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YIELD POTENTIAL AND MONETARY ADVANTAGE INDEX OF MAIZE INTERCROPPED WITH GRAIN LEGUMES IN ANYIGBA, KOGI STATE, NIGERIA

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ABSTRACT

Traditional mixtures of food crop species involve intercrop of plants with dissimilar size and growth cycle on the field. However, the Relative Yield Potential (RYP) and Land Equivalent Ratios (LER) of these mixtures are given less prejudice especially in monetary terms by ancient farmers. This necessitate an experiment conducted during the 2016 and 2018 rainy seasons. The treatments consisted of Maize (TZESR – Open Pollinated), Cowpea (Sampea - 7), Peanut (Samnut - 24) and Soybean (TGX 713 – 09D) as sole crops sown at seed rates of 25 and 50 kgha-1 for maize and legumes respectively. The grain legumes were intercropped with maize in the ratio of 4:1, 2:1 or 1:1 as additional rows in between the normal rows of maize planted at a spacing of 75 x 25cm. Results revealed that intercropping of maize with either cowpea, peanut or soybean in 2:1 ratio was most productive in terms of maize equivalent yield and declined thereafter, with increase in the legume proportion, though maintained its superiority over sole planting of maize. Maize intercropped with soybean in the ratios 4:1 gave the highest mean biological maize equivalent compared to its sole planting at different combinations of legumes. Maize + Peanut gave the highest mean Land Equivalent Ratio (1.81) followed by maize + Cowpea (1.74) and maize + soybean (1.59) all sown in the ratio of 2:1. Intercropping of legumes with maize appeared to be more aggressive than sole planting of maize or legumes. Maize + Peanut (2:1) gave the highest mean Monetary Advantage Index (MAI) of 7789.0, Mean Yield Index (MYI) of 79.0. However, regardless of the ratio in which Maize + peanut was combined, result of 47% MAI showed a greater biological relationship, effective competition, hence recommended. Highest cost/benefit ratio (5.09 and 4.45) was obtained with maize + soybean (4:1) during 2016 and 2018, respectively.

Keywords: Aggressivity Index (AI), Cost-Benefit Ratio (CBR), Land Equivalent Ratio (LER), Mean Yield Index (MYI) and Maize Biological Equivalent (MBE).

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INTRODUCTION

Early cropping systems were certainly mixtures of desirable species used for food, fiber, and other needs in the community. Plucknett and Smith (1986), described six stages in the evolution of crop domestication over the past 10,000 years. Mono-cropping according to the author is a relatively recent innovation in agriculture. Intercropping defines the growing of two or more crops simultaneously in the same field, thus resulting in crop intensification in time and space (Kinde *et al*, 2015). Several reviews have described the evidence for plant diversity in these early systems (Bakers and Hawkes, 1970), where intercropping was shown to play a vital role in subsistence food production in both advanced and emerging countries (Adeoye *et al*., 2005). Authors have also described the relative stability and efficient nutrient use that this diversity brings to the natural ecosystem (Seran and Brintha, 2009), although there is no total agreement in this area. Most of the traditional mixtures of food crop species, maize – bean, sorghum – pigeon pea, banana – coffee, maize – groundnuts, maize – cowpea, millet – groundnut, maize – cassava, and rice – pulses (Matusso *et al*., 2012), which involve intercrops of plants with dissimilar size and growth cycle in the field. This type of intercrop gives a better vertical distribution of leaves in the total canopy. Willey (1979a) and Trenberth (1976) described the potential advantages of modified light distribution in a canopy of distinct species, while building on the theoretical work of Kasanaga and Monsi1 (1954), this has been reflected in the work of Bassi and Dugje (2016), where more pods per plant of the legumes was obtained in legumes-grain intercrop compared with the other intercrop combinations resulting from effective transmission of photosynthetic energy to the lower storey of the legumes components toward grain development due to modified light interception. If a tall crop, especially a cereal with C4 light response, were combined with a shorter dense crop with C3 response, the total use of light could be enhanced in the mixture [Crookston and Kent (1976), Henrich (2013), Willey (1979b), IAPPS (2007)]. Another Practical example of this reaction include the maize - bean intercrop combination, with apparent differences in total yield depending on bean plant type (Clark and Francis 1985b). Cereals and legumes have become a popular combination among farmers probably due to the ability of legumes to combat erosion and raise soil fertility levels (Matusso *et al*., 2012). Legumes can relocate fixed nitrogen to intercropped cereals through their joint growing period and this nitrogen is an essential resource for the cereals (Bhagad *et al*., 2006). Development of a feasible and economically viable intercropping system largely depends on the adaptation of planting pattern and selection of compatible crops (Seran and Brintha, 2009). There are no much researches on the intercropping system of basically starchy grains and grain legumes, hence this research becomes a necessity. This research was carried out to investigate the role of different leguminous crops intercropped with maize production.

MATERIALS AND METHODS

Study Area

The experiment was conducted during 2016 and 2018 cropping season at the Kogi State University Student Research Farm, Anyigba (Lat. 70 29' and Long 70 11'E). the soil is sandy-loam, and low in organic carbon (0.4%) and available P (9 kg P_2O5/ha) but medium in available K (109 kg K_2Oha-1) with pH ranging from 6.5 -7.5. the mean precipitation received during the respective growing seasons were 200mm and 179mm respectively.

Treatments and Experimental Design

The treatments consisted of Maize (TZESR – Open Pollinated), Cowpea (Sampea - 7), Peanut (Samnut - 24) and Soybean (TGX 713 – 09D) as sole crops sown at seed rates of 25 and 50 kgha-1 for maize and legumes respectively. The grain legumes were intercropped with maize in the ratios of 4:1, 2:1 or 1:1 as additional row in between the normal rows of maize planted at a spacing of 75 x 25cm. While in the case of 1:1 (100% maize and 100% legume), two rows of intercrop were accommodated in between the normal rows of maize. Maize crop was fertilized with 90, 60 and 30 Kg N, P_2O_5 and K_2Oha-1 while legumes (sole) were fertilized with 20, 60 and 30 Kg N, P_2O_5 and K_2Oha-1 respectively. No additional fertilizer was applied to maize when intercropped with legumes. Nitrogen was applied to maize in three equal splits at plantings, tasseling and grain formation, while in the case of legumes (sole) all the three fertilizers were applied as basal. The experiment was conducted in a Randomized Complete Block Design (RCBD) with four replications. At harvest, final grain yields from crops mixtures were divided to determine the component mixtures with the highest yield, monetary advantage index and land equivalent ratio as competition is believed to be highest in crop mixtures than sole cropping.

RESULTS

Mean Yield Index and Maize Equivalent Yield

Data on Mean Yield Index (Table 1) shows that yield index of maize increased consistently when intercropped either with cowpea (102.2), peanut (101.2) or soybean (103.0) in the ratio of 2:1 and decreased with increase in the legume proportion. This same trend was observed with mean yield index of legumes (71.8), (79.0) and (55.8) respectively. Grain yield of maize (maize equivalent basis) increased consistently and significantly when intercropped with either of legumes irrespective of the legume proportion compared to sole planting of maize during both years under consideration. However, increased proportion of legumes beyond

50% may have resulted in competition for space, nutrients, moisture and light interception leading to reduced yield. The result explicitly indicate that all the three legumes find place in the intercropping system of maize sown in the proportion of 2:1 without compromising the plant density of maize. However, maize + soybean in the ratio of 4:1 significantly gave the highest mean biological maize equivalent (193.6) compared to sole planting of maize or in combination with different legumes (Table 1). The higher biological yield may be attributed to aggressive plant competition resulting in higher straw and low grain yield.

Land Equivalent Ratio (LER) and Aggressivity

Mean LER (1.81) was highest when maize + peanut was sown in 2:1 ratio followed by maize + cowpea (1.74) and maize + soybean (1.59) all sown in the proportion of 2:1 (Table 2, Figure 1). However, LER computed from combined intercrop yields was always higher compared to sole crop. Aggressivity was computed as proposed by Mc Gilchrist and Trenbath (1971). The beneficial effects of intercropping maize with legumes are also clear from the data on Aggressivity (Table 2) which shows that maize was dominated by intercrops of cowpea, peanut and soybean irrespective of their proportion. The negative values obtained indicate the nature of aggression of intercrops on maize.

Monetary (₦) Advantage Index and Cost-Benefit Ratio

Monetary Advantage Index was calculated according to equation proposed by Willey (1979b). Intercropping of maize either with cowpea, peanut or soybean in the ratio of 2:1 recorded maximum mean Monetary Advantage Index. (Table 2, Figure 2). Highest mean Monetary Advantage Index was recorded with maize + peanut (7789.1) followed by maize + cowpea (7492.2) and maize + soybean (6862.7) all in the ratio of 2:1 (Figure 3). General evaluation of the MAI, irrespective of the ratios in which the crops were combined also showed that Maize + Peanut was the highest (47%), therefore exhibited greater biological relationship and effective competition (Figure 3). The data clearly indicates the higher monetary advantage index with increasing proportion of legume from 25 to 50% and declined thereafter. The lower monetary advantage index may be attributed to lower value of the combined intercrops as a result of yield reduction beyond 50% proportion of legume component. The higher index values are indications of a better cropping system (Mahaptra, 2011). Data on cost-benefit ratio (Table 2) revealed that maize intercropped either with cowpea, peanut or soybeans in the ratio of 4:1 gave highest cost-benefit ratio of 4.84, 4.28 and 5.09 (2016) and 4.49, 4.15 and 4.45 (2018) respectively. Although the higher mean monetary advantage index was obtained up to 50% legume component but the cost-benefit ratio declined after 25% legume only and may be attributed to the additional cost of the seed which did not match well with yield advantage.

Table 1: Grain Yield, Mean Yield Index, Maize Equivalent and Mean Maize Biological Equivalent* *Figures in parenthesis are grain legume yields.*

Treatments	Grain yield (kg/ha)				Mean Yield Index		Maize Equivalent		Mean Maize Biological Equivalent
	2016		2018				2016	2018	
Sole maize	46.2	(-)*	48.3	(-)	100	(-)	46.2	48.3	169.4
Sole cowpea	-	(15.7)	-	(14.8)	-	(100.0)	31.4	29.6	48.5
Sole peanut	-	(11.3)	-	(12.1)	-	(100.0)	27.1	29.0	45.0
Sole soybean	-	(21.9)	-	(23.4)	-	(100.0)	43.8	46.8	90.3
Maize + cowpea (4:1)	46.6	(5.2)	48.5	(4.9)	100.6	(33.1)	57.0	58.8	178.8
Maize + cowpea (2:1)	47.8	(10.7)	48.8	(11.2)	102.2	(71.8)	69.2	71.2	155.3
Maize + cowpea (1:1)	45.5	(8.7)	47.1	(10.3)	97.9	(62.2)	62.9	66.7	178.3
Maize + peanut (4:1)	46.7	(10.7)	48.6	(4.5)	100.8	(64.9)	72.4	58.4	174.1
Maize + peanut (2:1)	46.8	(10.9)	48.9	(7.6)	101.2	(79.0)	73.0	67.1	157.5
Maize + peanut (1:1)	45.4	(8.4)	47.6	(6.6)	98.4	(61.1)	65.6	62.4	180.8
Maize + soybean (4:1)	46.4	(6.5)	47.2	(7.8)	99.0	(31.1)	59.4	62.8	193.6
Maize + soybean (2:1)	48.2	(12.1)	49.2	(13.2)	103.0	(55.8)	72.4	75.6	157.6
Maize + soybean (1:1)	46.1	(11.3)	47.0	(12.1)	102.7	(51.6)	68.4	71.2	181.9
CD at 5%	-	(-)	-	(-)	-	-	3.8	4.2	2.1

Table 2: The Land Equivalent Ratio (LER), Aggressive Index and Cost/benefit Ratio in intercropping system

Treatment	Land Equivalent Ratio			Aggressivity Index		Monetary(₦) Advantage Index (MAI)			Benefit/cost ratio	
	2016	2018	Mean	2016	2018	2016	2018	Mean	2016	2018
Sole maize	1.00	1.00	1.00	-	-	-	-	-	3.85	3.92
Sole cowpea	1.00	1.00	1.00	-	-	-	-	-	1.17	0.96
Sole peanut	1.00	1.00	1.00	-	-	-	-	-	0.75	0.80
Sole soybean	1.00	1.00	1.00	-	-	-	-	-	2.39	2.55
Maize + cowpea (4:1)	1.34	1.34	1.34	-0.12	-0.13	3615.7	3698.1	3656.9	4.84	4.49
Maize + cowpea (2:1)	1.72	1.77	1.74	-0.06	-0.07	7241.9	7743.5	7492.2	4.55	4.46
Maize + cowpea (1:1)	1.54	1.67	1.61	-0.02	-0.03	5513.9	6790.3	6152.1	4.24	3.96
Maize + peanut (4:1)	1.96	1.38	1.67	-0.19	-0.17	8774.7	4089.1	6431.9	4.28	4.15
Maize + peanut (2:1)	1.98	1.64	1.81	-0.09	-0.08	9027.9	6550.2	7789.1	3.99	4.05
Maize + peanut (1:1)	1.73	1.53	1.63	-0.04	-0.03	6916.0	5493.9	6204.9	3.90	3.74
Maize + soybean (4:1)	1.30	1.31	1.30	-0.09	-0.08	3426.9	3715.3	3571.1	5.09	4.45
Maize + soybean (2:1)	1.60	1.58	1.59	-0.04	-0.04	6787.5	6937.9	6862.7	4.39	4.38
Maize + soybean (1:1)	1.51	1.50	1.51	-0.01	-0.01	5800.8	5933.3	5867.1	4.24	4.11

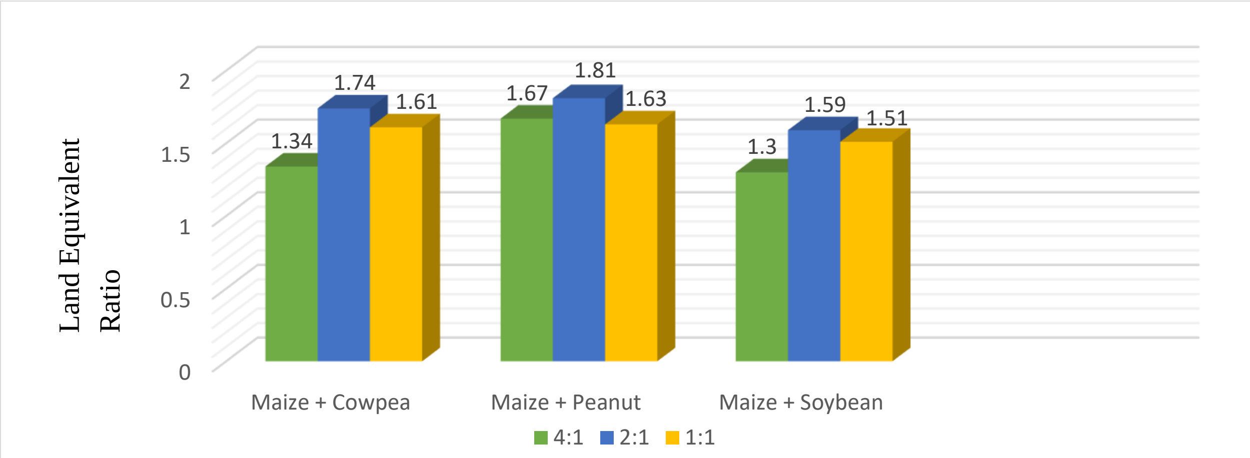

Fig 1. Land equivalent ratios for the intercrop of various legumes with maize.

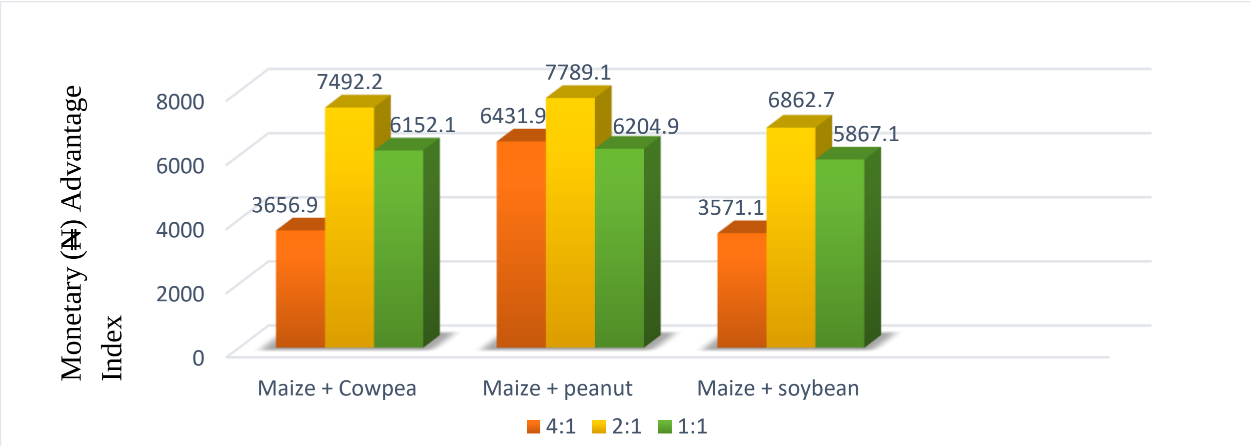

Fig 2. Monetary (₦) Advantage Index of Maize intercropped with various leguminous crops.

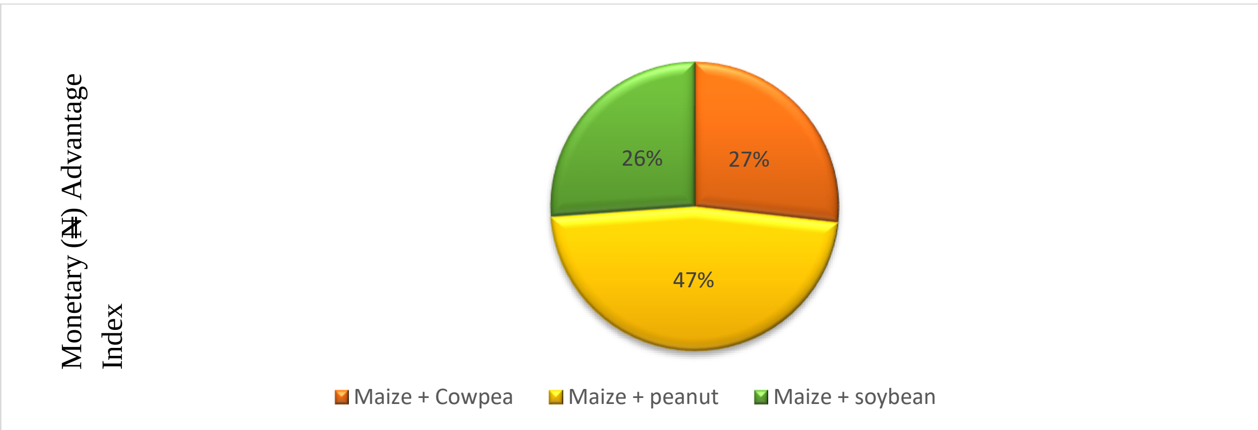

Fig 3. Monetary (₦) Advantage Index of Maize intercropped with various leguminous crops irrespective of their various intercropping ratios.

DISCUSSION

The lower mean yield index of maize or legume may be attributed to the crowding effect as a result of higher plant density per unit area resulting in increased inter row competition. This result is in agreement with those reported by Das *et al*. (2002) as they found a reduction in yield of a base crop due to intercrop competition. Similar results indicating the depressive effect of wheat yield with increasing Mustard population have been reported (Sharma *et al*., 1986). Increase in grain yield of maize (maize equivalent basis) may be attributed to nitrogen fixing behavior of legumes and higher canopy cover resulting in reduced evapo-transpiration, similar results were reported by Jha *et al*. (2000) and Das *et al*. (2002) where adequate space and treatments was made available during the crop growth period which ultimately enhanced yield. The higher LER computed from combined intercrop yields indicates greater biological efficiency of intercropping system Ajayi *et al*. (2017). Similar beneficial effects of intercropping on land utilization have been reported by (Francis *et al*., 1978). Nwamini *et al* (2020), had also reported LER values of more than 1 which he attributed to the superiority of intercropping over sole cropping. The higher Mean Monetary Advantage index (up to 50%) legume component agrees with those of Henriet *et al*. (2009) who indicated that higher proportion of legumes is necessary for higher net returns from cereal- legume intercropping systems. Bassi and Dugje (2016) had also reported the highest gross monetary returns at SOSAT-C-88 and the legumes combinations compared with other intercrop treatments. Higher Monetary Advantage Index was recorded with maize + peanut (7789.1) is supported by Ajayi *et al*. (2017) who obtained higher values of MAI with okra-groundnut intercropping system as compared to okra-cowpea intercropping system where he pronounced groundnut the most valuable economic mixture.

CONCLUSION

Intercropping maize with either cowpea, peanut or soybean in 2:1 ratio is most productive in terms of maize equivalent yield and thus maintained superiority over sole planting of maize in Anyigba environment. Mean biological equivalent is highest with maize in 4:1 combination with soybean while LERs were very high (>1) in maize + all legumes, tested in Anyigba environment; this is however showing positive combination potential. Maize + Peanut intercrop in 2:1 ratio recorded the highest mean Monetary Advantage Index while the highest cost-benefit ratio was obtained with maize + soybean (4:1) in both years of the experiment.

AUTHORS' CONTRIBUTIONS

This work was carried out in collection between both authors. Author UTM designed the study, wrote the protocol and interpreted the data. Author YMJ anchored the field study, gathered the initial data and performed the preliminary data analysis. Authors YMJ and UTM managed the literature searches and produced the initial draft. Both authors read and approved the final manuscript.

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