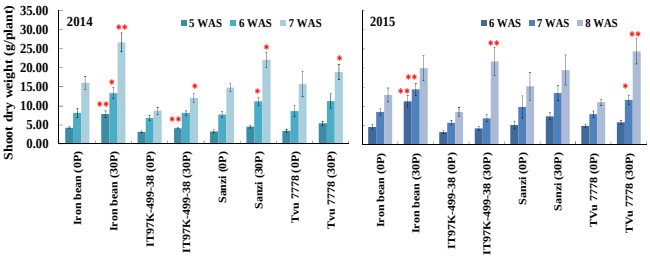

Figure 3 Shoot dry weights at the vegetable growth stage for four cowpea lines in 2014 and 2015

In 2014, the data was collected at 5, 6, 7 WAS. In 2015, the data was collected at 6, 7, 8 WAS.
Two asterisks represent the significant difference at $P < 0.01$, and one asterisk represents the significant differences at $P < 0.05$ by Tukey's method, compared to 0P in each line at each WAS.
Vertical bar represents standard error.

Conclusions

- P and N uptake at 5 WAS in two low P tolerant and two low P sensitive genotypes were very small under with and without P application. However, at 7 WAS, the nutrient uptake was increased sharply, except for IT97K-499-38.
- Shoot dry weight in three genotypes was increased at 7WAS. Shoot dry weight of IT97K-499-38 was increased at 8 WAS.
- Small biomass genotypes like IT97K-499-38 are not strongly affected by the presence or absence of P at the vegetative growth stage.
- According to this observation, cowpea needs sufficient P nutrient to promote N uptake from 7 and 8 WAS.
- P application affects strongly seed weight per pod.

References

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