Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.6, No.12 2016

Effects of Phosphorus and Rhizobium Inoculation on Yield Components and Grain Yield of Some Selected Cowpea Genotypes

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The research is financed by the Center for Dryland Agriculture, Bayero University, Kano,Nigeria.

Abstract
The effects of phosphorus (0, 20, 40kg $P^2O^5ha^{-1}$) and rhizobium inoculation (inoculated and un-inoculated) on the yield components and grain yield of three cowpea genotypes (IT93K-452-1, IT97K-573-1-1 and IT98K-499-35) were investigated under field conditions at Bayero University, Kano, Teaching and Research Farm ($11^0$59 N; $8^0$25 E; 466m above sea level) and Agricultural Research Station Farm, Minjibir ($12^0$10' N, $8^0$39' E; 402m above sea level) in 2014 rainy season. Cowpea genotypes were assigned to the main plot, while phosphorus levels were assigned to the sub-plots. The inoculation was assigned to the sub-sub plot. These were laid out in Split-split plot design and replicated three times. Results of the study indicated significant effect of genotype in all the characters measured except shelling percent. Significantly ($p< 0.05$) higher number of pods per plant, pod weight, fodder and grain yield was observed from IT99K-573-1-1 than all other genotypes evaluated. Similarly, the number of pods per plant, pod weight, fodder and grain yield were significantly influenced by application of phosphorus with better results recorded from 40 kg P_2O_5 treated plants. Inoculation of cowpea with rhizobium MC92 strain, also recorded significant effect on the measured characters and grain yield. Inoculation of cowpea with rhizobium MC92 along with 40kgP_2O_5 ha^{-1} could enhance performance of cowpea particularly with an adaptable genotype like IT99K-573-1-1.
Keywords: Cowpea, grain yield, inoculation, yield components

1. Introduction

Subsistence farmers in the semi-arid and sub humid region of Africa are the major producers and consumers of cowpea. These farmers not only grow cowpea for the dry seed but also for human consumption, fodder for animal as well as vegetable material (Ferry, 2002). About two third of the world production is from Africa, cultivated on at least 12.5 million hectares, with an annual production of over three (3) million tons (Quin, 1997).

Even though phosphorus is a major mineral nutrient required by plants, it remains the most immobile and un-accessible (Narrang *et al*., 2000). Phosphorus was reported to influence nodule development through its basic functions as an energy source (Bekere *et al*., 2012). It is also essential for seed production and formation of healthy and sound root system which is essential for the uptake of nutrients from the soil (Das *et al*., 2008). Owolade *et al* (2006) reported that application of higher dose of phosphorus significantly increase number of pods per plant. Similarly, cowpea was reported to exhibit significant response to applied phosphors on number of pods per plant, with the highest response recorded with application of 60kg ha^{-1}. (Singh *et al*, 2011). The element is however, generally deficient in savanna soils thus limiting biological nitrogen fixation (Kumaga and Ofori, 2004).

Rhizobia are special bacteria that can live in the soil or in root nodules of legumes. In root nodules, they form a symbiotic association with the legume, obtaining nutrients from the plant and producing nitrogen in a process called Biological Nitrogen Fixation (Uchida, 2000). Nitrogen fixation is one of the ways through which soil fertility can be improved (Mclaughlin, *et al*.,1990). On the other hand, rhizobium inoculation is a significant technology employed for the manipulation of rhizobia in improving crop productivity and soil fertility. This can lead to establishment of large rhizobia in the rhizosphere, as well as improved nodulation and nitrogen fixation even under adverse soil conditions *(*Peoples *et al.,* 1995*)*. The combination of rhizobia inoculation and phosphorus supplementation in legume production was reported to improve production (Ndakidemi *et al*., 2006).

Despite these advantages, information on the response of cowpea to inoculation with MC92 strain of rhizobia in this agro-ecology is not sufficient. This research was conceived with the intent of studying the yield response of some selected cowpea genotypes to phosphorus and rhizobium inoculation in this agro-ecology.

2. Materials and Methods

2.1 Experimental Sites

The trials were conducted at Bayero University, Kano Teaching and Research Farm ($11^0$59 N; $8^0$25 E; 466m above sea level) and Agricultural Research Station Farm, Minjibir ($12^0$10' N, $8^0$39' E; 402m above sea level) in

2014 rainy season. Both locations fall in the sudan savanna agro-ecology of Nigeria. These are characterized by two seasons, a wet season (May to September) and dry season (October to April). Mean annual rainfall and temperature in the locations is about 800mm and 31^0C, respectively (Nnoli *et al.,* 2006).

2.2 Cultural Practices

Soils of the experimental sites were collected at 0 – 15cm soil depths prior to sowing. These were bulked and analyzed for physico-chemical properties as described by Black (1965). The land was consequently ploughed, harrowed and made into ridges. Rhizobium Inoculants containing MC92 strain was used to treat cowpea seeds at 10g inoculants per kg of cowpea (Ankrumah, 2015). 30ml slurry sticker (30g gum Arabic + 10g inoculants) were used to ensure adhesion of the inoculants to the cowpea seeds. The mixed seeds were allowed to air-dry under shade for 15 minutes. These were planted immediately within maximum of two hours of inoculation at two seeds per hole and 20 x 75cm spacing.

Single super phosphate (SSP) was basally applied to plots as per treatment during sowing. Fields were kept free of weed by hand hoeing at 10, 20 and 50 days after emergence. Insect pests were also controlled using cyper-diforce (cypermethrin $30gl^{-1}$ + dimethoate $24gl^{-1}$) at the rate of 1liter ha^{-1}.

2.3 Treatments and Experimental Design

The treatments consisted of two levels of rhizobium (inoculated and un-inoculated), three levels of phosphorus (0, 20, 40 $kgP_2O_5\ ha^{-1}$) and three cowpea genotypes (IT93K-452-1, IT97K-573-1-1 and IT98K-499-35). Cowpea genotypes were assigned to the main plots, while phosphorus levels were assigned to sub-plots. Inoculation was also assigned to the sub-sub plot. These were laid out in Split-split plot design and replicated three times.

2.4 Data Collection and Analysis

Data were collected on number of pods per plant height, pod weight, shelling percent, fodder yield and grain yield. The grain yield was also extrapolated from the weights of the harvested net plots. These were subjected to Analysis of Variance using Genstat 17^{th} edition. Significant treatment means were compared at 5% level of probability using Duncan Multiple Range Test (Duncan, 1955).

3.0 Results and Discussion

3.1 Effect of Genotype on the Yield Components and Grain Yield of Cowpea

Genotypic variation had significant ($p< 0.05$) effect on number of pod per plant (Table 2). Results indicated that IT99K-573-1-1 out-performed IT97K-499-35 and IT93K-452-1 in BUK. This could be due to genotype differences. Nirmal *et al* (2003) reported similar observation that performance of cowpea as dictated by genotype. Similarly, IT99K-573-1-1 produced significantly the highest pod weight than all other genotypes evaluated. This finding also corroborates with the work of Acquah (2007) who reported the role of genotype in deciding cowpea performance, especially when augmented with improved practices. The shelling percent was however, not influenced by genotype in this study (Table 3). Results of this finding also showed significant ($p< 0.05$) effect of genotype in-terms of fodder and grain yields from both locations. IT99K-573-1-1 still out-performed all other genotypes evaluated. The superiority of IT99K-573-1-1 is an indication of the role of genotype in cowpea performance as buttressed by several authors (Nirmal *et al,* 2003., Acquah, 2007). IT99K-573-1-1 is spreading type with more fruit bearing branches, and hence higher fodder and grain yield.

3.2 Effect of Rhizobia Inoculation on the Yield Components and Grain of Cowpea

Significant ($p< 0.05$) effect of rhizobia inoculation on number of pods per plant was observed in BUK in this study. The lack of response to rhizobium inoculation in Minjibir may be attributed to low P (7.95mg/kg) in this soil (Table 1). This corroborates with the work of Sahu and Verma (1972) who attributed an increase in soil N to applied P by 18 – 26%. Results of the study further revealed non-significant response of cowpea in-terms of pod weight and shelling percent (Table 3). This is an indication of the superiority of genotype in deciding these parameters as buttressed by Nirmal *et al* (2003). Inoculation with rhizobium MC92 strain recorded significant response on fodder and grain yield only in Minjibir. This could be explained by the fertility differences of the soils with BUK soils having more organic matter, organic carbon and P, and hence the effects of inoculation might be masked by the effects of these elements.

3.3 Effect of Phosphorus on the Yield Components and Grain Yield of Cowpea

The effect of phosphorus on number of pods per plant and pod weight is shown in Table 2. This reveals that number of pod per plant was significantly ($p< 0.05$) influenced by applied P in BUK only. This also increases with every increased applied P up to $40kgP_2O_5$. For the pod weight however, this also increases with each increase in P up to 40kgP2O5 in Minjibir only. Feller (1995) also reported significant effect of applied P in soils that P is limiting. There was however, no significant response of cowpea in terms of shelling percent to applied P as all the treatments were similar (Table 3). The results of this finding further revealed significant ($p < 0.05$) response of cowpea to applied P on fodder and grain yields in Minjibir only. This showed a linear increase in these parameters with every increase in applied P up to 40kgP_2O_5. Similar work was reported by Uarrota (2010) for a significant increase in yield of cowpea with every increase in applied P up to 40kg P_2O_5 ha^{-1}. This could also be due the role of P in increasing soil nitrogen by 18 – 26% as reported by Sahu and Verma (1972), which consequently leads to increase in dry matter production and hence increase in yield. Similar results was reported by Feller (1995) on the effect of P on cowpea particularly in soils that are P deficient.

4.0 Conclusion and Recommendation

Genotypic variation had significant ($p < 0.05$) effect on yield components and grain yield of selected cowpea genotypes. IT99K-573-1-1 out-performed IT97K-499-35 and IT93K-452-1 in this study. Similarly, number of pods per plant, fodder and grain yields were significantly influenced by inoculation with rhizobium MC92 strain. The effects however, differed with location with Minjibir producing better fodder and grain yields respectively. Similarly, all the measured yield components and the grain yield responded favorably to applied phosphorus with the exception of the shelling percent. Results of this finding suggests adoption of rhizobium inoculation technology along with 40kgP_2O_5 in P deficient soils would boost cowpea production particularly with an adaptable variety and improved agronomic practices in this agro-ecology.

Acknowledgement

The authors acknowledge the Center for Dryland Agriculture, Bayero University, Kano for the grant awarded which makes the conduct of this research achievable.

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Table 1: Physico-chemical properties of soils taken from 0 - 30cm depths at the experimental sites in 2014.

Soil Characteristics	B.U.K	Minjibir
Particle Size		
Sand (%)	89	86
Silt (%)	4.2	7.0
Clay (%)	6.0	7.0
Textural class	Sandy loam	Sandy loam
Chemical Composition		
pH in water	6.1	6.8
Organic carbon (%)	0.490	0.470
Total nitrogen (%)	0.08	0.06
Available phosphorus (mg/kg)	15.55	7.95
Exchangable bases (Cmol/kg)		
Ca	0.30	2.25
Mg	4.12	0.833
K	0.61	0.334
Na	0.31	0.178
CEC	4.330	4.866

Analyzed at the Laboratory of the Soil Science Department, Bayero University, Kano.

Table 2: Number of pod per plant and pod weight of cowpea as influenced by variety, inoculation and phosphorus at BUK and Minjibir.

	Number of pods per plant		Pod weight (grm)	
Treatment	BUK	Minjibir	BUK	Minjibir
Variety (V)				
IT 99K – 573-1-1	29.78a	22.06	1599a	1299a
IT 97K – 499 – 35	21.94b	18.61	1089b	1058b
IT 93K – 452 – 1	19.94c	16.11	973b	967b
SE ±	0.484	1.237	70.4	49.7
Inoculation (I)				
Inoculated	25.30a	19.78	1172	1173
Un-inoculated	22.48b	18.07	1244	1043
SE ±	0.879	0.768	60.3	19.3
Phosphorus				
0	20.17c	17.78	1308	947c
20	24.28b	17.72	1183	1133b
40	27.22a	21.28	1134	1243a
SE ±	0.437	1.141	49.6	28.5
Interaction				
V*P	ns	ns	ns	ns
V*I	ns	ns	ns	ns
P*I	ns	ns	ns	ns
V*P*I	ns	ns	ns	ns

Means followed by different letter within a column are significantly different at 5% level of probability using DMRT.

Table 3: Some yield components and grain yield of cowpea as influenced by variety, inoculation and phosphorus at BUK and Minjibir.

	Shelling Percent (%)		Fodder Yield kg/ha		Grain Yield kg/ha	
Treatment	BUK	Minjibir	BUK	Minjibir	BUK	Minjibir
Variety (V)						
IT 99K – 573-1-1	63.86	61.28	2153a	1703a	1033a	806a
IT 97K – 499 – 35	68.62	61.96	1770ab	1199b	746b	682b
IT 93K – 452 – 1	60.06	62.49	1473b	1054c	635b	605b
SE +	2.824	2.624	196.2	15.5	63.8	57.3
Inoculation (I)						
Inoculated	64.20	60.40	1669	1364a	781	764a
Un-inoculated	64.16	63.42	1929	1274b	828	631b
SE +	1.302	1.046	142.7	43.9	55.2	17.8
Phosphorus						
0	64.24	60.47	1765	1170b	845	572c
20	65.08	60.96	1981	1312b	833	692b
40	63.22	64.30	1650	1475a	736	828a
SE +	1.413	1.703	129.2	52.7	43.1	33.0
Interaction						
V*P	ns	ns	ns	ns	ns	ns
V*I	ns	ns	ns	ns	ns	ns
P*I	ns	ns	ns	ns	ns	ns
V*P*I	ns	ns	ns	ns	ns	ns

Means followed by different letter (s) within a column are significantly different at 5% level of probability using DMRT.