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Research Application Summary

Response of local and improved cowpea varieties to Rhizobia inoculation and phosphorus in West Nile region of Uganda

Nyamaizi, S[1]., Olupot, G[1]., Tumuhairwe, J.B[1]., Amayo, R[2]., Obaa, B. B.[1] & Tereka, E.[1]
[1]Department of Agricultural Production, School Agricultural Sciences, Makerere University P.O. Box 7062, Kampala, Uganda
[2]Dryland Legumes Research Program, National Semi-Arid Resources Research Institute, National Agricultural Research Organization, P. O. Box 56, Soroti, Uganda
Corresponding author: giregono@gmail.com

Abstract

Cowpea (*Vigna unguiculata* L.Walp) is an important food security and cash crop among poor households especially in eastern and northern Uganda. However farmers have reported grain yields as low as 50 kg ha^{-1}, far below the potential yield of cowpea estimated at 2500 kg ha^{-1}. This study compared responses of two cowpea varieties: Agondire, a local spreading landrace, and SECOW 2W, an improved variety to inoculation with Rhizobia and phosphorus fertilization for adaptation to Northern Uganda's West Nile sub-region. We tested the hypothesis that the local landrace cowpea variety could perform as good as or even better than the improved cowpea variety when subjected to similar conditions. To test this hypothesis, the two cowpea varieties were subjected to four levels of phosphorus: P0, P10, P20 and P40 kg ha^{-1} without (-R) or with (+R) inoculation with Rhizobia in a randomized complete design replicated thrice with slope as the blocking factor during the short and long rains of 2015. Data were collected on nodule effectiveness and grain yield and subjected to ANOVA using the GenStat statistical package. Initial soils characterization showed low soil fertility with low organic matter, nitrogen, phosphorus and potassium far below the critical levels for optimization of crop yields in tropical soils. Agondire responded significantly ($p < 0.05$) better than SECOW 2W when high rates of inorganic phosphorus were applied with Rhizobia inoculation. At the low rates of P with Rhizobia inoculation, SECOW 2W performed better at P (20 and 10 kg ha^{-1}). The study therefore recommends SECOW 2W, which responds better to Rhizobia inoculation at low rates of P fertilizer.

Key words: Agondire , Northern Uganda, SECOW 2W, Phosphorus, Rhizobia inoculation, soil fertility

Résumé

Le niébé (*Vigna unguiculata* L.Walp) est une culture importante de sécurité alimentaire et de revenu pour les ménages pauvres, en particulier à l'Est et au Nord de l'Ouganda. Cependant, les agriculteurs ont rapporté des rendements en grain en dessous de 50 kg ha^{-1}, ce qui de loin très inférieur au rendement potentiel du niébé estimé à 2500 kg ha^{-1}. La présente étude a comparé les réponses de deux variétés de niébé (Agondire, une variété locale et SECOW 2W, une variété améliorée) à l'inoculation avec du Rhizobium et la fertilisation du phosphore pour permettre l'adaptation dans la sous-région Nil du Nord de l'Ouganda. Nous avons testé l'hypothèse selon laquelle la variété locale de niébé pourrait être aussi bonne ou

même meilleure que celle améliorée lorsque soumise aux conditions similaires. Pour tester cette hypothèse, les deux variétés de niébé ont été soumises à quatre niveaux de phosphore: P0, P10, P20 et P40 kg ha-1 sans (-R) ou avec inoculation (+ R) de Rhizobium dans un bloc aléatoire complet répété trois fois considérant la pente comme facteur de bloc pendant les courtes et longues pluies de 2015. Des données ont été collectées sur l'efficacité du nodule et le rendement des grains, et soumises à une ANOVA en utilisant GenStat. La caractérisation initiale des sols a montré une faible fertilité du sol avec des valeurs de matières organiques, d'azote, du phosphore et du potassium faibles et bien en dessous des niveaux critiques d'optimisation des rendements des cultures dans les sols tropicaux. Agondire a répondu de manière significative ($p < 0,05$) et mieux que SECOW 2W lorsque des taux élevés de phosphore inorganique ont été appliqués avec l'inoculation du Rhizobium. Aux faibles taux de P avec l'inoculation du Rhizobium, SECOW 2W a eu une meilleure performance à P (20 et 10 kg ha-1). L'étude recommande donc SECOW 2W, qui répond mieux à l'inoculation du Rhizobium avec de faible taux d'engrais phosphoriques.

Mots clés: Agondire, Nord Uganda, SECOW 2W, Phosphore, inoculation du Rhizobium, fertilité du sol

Introduction

Cowpea (*Vigna inguiculata* L.Walp), an annual herbaceous legume, is majorly grown in the tropics and subtropical regions mainly for its leaves and grains and, to a lesser extent, as a fodder crop (Adejumo, 2012). It is the most important food grain legume in the dry savannas of tropical Africa where is grown on about 12.5 million hectares and consumed by over 200 million people (Oyewale, 2013). West Africa accounts for about 9.3 million hectares, which leaves only 33% being grown elsewhere in the world (Singh *et al.,* 2003). In Sub Saharan Africa (SSA), the total area harvested to all food legume crops totaled 20 million hectares by 2006-2008 of which 54% of the area harvested was under cowpea (Langyintuo *et al.,* 2003). Cowpea therefore forms an important component of agricultural food crops consumed by small holder farming households in SSA and thus plays an important role in achieving food and nutrition security. Despite the crop's importance, yields are low in range of between 50 kg ha^{-1} and 300 kg ha^{-1} in farmers' fields (Bationo, 2003).

Literature summary

The low cowpea yields have been attributed to abiotic and biotic constraints affecting physiological growth including low soil fertility with phosphorus being the most limiting factor in the growth of cowpea and its production in most soils (Bationo, 2003). Soils with low quantities of P need addition of up to 10 kg ha^{-1} of N and 40 to 70 kg ha^{-1} P_2O_5 and K_2O may be needed in low fertility soils for proper growth of some varieties (FAO, 2011). However, there is lack of knowledge on growth and performance of specific cowpea varieties to phosphorus. Cowpea requires P for both physiological growth and efficient nodulation. It has been reported that most cultivated soils in Uganda lose more P than

gained which thus requires additions through fertilizers (Bationo, 2003). Nitrogen is also limiting but cowpea is a legume known to fix Nitrogen biologically in the soil, it is non-selective in Rhizobium species and can undertake effective symbiosis with a broad host range. However Babaji *et al.* (2011) indicated the need for Rhizobia inoculation to boost cowpea production.

Research Methodology

The study was carried out in Arua in the West Nile region of Northern Uganda. The trials were conducted in a participatory manner where farmers were involved at all stages of evaluation from site selection through land preparation, planting, field management, and data collection to harvesting. Unlike dominant farmer practice (broadcasting), row planting was used. SECOW 2W was spaced at recommended spacing of 60 cm by 30 cm while Agondire was planted at a spacing of 100 cm by 60 cm taking into consideration its spreading nature. Four seeds were planted per hole and later thinned to three plants per hole after first weeding (14 days after emergence). Weed control was done manually by farmers following their common practice, as well as for pests and disease control. The experiment was repeated twice and established in a randomized complete block design replicated thrice.

Growth parameters were measured along with number of nodules determined through physical counts at 50% flowering; effective nodules were those that were found with a red or pinkish coloration after cross section cuts. Percentage of effective nodules was determined using the formula of number of effective nodules/total number of nodules *100. Yield parameters were determined at physiological maturity including seeds per pod of the randomly sampled 10 plants excluding those in guard rows, 100 seed dry weight and grain yield. Data collected were subjected to analysis of variance, and significant means were separated using L.S.D at 5% significance level using Genstat Statistical package.

Results and discussion

The effect of P fertilizer application on effective nodulation for both Agondire and SECOW 2W was not significant ($p > 0.05$). Agondire showed highest percentage of effective nodules even at no P fertilizer application (Fig. 1). However, the effect of P was significant with Agondire giving higher number of effective nodules than SECOW 2W at P0, P10 and P20 kg ha^{-1} with exception of P 40 kg ha^{-1}. Under soil Rhizobia inoculation, SECOW 2W had higher percentage of effective nodules at all P rates with exception of P at 40 kg ha^{-1}. Results in Table 1 show that the effect of P application was highly significant ($p < 0.001$) between the varieties. Agondire recorded higher yield than SECOW 2W at the extreme rates (controls and at the highest rate, P at 40 kg ha^{-1}). In contrast, SECOW 2W recorded higher yield than Agondire at low P rates (P at 10 and 20 kg ha^{-1}).

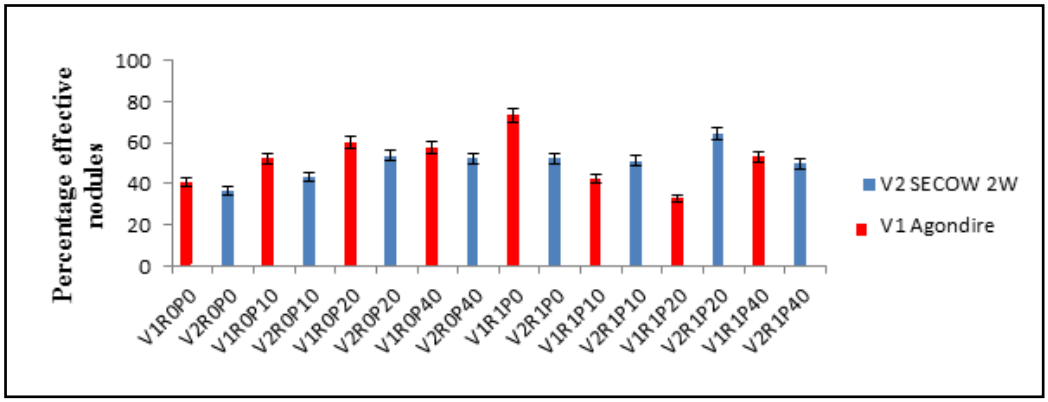

Figure 1. Influence of P and soil Rhizobia inoculation on nodulation under two varieties of cowpeas

Table 1. Grain yield of two cowpea varieties under varying levels of P and Rhizobia inoculation

Treatment	Seeds per pod	100 seed weight (kg)	Yield (kg ha^{-1})
VIR0P0 (C)	5	0.00778	436.7
V2R0P0(C)	6	0.00911	347.2
V1R0P10	6	0.01189	578.7
V2R0P10	6	0.01211	689.8H
V1R0P20	8	0.01389	705.2
V2R0P20	7	0.01289	1288.6H
V1R0P40	7	0.01500	1720.7
V2R0P40	8	0.01656H	1026.2
VIR1P0	8	0.01189	452.2N
V2R1P0	6	0.01100N	338.0N
V1R1P10	7	0.01400	1032.4
V2R1P10	7	0.01189	1541.7H
V1R1P20	7	0.01356	1146.6
V2R1P20	7	0.01289	1708.3H
V1R1P40	8	0.01633	1933.6
V2R1P40	8	0.01789H	1066.4
L.S.D (0.05)	1.0	0.00245	110.1

The N-yield obtained not significant from the control of the same variety and H-SECOW 2W recorded higher yield than Agondire under same treatments.

Due to higher temperatures experienced in Arua district, some of the Rhizobia cells may not have survived throughout the growth of cowpea resulting in low number of effective nodules across most treatments (Mariangela and Milton, 2000). At the low rates of P (P

at10 and 20 kg ha^{-1}), high yield of SECOW 2W was attributed to the efficiency of the variety to utilize available nutrients to assimilate carbohydrates which are deposited in the seeds, while on the other hand, addition of any unit of P could have led to delayed uptake of other nutrients by the variety hence low growth and yield (Saginga *et al.,* 2000). On the other hand, Agondire requires more units of P for it to be able to effectively carry out its physiological activities and attain its optimum yield when compared to SECOW 2W that yielded its optimum at 20 kg ha^{-1} which makes it a more effective variety. The varieties' response to P additions could have varied due to a mixture of environmental requirements and genetic make-up brought about by variety differences (Magani and Kuchida, 2009). However, the proportionate increase of yield with P addition for both varieties was attributed to the effective growth induced by P application that has multiple effects on plant nutrition including photosynthesis (Karikari *et al.,* 2015). On the other hand for the case of SECOW 2W, a lot of P could have led to a negative effect on seed growth though the average seed numbers were similar as that of Agondire. This corroborates with the study of Saginga *et al.* (2000) who noted that a lot of P surpassing variety requirements could instead lead to reduced seed development. Agondire performed better at high rates of P (P20 and P40) kg ha^{-1} input and could therefore be grown by farmers in the presence of fertilizer since it responded better to higher P addition. As for SECOW 2W, lower rates could be applied but the variety also requires additional support through Rhizobia inoculation for it to effectively nodulate in North Western Ugandan soils and other similar soils.

The study recommends cultivation of SECOW 2W since it responded better to low levels of P with Rhizobia inoculation when compared with Agondire that required higher P rates. With limiting nitrogen in the soil, Agondire nodulates better than SECOW 2W without Rhizobia inoculation and therefore Rhizobia inoculation is more vital for SECOW 2W than for Agondire variety.

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