

MODELLING THE DUAL POTENTIAL OF COWPEA IN THE LAWRA-YAGTUURI IN THE UPPER WEST REGION

ABSTRACT

Aims: This research was conducted in pot of trials at the farm land of Lawra-Yagtuuri in the Upper West Region to determine the effect of Rhizobia inoculants, Boostxtra, and appropriate Phosphorus Fertilizer level required for cowpea growth and yield.

Study Design: The reseach design used in this study was experimental. Specifically, the experiment was run as a split-plot design.

Place and Duration of Study: Department of Statistics and Department of Mathematics, University for Development Studies, between November, 2015 and July, 2016.

Methodology: The experiment assessed the effects of rhizobia inoculants at two levels(2.5g and 5.0g) per kg, boostxtra and four levels of phosphorus fertilizer (0 kg P_2O_5 ha⁻¹, 25 kg P_2O_5 ha⁻¹, 50 kg P_2O_5 ha⁻¹ and 75 kg P_2O_5 ha⁻¹) on the growth and yield of cowpea. It was run in a split-plot design. The analysis was done using Generalized Linear Model and Subset Regression.

Results: Phosphorus Fertilizer and Boostxtra significantly enhanced cowpea growth and yield; Pod weight plant (g), Nodule dry weight (g), Pod and Nodule numbers in all the weeks of measurement were significantly improved. However, the highest yield was observed at 50 kg P_2O_5 ha⁻¹. Cowpea response to rhizobia inoculation was not sufficient to raise cowpea yield. The model was significant ($P<0.05$) accounting for 77.70% total variation in the yield. The subset regression analysis had $C(p)=5.28$ from six variables in the model with the Adjusted R Square = 0.9318.

Conclusion: The ability to optimize cowpea grain yield depends on the application of 50kg P_2O_5 /ha and Boostxtra and care should be taken to apply the right amount of Phosphorus Fertilizer.

Keywords: Cowpea, Leguminous crop, Subset Regression, Yield, Generalized Linear Model

1. INTRODUCTION

Cowpea (*Vigna unguiculata*(L.) Walp) is an important leguminous crop in the dry savannah of the tropics covering 12.5million hectares with annual production of about 3 million tons (FAO, 2005). Cowpea in Africa; Ghana is popularly called 'beans' and 'niebe' in the Francophone Countries. The largest production is in the moist and dry Savannas of Sub Saharan Africa (SSA), where it is intensively grown as an intercrop with other cereal crops like millet, sorghum and maize (Ishiyaku et al., 2010). Though it is grown in other parts of the world, Nigeria remains the largest producer and consumer of Cowpea in the world, FAO data (2005). According to FAO data (2001-2005), Nigeria produces an average of 2.58 ± 0.31 million metric tons of cowpea per year.

Both grain and leaves are edible products of cowpea that are rich and cheap sources of high-quality protein. They supplement to the lower quality cereal or root and tuber protein commonly consumed in tropical Africa (Kitchet al., 1998; Karikari and Molatakgosi, 1999). On average cowpea grains contain 23-25% protein and 50-67% starch in dry bases (Quin, 1997). From a single planting, one may be

able to have several products such as leaves, immature pods, immature and mature seeds. Careful and positive attention to cowpea would support 850 million people in the world with high incidence of undernourishment in sub-Saharan Africa as documented by FAO (2005, 2006).

The area under cowpea cultivation in Ghana peaked in the year 2003 with 190,400ha, but cowpea production continues to be lower than its consumption rate in Ghana in 2010 (MOFA, SRID, 2011). This is evidenced by the import of 3,380MT of cowpea grains which supplemented the country's production of 219,300MT in 2010 (MOFA, SRID, 2011).

The inability of Ghana to produce enough cowpea to feed the citizenry is multi-faceted. Specific fertilizer recommendation and integration of biological materials to increase the yield of cowpea farmers may prove successful. The effectiveness of applied fertilizer, rhizobia inoculants and boostxtra are constrained by the use of the inappropriate rate and improper timing of sowing. Hence, the low yield of cowpea among smallholder farmers in the Country especially in the Lawra-Yagtuuri in the Upper West Region requires attention.

The main objective of the study is to model the yield of Cowpea production in the Lawra-Yangtuur using Generalized Linear Model.

2. METHODOLOGY

The data was obtained in the experimental field at Yagtuuri in a split-plot design with inoculation rates (5.0 and 2.5kg of rhizobia inoculants per ha), phosphorus rates (0, 25, 50, and 75kg P₂O₅/ha) and boostxtra. The plant height, shoot dry weight, nodule dry weight and nodule number per plant were recorded at two weeks after planting (2 WAP), six weeks after planting (6 WAP), eight weeks after planting (8 WAP), ten weeks after planting (10 WAP), twelve weeks after planting (12 WAP) and fourteen weeks after planting (14 WAP). Plant height was taken from the ground level to the apex of the plant with a graduated pole and the average was calculated for each plot. Pods on these plants were removed and counted to obtain the pod number/plant.

Mainly two models were used in the analysis: The Subset Regression analysis and the Generalized Linear Model. The Generalized Linear Model is given by

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k + \epsilon_i \dots \dots \dots (1)$$

Where **Y** is the dependent variable, **X_i** are the independent or predictor variable, the parameters **β₀, β₁, ..., β_k** are the regression coefficients and **ε_i** is the error term in the model.

3. RESULTS

The study revealed that fertilizer at level 2 showed the highest average performance of 3017.6658kg/ha and 2837.5428kg/ha at level 3 as compared to the control at level 0 (Table 1).

Table 1: Estimates of the mean of the variables levels

Variable	Category	Mean	Std. Error	95% Wald Confidence Interval	
				Lower	Upper
Inoculation	0	2732.8327	.1415	2732.5553	2733.1101
1	2711.9509	.1476	2711.6616	2712.2401	
Boostxtra0	2575.4025	.1479	2575.1127	2575.6922	

79	1	2869.3811	.1418	2869.1033	2869.6590	
80	Fertilizer	0		2521.6253	.2045	2521.2245 2522.0260
81	1	2512.7333	.2041	2512.3333	2513.1334	
82	2	3017.6658	.2043	3017.2654	3018.0662	
83	3	2837.5428	.2050	2837.1410	2837.9446	

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86 **Inoculation (0) = 5.0g of inoculants per kg, Inoculation (1) = 2.5g of inoculants per kg, 0 = No**
87 **boostxtra, 1 = Boostxtra, 1 = 25kg P/ha, 3 = 75kg P/ha, 2 = 50kg P/ha, 0 = 0kg P/ha**

88 However, the control level average is higher than the fertilizer at level 1. This is followed by boostxtra
89 with 2869.3811kg/ha higher than the control mean value of 2575.4025kg/ha. There is slight difference
90 in the average performance of inoculation at 5.0g and 2.5g of rhizobia inoculants per kg with
91 2732.8327kg/ha and 2711.9509kg/ha respectively (Table 1).

92 The study showed (Table 2) that the parameter estimates of the model are statistically significant with
93 significant difference in their performance over the controls ($P < 0.05$).

94 **Table 2: The Test of Parameter Estimates**

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	Df	Sig.
Inoculation=0	2679.056	.2437	2678.578	2679.533	120854966.524	1	.00
Inoculation=1	2658.174	.2503	2657.683	2658.664	112746228.409	1	.00
Fertilizer=1	-8.892	.2889	-9.458	-8.326	947.131	1	.00
Fertilizer=3	315.918	.2888	315.352	316.484	1196597.144	1	.00
Fertilizer=2	496.041	.2893	495.473	496.608	2939744.503	1	.00
Fertilizer=0	0	.	.	.	.	.	.
Boostxtra=0	-293.979	.2052	-294.381	-293.576	2052500.768	1	.00
Boostxtra=1	0	.	.	.	.	.	.

95 **Inoculation (0) = 5.0g of inoculants per kg, Inoculation (1) = 2.5g of inoculants per kg, Fertilizer**
96 **(1) = 25kg P/ha, Fertilizer (3) = 75kg P/ha, Fertilizer (2) = 50kg P/ha, Fertilizer (0) = 0kg P/ha,**
97 **Boostxtra (0) = No boostxtra, Boostxtra (1) = Boostxtra**

98 Fertilizer at levels (2 and 3) performed better with 496.041kg/ha and 315.918kg/ha respectively over
99 the control. No difference in the performance of Fertilizer at level 1 compared to the Control was
100 recorded. Inoculation rates (0 and 1) indicated no difference in their performance. The Boostxtra
101 showed that level 0 performed -293.979kg/ha over the control (Table 2).

102

103 The research again revealed that the performance of fertilizer level 2 and boostxtra are statistically
104 significant over the controls ($P < 0.05$). Fertilizer levels 2 vs. 1 group also showed significance in
105 performance (Table 3).

106 **Table 3: The Individual Test Results of the Variable levels**

Variable	Level	Contrast Estimation	Std. Error	Wald Chi-Square	df	sig
Inoculation	0 vs.1	20.882	149.517	0.020	1	.89

108	Boostxtra	0 vs.1	-293.979	150.040	3.839	1	.84
109	1 vs.0	-8.892	211.264	-.002	1	.97	
110	2 vs.0	496.041	211.542	5.498	1	.02	
111	Fertilizer	3 vs.0	315.918	211.171	2.238	1	.14
112	3 vs.1	32.481	21.847	2.210	1	.14	
113	2 vs.1	50.493	21.809	5.360	1	.02	
114	2 vs.3	18.013	21.895	0.677	1	.41	

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117 There had been 20.882kg/ha difference in the performance of the inoculation rates. The boostxtra
118 level 0 also showed -293.979kg/ha significant difference in its performance over the control. There
119 was also a noticeably 496.041kg/ha significant difference in the performance of fertilizer at level 2
120 over the control (Table 3). Fertilizer at level 3 and level 1 respectively indicated 315.918kg/ha and -
121 8.892kg/ha performance difference over the control. The fertilizer rates (2 vs. 1) indicated
122 50.493kg/ha significant difference in performance.

123

124 From Table 4, the analysis of variance showed that there is linear relationship between dependent
125 variable (grain yield kg/ha) and at least one of the explanatory variables with a p-value of 0.005. This
126 indicated that the model is significant and good for predicting Grain yield.

127 The estimated model becomes;

128 $\hat{Y} = 496.041 \cdot \text{Fertilizer (2)} - 293.979 \cdot \text{Boostxtra (0)}$

129 Where $\hat{Y}$ = Grain yield kg/ha, Fertilizer (2) = 50kg P/ha and Boostxtra (0) = Presence of Boostxtra

130 **Table 4: Analysis of variance**

Source	DF	SS	MS	F	P
Regression	16	18901835	1181365	2.41	.01
Residual Error	79	38778175	490863		
Total	95	57680010			

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132 The R Squared Adjusted (.78) indicated that 78% of the variation in grain yield is explained by
133 Inoculation, Fertilizer, and Boostxtra (Table 5). The Durbin Watson value of 1.57 indicated a positive
134 autocorrelation in the data set.

135 **Table 5: Selection for model summary**

Model	R	R-Squared	Adj.R-Squared	Std.Error of the Estimate	Statistics	Durbin Watson
F	Sig.					
.885	.784	.777	134.0667	112.284	.00	1.565

136

137 Based on the above statistics, a subset regression was conducted for the test of multicollinearity to
138 identify a best subset that optimizes grain yield using the Mallows C(p) approach; Pod number, Pod
139 weight plant (g), Nodule number, and Nodule dry weight (g) for all the weeks of measurement
140 constituted the best subset of variables that optimized grain yield. The subset had a C(p)=5.28 from
141 six variables in the model with Adjusted R Squared = 0.9318.

4. DISCUSSION

The study indicated that Rhizobia inoculation rates could not significantly increase nodules formation and grain yield. This agrees with the studies of Okogunet *al.* (2005) and Chemining'waet *al.* (2007) who reported no significant increase in nodulation and seed following rhizobia inoculation. However, Katulande (2011) and Albaredaet *al.* (2009) reported a significant increase in nodule number due to rhizobia inoculation.

Phosphorus Fertilizer rates and Boostxtra significantly increased grain yield ($P < 0.05$). The Phosphorus Fertilizer applications at 50kg P_2O_5 /ha significantly optimized grain yield over the Control (0kg P_2O_5 /ha). Fertilizer rate 50kg P_2O_5 ha⁻¹ gave the highest average grain yield of 3017.6658kg/ha followed by 75kg P_2O_5 ha⁻¹ with 2837.5428kg/ha over the control (0 kg P_2O_5 /ha). This was in contrast to Aziz et al. (2016) that Phosphorus applications at 22.5 P_2O_5 /ha and 45 kg P_2O_5 /ha induced significantly similar responses with respect to grain yield and seed size but both were significantly higher than that of the control (0 kg P_2O_5 /ha). This is contrary to the reports of other researchers that 30 – 0 – 30 kg N- P_2O_5 - K_2O ha⁻¹ gives the highest grain yield of 1.85 and 1.80 tons ha⁻¹ for the 2 years (Chiamaka, 2014). This could be attributed to the levels of P (16.98 mgkg⁻¹) available in the soil before treatments were applied Chiamaka (2014).

The increase in P fertilizer rate from 25kg P_2O_5 to 50kg P_2O_5 resulted an increase in grain yield and decline as the rate increased to 75kg P_2O_5 . This response to P_2O_5 is similar to the observation of Ahamefule and Chinedu (2014) that increased P fertilization led to increased grain yield up to 30 kg P_2O_5 ha⁻¹ treatment beyond which yield decline was observed.

The generalized linear model is significantly high and explains about 77.70% of the total variation in cowpea farming in the study area. Boostxtra and fertilizer were the two most influential variables that defined yield in the study area. This result is a clear indication of the presence of multicollinearity. A further subsets regression analysis was performed and the results indicated that Pod number, Pod weight plant (g), Nodule number, and Nodule dry weight (g) for all the weeks of measurement constituted the best subset of variables that optimized grain yield with $C(p) = 5.28$ and Adjusted $R^2 = 0.9318$. This is not different from Aziz et al. (2016) that the application of Phosphorus fertilizer of 22.5 and 45 kg P_2O_5 ha⁻¹ significantly increase pod number, nodule number, plant height, biomass and shoot dry weight over the control treatment (0 kg P_2O_5 ha⁻¹) for all the weeks of measurements. Also, Nkaa et al. (2014) observed that the application of phosphorus fertilizer rates 40 and 60 kg/ha significantly enhanced both number and dry weight of nodules of cowpea varieties.

5. CONCLUSION

The study revealed that the most influential variables that optimize cowpea yield in Lawra-Yagtuuri are the application of phosphorus fertilizer at 50 kg P_2O_5 /ha and boostxtra. The application of phosphorus fertilizer at 50 kg P_2O_5 /ha increased cowpea growth and grain yield and care should be taken to apply the P in the right amount.

Additionally, for optimum grain yield of cowpea, farmers should use 50kg P_2O_5 /ha. In the event that the soil fertility is not sufficient enough, farmers can adopt 75kg P_2O_5 /ha for yield optimization. Farmers are also advised to save the cost of buying artificial inoculants.

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