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Profitability of Cowpea Intercropped With Maize in West Africa Guinea Savanna

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Abstract

An on-farm trial was conducted over a 2-year period in Tibali in the Savelugu district of Northern region of Ghana to evaluate the productivity and economic returns of hybrid and open pollinated maize (OPV) either in pure stands or intercropped with erect and trailing cowpea. The maize varieties used were medium maturing (110 days) whie the cowpea varieties were early maturiing (70 days). The experiment was conducted in a randomized complete block design with 14 treatments (sole pan53, sole Etubi, sole mamaba, sole obatampa, sole erect cowpea, sole trailing cowpea, erect cowpea + pan53, erect cowpea+etubi, erect cowpea+mamaba, erect cowpea+obatampa, traing cowpea + pan53, traling cowpea+etubi, trailing cowpea+mamaba and trailing cowpea + obatampa) replicated on 10 farms. Intercropping had better productivity and economic returns than sole cropping. Intercropping maize with trailing cowpea type had better productivity and economic return than intercropping with erect type of cowpea. Intercropping the OPV maize with cowpea had better productivity and economic return than intercropping hybrid maize with cowpea. Farmers may either intercrop OPV maize with trailing cowpea type or hybrid maize variety Pan 53 maize with trailing cowpea type for better productivity and economic return.

Keywords: erect and trailing cowpea, gross margin, mixed cropping, on-farm, open pollinated maize

1. Introduction

Intercropping maize with cowpea is one of the most popular mixed cropping combinations under small-holder rain-fed agriculture in the tropics (Abdulraheem & Emmanuel, 2014). Maize-cowpea intercropping has been practiced by small-scale farmers in the West Africa Guinea and Sudan savannah zone for years (Norman, 1975). Small scale farmers in Northern Ghana practice intercropping of maize and cowpea using open pollinated varieties of maize. Intercropping practice helps to increase profit margin of the farmers, restore farm biodiversity (Jackson et al., 2007; Mucheru-Muna et al., 2010) and decrease the dependency on chemical herbicides in weed control (Banik et al., 2006).

The production of hybrid maize in Northern Ghana is gaining popularity in recent years with about 10,000 farmers producing hybrid maize in the pure stands on 21,000 ha of land in the three Northern regions of Ghana (Lambrecht & Ragasa, 2016).

However, quantitative data on the effect of intercropping hybrid maize with legumes, especially in Guinea and Sudan Savanna zones of West Africa is limited. We therefore, hypothesized that intercropping cowpea with hybrid maize will not affect yield and profit of the farmer.

2. Materials and Methods

2.1 Experimental Site

The experiment was conducted at Tibali (9.66853° N and longitude 0.84728° W) a suburb of Savelugu District in Northern region of Ghana during the 2014 and 2015 cropping seasons. The mean total annual rainfall ranges from 800-1200 mm and occurs between May and October with a dry season characterized by harmattan winds occurring between October and April. Atmospheric temperature is relatively high, ranges within a minimum of 26 °C in December and January during the harmattan to a maximum of 39 °C in March. The annual mean of 32 °C is recorded in the rainy season. The soils of Guinea Savanna of Ghana are low in organic carbon (< 15 g/kg), total nitrogen (< 5 g/kg), exchangeable potassium (< 100 mg/kg) and available phosphorus (< 10 mg/kg) (Tetteh et al., 2016).

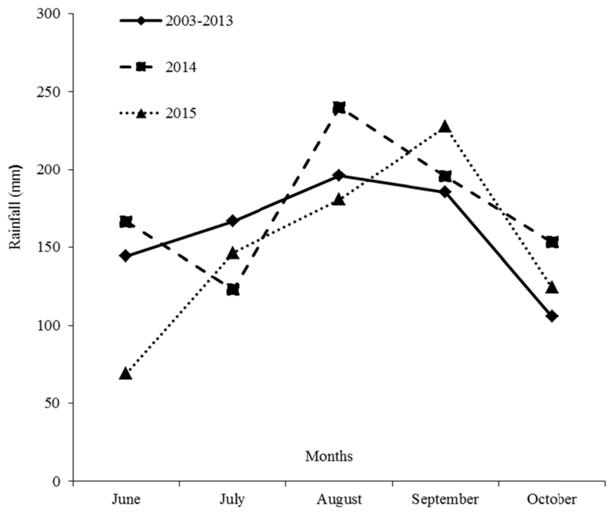

Figure 1. Rainfall distribution for long term average (2003-2013), 2014 and 2015 cropping season at Nyankpala, about 30 km from the study area

Source: Council for Scientific and Industrial Research-Savanna Agricultural Research Meteorological data, 2015.

2.2 Experimental Design and Treatments

The experimental design was Randomized Complete Block Design with 14 treatments (Table 1) replicated on 10 farms. All farm practices were carried out together with the farmers. The plot size for a treatment was 5 m × 4.5 m with an alley of 1 m between plots. Six rows of maize and 5 rows of cowpea intercropped were obtained in each plot. The planting distance for the maize was 75 cm × 40 cm with two plants per stand which gave a plant population of 150 per plot or 66,667 plants per hectare. The planting distance for the cowpea was 20 cm apart between each 2 rows of maize with 2 plants per stand which gave a plant population of 250 per plot or 133,333 per hectare. In 2014 cropping season, planting of maize was done on the 18th June, while that of 2015 season was on 5th July. The cowpea was sown between the rows of maize two weeks after the maize was planted. A compound fertilizer of N-P_2O_5-K_2O (15-15-15) was applied as a basal fertilzer at a rate of 40-40-40 kg N-P_2O_5-K_2O to the maize two weeks afer planting. Sulphate of ammonia was also used to top-dress the maize at 50kg N/ha at six weeks after planting.

2.3 Yield and Productivity Measurement

Maize cobs from plants in the two middle rows (7.5 m^2) of each plot were harvested, shelled and oven dried at 65 °C to moisture content of 13% before measuring grain yield. Cowpea pods in the three middle rows (11.25 m^2) of each plot were also harvested thressed and dried to a moisture content of 12% before measuring the grain yield.

To evaluate the productivity of the intercrop performance against the sole crops, the competition function known as land equivalent ratio (LER) was calculated. It is an accurate assessment of the biological efficiency of the intercropping situation for informed decision making. The total LER was the addition of the partial LERs of the two component crops. When the LER is greater than 1, the productivity of the intercrops is better than that of the sole crops but when it is less than 1, the productivity of the sole crop is better compared to the intercrops (Ofori & Stern, 1987; Dhima et al., 2007). The LER of maize as affected by the cowpea intercropping systems were calculated by expressing the intercrop grain yield as a ratio of the sole grain yield as follows:

$$LER = La+Lb = Ya/Sa + Yb/Sb \quad (1)$$

Where, La and Lb are the partial LER or crop species a and b respectively; Ya and Yb are the individual crop yields in the intercrops; Sa and Sb are their sole crop yields.

2.4 Economic Measurements

Farmers would most likely choose and adopt an alternative method or practice if the net benefit is higher than what is currently being used. It was therefore very necessary to compare the extra costs with the extra benefits of the new treatments. Partial budgeting is a method of organizing experimental data and information about various alternative treatments carried out.

The cost of all the variable inputs and seasonal average operational cost that prevail in the study area of the cropping seasons on all the treatments were considered. Variable cost included amount paid by farmers for land preparation, planting, cost of materials such as seed, labour for weeding, harvesting and carting of farm produce to the house. The gross income was also estimated from the sale of harvested farm produce. The value or net return per hectare for each treatment was then calculated as the difference between the gross income and total cost of production. There were no charges on capital cost such as land, interest on capital, depreciation on farm equipment and other overheads.

2.5 Statistical Analysis

The General Linear Model of Statistical Analysis System Package (SAS, 2011) was used to analyze yield data. The analysis was done on yearly basis and the model used was:

$$Y_{ijkl} = \mu + B_i + T_j + e_{ijkl} \quad (2)$$

Where, Y_{ijkl} is an observation, μ is experimental mean, B_i is block effect, T_j is cowpea intercropping effect and e_{ijkl} is residual error. Standard errors and P-values were used to determine differences among treatments. Treatment means of significant differences were determined at probability of 0.05.

3. Results and Discussion

Table 1. Effect of intercropping on grain yield and land equivalent ratio

Treatment	Grain yield (kg/ha)				Land equivalent ratio	
	Maize		Cowpea			
	2014	2015	2014	2015	2014	2015
Sole Pan 53	3235.9	2736	-	-	-	-
Sole Etubi	2274.5	1775	-	-	-	-
Sole Mamaba	2026.6	1526	-	-	-	-
Sole Obatanpa	2403.6	1879	-	-	-	-
Sole errect cowpea	-	-	481.4	499.2	-	-
Sole trailing cowpea	-	-	398.7	414.6	-	-
Errect cowpea + Pan 53	2814.8	1315	211.5	261.8	1.3	1.3
Errect cowpea + Etubi	2046.9	1422	237.7	282.8	1.4	1.3
Errect cowpea + Mamaba	1660.4	1049	296.2	343.8	1.4	1.4
Errect cowpea + Obatanpa	2006.8	1560	248.0	298.1	1.3	1.3
Trailing cowpea + Pan 53	2863.4	2368	210.0	260.1	1.4	1.5
Trailing cowpea + Etubi	2148.1	1621	225.2	272.8	1.5	1.3
Trailing cowpea + Mamaba	1834.4	1361	262.5	315.3	1.5	1.5
Trailing cowpea + Obatanpa	2170.2	1695	258.5	311.1	1.5	1.6
S.e	206.80	191.55	26.16	36.00	0.10	0.11
P-value	***	***	***	***	-	-

Note. *** $P \leq 0.0001$. ** $P \leq 0.01$. * $P \leq 0.05$. Ns not significant.

3.1 Yield and Productivity

The intercropping affected maize grain yield with sole Pan 53 recording higher ($P < 0.01$) grain yield than the other maize varieties in both seasons (Table 1). Similarly, to the maize grain yield, the intercropping affected cowpea grain yield with erect type of sole cowpea yielding more ($P < 0.01$) grain yield than the other cowpea type in both seasons. The seasonal differences grain yields may possibly due to the rainfall distribution (Figure

1). In 2014 growing season, the grain filling stage coincided with the peak of the rainfall in the month of August for which optimum yield production was obtained as compared to that of the 2015 growing season which was in September with low amount of rainfall. The land equivalent ratios of all the intercrops were greater than one which shows better productivity compared to their sole crops.

Though there were similar yield reductions in grain yield of both maize and cowpea in their intercrop, all their LER were above one, which clearly showed that there was an advantage in intercropping over the sole cropping. Similar results have been reported on bean-wheat intercropping (Hauggaard-Nielson et al., 2001), pea-barley intercropping (Chen et al., 2004) and maize-legume intercropping (Yilmaz et al., 2008; Rusinamhodzi et al., 2012).

Table 2. Net returns of maize and cowpea affected by the intercropping systems

Treatment	Net returns (Ghana Cedi/ha)	
	Season	
	2014	2015
Sole Pan 53	1,856.3	1,574.7
Sole Etubi	1,135.1	771.4
Sole Mamaba	911.9	552.7
Sole Obatanpa	1,310.4	940.5
Sole errect cowpea	1,237.9	1,405.1
Sole trailing cowpea	999.7	1,139.8
Erect cowpea + Pan 53	1,905.3	1,782.5
Erect cowpea + Etubi	1,436.9	1,116.9
Erect cowpea + Mamaba	1,264.6	943.6
Erect cowpea + Obatanpa	1,490.8	1,370.4
Trailing cowpea + Pan 53	1,954.6	1,841.4
Trailing cowpea + Etubi	1,500.5	1,294.2
Trailing cowpea + Mamaba	1,329.9	1,173.5
Trailing cowpea + Obatanpa	1,679.4	1,558.7
S.e	87.17	99.87

Note. 1 US Dollar = 4.5 Ghana cedi as at May 2018.

3.2 Economic Returns

The net returns of the maize-cowpea intercropping are shown in Table 2. Generally, all the intercrops had relative higher net returns as compared to their respective soles in both seasons. Trailing cowpea intercropped with Pan 53 variety recorded the highest net return per hectare, whilst erect cowpea type intercrop with Mamaba maize variety had the least net return per hectare in both seasons. However, on the average intercropping the OPV (Obantapa) with any of the cowpea type had better net return per hectare compared to the intercropping the hybrid with any type of the cowpea in both growing seasons.

The increase in net return of the intercropping may possibly be due to the high LER values of the intercropping (Dhima et al., 2007). Similarly, more net income was obtained from intercropping bush beans with sweet maize (Santalla et al., 2001) and maize-legume intercropping (Yilmaz et al., 2008; Mucheru-Muna et al., 2010; Ngwira et al., 2012).

4. Conclusion

Intercropping maize with cowpea had better productivity and net returns than the sole cropping. Intercropping OPV maize variety with cowpea had better productivity and net return than intercropping hybrid maize with cowpea. Farmers may either intercrop OPV (*e.g*. Obatanpa) with trailing type or Pan 53 hybrid maize variety with trailing type of cowpea for better productivity and economic return.

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References

Abdulraheen, M. I., & Emmanuel, A. (2014). Effect of cowpea on growth and yield parameter in maize-cowpea intercrop. *Journal of Management & Science, 4*(1).

Banik, P., Midya, A., Sankar, B., & Ghose, S. S. (2006). Wheat and chickpea intercropping systems in an additive experiment. Advantages and weed smothering. *Eur. J. Agron., 24*, 325-332. https://doi.org/10.1016/j.eja.2005.10.010

Chen, C., Westcott, M., Neill, K., Wichman, D., & Knox, M. (2004). Row configuration and nitrogen application for barley–pea intercropping in Montana. *Agron. J., 9*6, 1730-1738. https://doi.org/10.2134/agronj2004.1730

Dhima, K. V., Lithourgidis, A. A., Vasilakoglou, L. B., & Dordas, C. A. (2007). Competition indices of common vetch and cereal intercrops in two seeding ratio. *Field Crop Res., 100*, 249-256. https://doi.org/10.1016/j.fcr.2006.07.008

Hauggard-Nielson, H., Ambus, P., & Jensen, E. S. (2001). Evaluating pea and barley cultivars for complementary in intercropping at different levels of soil N availability. *Field Crop Res., 72*, 185-196. https://doi.org/10.1016/S0378-4290(01)00176-9

Jackson, L. E., Pascual, U., & Hodgkin, T. (2007). Utilizing and conserving agro biodiversity in agricultural landscapes. *Agr. Ecosyst. Environ., 121*, 196-210. https://doi.org/10.1016/j.agee.2006.12.017

Lambrecht, I., & Ragasa, C. (2016). Do development projects crowd out private-sector activities? A survival analysis of contract farming participation in northern Ghana. *Ifpri Discussion Papers 1575*. Intl. Food Policy Res. Inst.

Mucheru-Muna, M., Pypers, P. Mugendi, D., Kung'u, J., Mugwe. J., Merckx, R., & Vanlauwe, B. (2010). A staggered maize-legume intercrop arrangement robustly increases crop yields and economic returns in the highlands of Central Kenya. *Field Crops Res., 115*, 132-139. https://doi.org/10.1016/j.fcr.2009.10.013

Ngwira, A. R., Aune, J. B., & Mkwinda, S. (2012). On-farm evaluation of yield and economic benefit of short term maize legume intercropping systems under conservation agriculture in Malawi. *Field Crops Res, 132*, 149-157. https://doi.org/10.1016/j.fcr.2011.12.014

Norman, D. W. (1975). Rationalising mixed cropping under indigenous conditions: The example of Northern Nigeria. *Samaru Agric. Bull, 232*, 3-21.

Ofori, F., & Stern, W. R. (1987). The combined effects of nitrogen fertilizer and density of the legume component on production efficiency in a maize/cowpea intercrop system. *Field Crops Res., 16*, 43-52. https://doi.org/10.1016/0378-4290(87)90052-9

Rusinamhodzi, L., Corbeels, M., Nyamangara, J., & Giller, K. E. (2012). Maize-grain legume intercropping is an attractive option for ecological intensification that reduces climatic risk for smallholder farmers in central Mozambique. *Field Crops Reseach, 136*, 12-22. https://doi.org/10.1016/j.fcr.2012.07.014

Santalla, M., Rodino, A. P., Casquero, P. A., & De Ron, A. M. (2001). Interactions of bush bean intercropped with field and sweet maize. *Eur. J. Agron., 15*, 185-196. https://doi.org/10.1016/S1161-0301(01)00104-6

Statistical Analysis System Institute Incorporation. (2011). *The SAS system for Windows*. SAS Institute Inc., Cary, NC, USA.

Tetteh, F. M., Larbi, A., Nketia, K. A., Senaya, J. N., Hoeschle-Zeledon, I., & Abdul Rahman, N. (2016). *Suitability of soils for cereal cropping in Northern Ghana: Evaluation and recommendations* (p. 19). International Institute of Tropical Agriculture (IITA) report. IITA, Ibadan, Nigeria.

Yilmaz, Ş., Atak, M., & Erayman, M. (2008). Identification of advantages of maize-legume intercropping over solitary cropping through competition indices in the East Mediterranean Region. *Turkish Journal of Agricultural and Forestory, 32*, 111-119.

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