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PRODUCTIVITY OF MAIZE/SORGHUM INTERCROP AS INFLUENCED BY COMPONENT CROP DENSITY AND ARRANGEMENT

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ABSTRACT

Productivity of maize-sorghum mixture was examined at two crop densities and four crop arrangement patterns of the component crops in the northern guinea savanna agro-ecological zone of Nigeria. The study aimed at determining the appropriate crop density and arrangements for obtaining desirable yields of sorghum cv. SAMSORG 14 and maize cv. TZESRW. The crop density by arrangement interaction effect on all parameters measured was not significant. Establishment of the mixture components at full sole crop density generally increased sorghum grain and stover yields but decreased maize cob weight per plant and sorghum panicle weight per plant as compared to growing the components at half sole crop density. Although maize stover yield was also increased by full sole crop density, the grain yield was not significantly affected. Sorghum appeared to be more competitive in the mixture than maize and seemed to have benefitted more from the association, particularly when it was arranged at closer proximity to maize. Cultivating the components in alternate single rows across ridges appeared promising, but alternate double ridge arrangement tended to reduce yield advantage as compared to alternate single ridge and alternate stands along and across ridges

Key words: Crop arrangement, density, intercrop, maize, sorghum, productivity.

INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is the most widely cultivated staple food crop in Nigeria savanna with most of the production coming from fields of small scale farmers, because the local sorghums are photoperiod sensitive, they are sown at the onset of rains, mature the grains on residual soil moisture and harvested towards the end of the season. Mixed cropping is widespread since pronounced complexity arises from the multiple objectives of crop enterprises which are to produce food and cash. (Elemo *et al.,*1988). In the northern guinea savanna, sorghum/millet mixture used to be the most predominant (Norman, 1968; 1974) but subsequently maize (*Zea mays* L.) gained popularity as a component crop of mixture with sorghum. Availability of fertilizer technology and adaptable varieties, among other factors had pushed maize production further into where the cultivation had hitherto been restricted. Crop combinations with maize have been found to yield better than the standard millet/sorghum mixture (Agyare *et al.,* 2006; Stoop, 1987).

However literature is scanty on maize/sorghum intercrop. Lere (1985) found crop proportion of 2:1 (67:33) maize to sorghum and producing higher grain yield than 1:1 (50:50) irrespective of row arrangement. (Chobe, 1987) reported increased grain yield of maize but decreased sorghum yield as the maize proportion in the mixture increased. Crop proportion 67:33 with maize cv. TZESRW as component was found to give the highest yield advantage irrespective of how row arrangement increased.

For intercropping to give yield advantage, the total plant density optimum may be higher than for either sole crop (Willey, 1979) since individual plants could be at less stress than the sole crop (Andrew, 1972). Ridge cultivation is a common practice in the northern guinea savanna agro-ecological zone of Nigeria and the possible crop arrangements have not been extensively studied. This work was therefore initiated to determine the influence of component crop density and arrangement on the productivity of maize/sorghum mixture.

MATERIALS AND METHODS

A field experiment was carried out during the wet seasons of 1986 to 1988 at the research farm of the Institute for Agricultural Research, Samaru (11^{o}11' N, 07^o 38' E, and elevation of 686m above sea level) located in the northern guinea savanna agro-ecological zone of Nigeria. The trial site was characterized by a leached sandy loam soil (16% clay, 50% silt and 36% sand) derived from crystalline basement complex. The soil on the average tested pH 5.3 (in 1:1` soil-water suspension), 0.40% organic carbon, 0.06% N CEC of 3.60 m eq./100 soil and available P of 16.2 ppm.

Sorghum (medium maturing and white seeded cultivar SAMSORG 14) and maize (early maturing white seeded and streak resistant variety TZESRW) were established as sole crops and mixtures on the same date (25 June 1986, 16 June 1987 and 3 June 1988) on ridges spaced 75cm apart. Stand spacing within the ridge was 25cm. At two weeks after planting the crop plants were thinned to one per stand in sole crop, thus giving plant density of 53,333 plants/ha. For the component crop density treatments, each was maintained at equivalent of 26,667 plants/ha for the half sole crop treatment and 53,333 plants/ha for the full sole crop treatment. The crop arrangement treatments, alternate double ridges of components, alternate stand along and across ridges and alternate single rows across ridges. The factorial experiment was laid out in a randomized complete block design with four replicates. Each plot had 6 ridges (4.5m wide) and was 7m long, i.e. 31.5m^2 in area. Grain yield from each plot was determined from the four inner ridges using the whole length of the plot (21m^2)

In the sole crops, fertilizer was applied based on the standard application regime – i.e. 64 kg N + 32 kg P_2O_5 + 32 kg K_2O/ha for sorghum and 120 kg N+ 60 kg P_2O_5 + 60 kg K_2O/ha for maize.

In the mixture, application was based on a rate suggested by Fisher (1984) which was derived from results of multi-location fertilizer trials – i.e. 90 kg N + 45 kg P_2O_5 + 45 kg K_2O/ha for the northern guinea savanna. The sources of N, P and K were calcium ammonium nitrate, single superphosphate and muriate of potash respectively. Half of the N was applied basally while the remainder was applied at 4, 6 and 8 weeks after sowing for maize, mixture and sorghum respectively. Pre-emergent application of Gardoprim A at the rate of 5 liters/ha was sprayed immediately after planting. Supplementary hoe weeding and remolding of the ridges were carried out twice at 5 and 10 weeks after planting.

RESULTS

Component crop density showed no effect on maize grain yield (Table 1). Only in 1987 did crop arrangement in alternate stand along and across ridges and the alternate single rows across ridges produced significantly higher grain yield than in alternate single and double ridges. While no treatment effect was significant for cob weight per plant and 100 grain weight in 1986, significant higher values were obtained at half sole crop density than at full density in both 1987 and 1988. Alternating the components in single ridges significantly reduced the cob weight in 1987 while no difference was observed in 1988. Influence of crop arrangement on 100 grain weight was not consistent. For stover yield, full sole crop density produced higher than half the sole crop density in all the years. Nevertheless crop arrangement effect was not significant. None of these parameters showed significant interaction effect between component crop density and arrangement. The treatment effects on maize shelling percentage, plant and ear heights and days to 50% silk were not significant.

For sorghum, the full sole crop density produced significantly higher grain yield than the half sole crop in both 1986 and 1988 (Table 2). In 1987, however, the reverse was the case possibly because of stem borer damage. Alternate double ridges resulted into significantly lower sorghum yields than the alternate single rows across ridges in both 1987 and 1988. In 1986, the crop arrangement effect was not significant. Similarly for the three years, the crop arrangement effect was not significant for the sorghum panicle weight per plant and the stover yield. (Table 2).

Although significantly heavier panicles were produced at half sole crop density, the stover yields were significantly lower. Component density effect was not significant for the sorghum grain size, but the crop arrangement effect was significant only in 1987 when alternating component stands along and across ridges gave higher values than in alternate single or double ridges. Again no interaction effect was significant for the parameters measured. Similarly, treatments effects on plant height, panicle length and days to 50% bloom were not significant.

Table 3 presents the land equivalent ratio values of the components and their combinations. The treatment effects were not significant for maize except in 1987 when alternating the components in single or double ridges produced significantly lower yield advantage.

Generally, maize in mixture produced yield that was less than 50% of the sole crop while mixture sorghum produced grain yield that was at least 70% of the sole crop. For sorghum and the combined land equivalent ratio, the treatment effects were not significant in 1986. Yield advantage tended to be higher in a full sole crop in both 1986 and 1988 while the reverse was true for 1987 when yield advantage was generally lower as components were alternated in single and double ridges. No interaction effect was significant for the land equivalent ratio of a component or the combined.

Table 1: Maize (cv. TZESRW) grain yield, cob weight per plant, stover yield and 100-grain weight as influenced by component crop density and crop arrangement in mixture with sorghum (cv. KSV8) at Samaru, Nigeria

Treatment	Maize grain yield (kg/ha)			Cob weight (g/plant)			Stover yield (kg/ha)			100-grain weight (g)		
	1986	1987	1988	1986	1987	1988	1986	1987	1988	1986	1987	1988
Component crop density												
Half sole crop	880	1440	1188	82	94a	93a	2950b	3829b	2228	16.8b	20.3a	18.7a
Full sole crop	890	357	1101	66	70b	65b	5088a	5306a	3087a	15.5	18.4b	16.9b
SE ±	63.7	106.9	72.0	5.	3.9	6.8	199.9	207.5	172.9	0.51	0.37	0.23
LSD (5%)	ns	ns	ns	ns	8.0	20.1	597.9	610.4	508.5	ns	1.09	0.68
Crop Arrangement												
Alternate single ridges	952	150b	1172	76	70b	89	3945	4477	2689	16.5	18.0c	17.9a
Alternate double ridges	1006	1979b	1303	81	77a	82	4258	4184	2494	16.5	18.8bc	17.6a
Alternate stands along and across ridges	876	1664a	1081	80	88a	74	4174	5141	2807	15.3	20.1ab	17.0b
Alternate single rows across ridges	705	1770a	1023	59	93a	73	3699	4470	2641	16.3	20.5a	18.5a
SE ±	90.1	151.2	101.8	14	5.5	9.6	282.6	293.5	244.5	0.72	0.52	0.33
LSD (5%)	ns	444.7	ns	ns	16.3	ns	ns	ns	ns	ns	1.54	0.96
Interaction												
Component density X crop arrangement	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

ns Not significant
*In a column, means followed by the same letter are not significantly different at 5% level of probability using DMRT

Table 2: Sorghum (cv. KSV8) grain yield, Panicle weight per plant, stover yield and 1000-grain weight as influenced by component crop density and crop arrangement in mixture with maize (cv. TZESRW) at Samaru, Nigeria

	Sorghum grain yield (kg/ha)			Panicle weight (g/plant)			Stover yield (kg/ha)			1000-grain weight (g)		
Treatment	1986	1987	1988	1986	1987	1988	1986	1987	1988	1986	1987	1988
Component crop density												
Half sole crop	1194b	1584a	1165b	104a	88a	61	5466b	5442b	5750b	35.0	38.0	26.6
Full sole crop	1411a	1370b	1578a	79b	70b	56	8974a	9302a	10490a	34.5	35.5	27.4
SE ±	70.3	64.5	51.1	4.0.	4.2	6.8	473.0	315.1	539.7	0.96	0.96	0.72
LSD (5%)	206.9	268.3	150.2	11.7	12.4	ns	1392.5	926.5	1587.5	ns	ns	ns
Crop Arrangement												
Alternate single ridges	1255	1463ab	1425a	87	77	65	6808	7636	7935	36.4	34.8bc	6.1
Alternate double ridges	1497	1248b	1148b	86	70	51	6198	6976	9475	35.7	34.0c	7.8
Alternate stands along and across ridges	1331	1488ab	1447a	10	76	57	7593	7649	7225	32.5	39.8	26.8
Alternate single Rows across ridges	99.5	1708a	1466a	93	94	63	8281	7406	7282	34.6	38.4ab	27.2
SE ±	ns	91.2	72.2	5.6	6.0	4.4	669.0	445.6	763.2	1.35	1.36	1.83
LSD (5%)	ns	268.3.	212.5	ns	ns	ns	ns	ns	ns	ns	4.0	ns
Interaction												
Component density X crop arrangement	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

ns Not significant

*In a column, means followed by the same letter are not significantly different at 5% level of probability using DMRT

Table 3: Maize (cv. TZESRW) and sorghum (cv. SAMSORG 4) land equivalent ratio (LER) and their combined effect at Samaru, Nigeria

Treatment	Maize LER			Sorghum LER			Combined LER		
	1986	1987	1988	1986	1987	1988	1986	1987	1988
Component crop density									
Half sole crop	0.43	0.33	0.33	0.88	0.88a	0.70b	1.31	1.21a	1.03b
Full sole crop	0.42	0.31	0.31	1.04	0.76b	0.95a	1.46	1.07b	1.26a
SE ±	0.031	0.022	0.020	0.055	0.035	0.031	0.072	0.044	0.033
LSD (5%)	ns	ns	ns	ns	0.102	0.092	ns	0.129	0.098
Crop Arrangement									
Alternate single ridges	0.45	0.27b	0.33	0.92	0.81a	0.86a	1.37	1.108bc	1.18
Alternate double ridges	0.48	0.25b	0.37	0.83	0.70b	0.69b	1.31	0.95c	1.06
Alternate stands along and across ridges	0.42	0.38a	0.31	1.11	0.83a	0.87a	1.53	1.2ab	1.17
Alternate single rows across ridges	0.34	0.38a	0.290	1.81	0.84a	0.88a	1.33a	1.33a	1.17
SE ±	0.044	0.031	0.028	0.078	0.049	0.044	0.102	0.062	0.047
LSD (5%)	ns	0.092.	ns	ns	0.144	0.131	ns	0.183	ns
Interaction									
Component density X crop arrangement	ns	ns	ns	ns	ns	ns	ns	ns	ns

ns Not significant
*In a column, means followed by the same letter are not significantly different at 5% level of probability using DMRT

Table 4: Grain yield of maize (cv. TZESRW) and sorghum (cv. SAMSORG 4) in sole and mixed crop at different component density and crop arrangement and the com bined land equivalent ratio (LER) at Samaru, Nigeria

Treatment	Maize grain yield* (kg/ha)			Sorghum grain yield* (kg/ha)			Combined LER*		
	1986	1987	1988	1986	1987	1988	1986	1987	1988
C1R1	894bc	1262cd	1291b	1120ab	1548abc	1274cd	1.26	1.14bc	1.12bc
C2R1	1010bc	1038cd	1062b	1390ab	1378c	1576abc	1.49	1.01bc	1.24ab
C1R2	1092b	1288bcd	1327b	995b	1289c	869c	1.26	1.02bc	0.90d
C2R2	921bc	871d	1280b	1262ab	1420bc	1428bc	1.27	0.88c	1.25ab
C1R3	966bc	1506bcd	1064b	1359ab	1555abc	1341cd	1.46	1.22ab	1.10bc
C2R3	787bc	1822b	1099b	1635a	1421bc	1554abc	1.59	1.21ab	1.25ab
C 1R4	568c	1702bc	1081b	1304ab	1943a	1178d	1.25	1.46a	1.01cd
C2R4	841b	1697bc	964b	1359ab	1474bc	1754a	1.41	1.19bc	1.33a
Sole Maize	2130a	4404a	3602a	-	-	-	1.0	1.00bc	1.00c
Sole sorghum	+	-	-	1459ab	1805ab	1668ab	1.0	1.00bc	1.00c
SE ±	135.0	213.0	147.7	121.9	153.8	96.5	0.135	0.078	0.059

C1 = Component at half sole crop density R1 = Alternate single ridges R3 = alternate stands along and across ridges
C2 = Components at full sole crop density R2 = Alternate double ridges R4 = Alternate single rows across ridges

ns Not significant
*In a column, means followed by the same letter are not significantly different at 5% level of probability using DMRT

Table 4 shows the maize and sorghum grain yield of the mixture relative to their respective sole crop and their combined land equivalent ratio. Maize in sole crop consistently out-yielded maize in mixture while sorghum in sole crop did not significantly all those in mixture. Mixture treatments of alternate stands along and across ridges and alternate single rows across ridges established at full sole crop density produced grain yield that were most consistently comparable to sole crop sorghum. This trend was reflected in the combined land equivalent ratio.

The mixture treatment of alternate stands along and across ridges established at full sole crop density gave yield advantage of 59, 21 and 25% in 1986, 1987 and 1988 respectively. Similarly, the alternate single rows across ridges established at full sole crop density gave yield advantages of 41, 19 and 33% in 1986, 1987 and 1988 respectively.

In both 1986 and 1988, maize cob weight per plant in sole crop was statistically at par with weights obtained in some of the mixtures (Table 5). The same was true for stover yield in 1987 and 100-grain weight of maize which showed this trend consistently from 1986 through 1988.

Table 5: Cob weight per plant, stover yield and 100-grain weight of maize (cv. TZESRW) in sole crop and mixture with sorghum (cv. SAMSORG 4) at different component density and crop arrangement at Samaru, Nigeria

Treatment	Maize cob weight* (g/plant)			Maize stover yield* (kg/ha)			Maize 100-grain weight* (g)		
	1986	1987	1988	1986	1987	1988	1986	1987	1988
C1R1	78.3abc	78.2bc	102.4ab	2910c	3906c	2679bcd	15.0abc	18.1bcd	18.4 bcd
C2R1	73.2bc	61.6c	74.7bc	4930b	5047bcd	2699bcd	17.4ab	17.8cd	17.4de
C1R2	95.0ab	97.0b	85.4bc	3158c	3454d	1920d	17.3ab	20.7b	18.9bc
C2R2	67.4bc	57.8c	78.4bc	5358b	4914bcd	3068bcd	15.4bc	16.8d	16.4c
C1R3	83.2abc	97.2b	93.5a	2890c	4399bcd	2348bc	16.8abc	20.9ab	17.6cde
C2R3	75.9abc	79.5bc	54.1c	5458b	5882ab	3267bc	13.8c	19.2abcd	16.5c
C 1R4	70.0bc	104.4b	91.2abc	2841c	3559d	1967cd	17.3ab	21.4a	19.7ab
C2R4	47.3	81.7bc	54.1c	4557b	5382bc	3315b	15.3bc	19.7abc	17.2de
Sole Maize	111.9a	146.9a	133.5a	6921a	7064a	5530a	18.8a	21.6a	20.5a
SE ±	11.27	8.49	13.04	379.7	460.0	396.4	0.96	0.87	0.44

C1 = Component at half sole crop density R1 = Alternate single ridges R3 = alternate stands along and across ridges

C2 = Components at full sole crop density R2 = Alternate double ridges R4 = Alternate single rows across ridges

ns Not significant

*In a column, means followed by the same letter are not significantly different at 5% level of probability using DMRT

Table 6 shows the panicle weight per plant, stover yield and 1000-grain weight of sorghum in mixture relative to the sole crop. In both 1986 and 87, some mixture of sorghum produced heavier panicles per plant than in sole crop. In both 1986 and 88, there was no significant difference in 1000-grain weight between sorghum in mixture and sole. However, in 1987 some mixture treatments gave heavier 1000-grain weight than in sole crop.

Table 6: Panicle weight per plant, stover yield and 100-grain weight of sorghum (cv. SAMSORG 4) in sole and mixed crop with maize (cv. TZESRW) at different component density and crop arrangement at Samaru, Nigeria

Treatment	Sorghum panicle weight* (g/plant)			Stover yield* (kg/ha)			100-grain weight* (g)		
	1986	1987	1988	1986	1987	1988	1986	1987	1988
C1R1	104a	80a	76a	4608d	4916b	6375cd	37.4	35.2bc	26.0
C2R1	91b	74b	54ab	9009b	1039a	9493bc	35.5	34.3bc	26.2
C1R2	97ab	83ab	44b	5540cd	5034b	5256d	35.9	36.1ab	26.5
C2R2	75b	57b	57ab	6855bcd	8918a	13695a	35.5	31.9c	29.2
C1R3	106a	83ab	61ab	6085cd	6014b	5380cd	31.1	39.0ab	27.9
C2R3	94a	69b	53ab	9101ab	9284a	8869bcd	33.9	40.5a	25.7
C1R4	108a	107a	65ab	5630cd	6203b	5789cd	35.8	41.5a	26.1
C2R4	77b	80b	60ab	10932a	8609a	9577bc	33.3	35.3abc	28.4
Sole sorghum	93b	60b	68a	7800bc	8910a	12302ab	28.4	34.2bc	26.2
SE ±	7.9	7.9	6.6	780.3	656.6	1218.1	1.94	1.85	1.39

C1 = Component at half sole crop density; R1 = Alternate single ridges; R3 = alternate stands along and across ridges

C2 = Components at full sole crop density; R2 = Alternate double ridges; R4 = Alternate single rows across ridges

ns Not significant

*In a column, means followed by the same letter are not significantly different at 5% level of probability using DMRT

DISCUSSION

The lack of interaction effect of component crop density and arrangement observed in this study suggests that the manner of crop arrangement was not influenced by crop density.

Generally, the grain and stover yields of components in the mixture tended to be higher at full sole crop density than at half sole crop density. The need for higher crop density in mixture than for the sole crop equivalent has been stressed by Willey and Osiru (1972) and Baker (1979).

This is partly because mixtures require higher population pressure to produce maximum yields. Nevertheless in this study maize did not respond dramatically to increased crop density. This could be attributed to the fertilizer regime applied. While the rate of 90 kg N + 45 kg P_2O_5 + 45 kg K_2O/ha has been suggested for maize sorghum mixture by Fisher (1984), higher levels of N are considered necessary to satisfy crop requirement at high population level. This is particularly

so as the sole crop requirement of maize is 120 kg N +60 kg P_2O_5 + 60 kg K_2O/ha . Perhaps, Fisher's suggestion could be appropriate for situations where maize crop density in mixture is less than in sole crop. Competition among maize plants which starts in the early vegetative phase of growth could be postponed by nitrogen application supplied in sufficient quantity (Eddowes, 1969). The need for this higher N dosage was corroborated by the lower yield of maize in mixture than in sole crop. Obviously maize contribution to yield advantage could be improved

by increased N rate.

Unlike maize, sorghum mixture yield outstripped those in sole crop suggesting more access to N than in sole crop where only 60 kg N/ha was applied. The sorghum variety matured in about 135 days while the maize matured in only 90 days. Higher sorghum yield in treatments like alternate single rows across ridges than in alternate double ridges was likely due to availability to sorghum of fertilizer applied to maize as the sorghum remained in the field much longer after the maize harvest. Therefore sorghum appeared to be more competitive than maize in this mixture as significantly higher grain yields were obtained in mixture than in sole crop. This explains why it is the sorghum component that contributed more to the total yield advantage obtained.

In a similar study where only half of the full sole crop density (replacement series) was used to establish the mixture, Haizel and Twumasi-Afriyie (1977) observed no yield advantage in maize/sorghum mixture. This could be attributed to the fact that the sorghum and maize varieties used matured in about the same time. For yield advantage in crop mixture to be easily obtainable, the need for wide overlap in crop maturity of the components have been stressed (Baker and Yusuf, 1976; Willey 1979).

REFERENCES

Agyare, W.A., Clottey, V.A., Mercer-Quarshie, H., Kombiok, J.M. 2006. Maize yield response in a long-term rotation and intercropping systems in the guinea savanna zone of northern Ghana. *Journal of Agronomy,* 5(2): 232-238.

Andrew, D.J. 1972. Intercropping with sorghum in Nigeria. *Experimental Agriculture,* 8: 139-150.

Baker, E.F.I. 1979. Mixed cropping in northern Nigeria II. Mixtures of cereals. *Experimental Agriculture,* 15: 41-48.

Baker, E.F.I., Yusuf, Y.Y. 1976. Mixed cropping research in the Institute for Agricultural Research, Samaru, Nigeria. In Monyo, J.H. *et. al* (eds.). Intercropping in semi-Arid areas. Report of a symposium held at the Faculty of Agriculture, Forestry and Veterinary Science. University of Dares Salaam, Morogoro, Tanzania, 10-12 May, 1976. IDRC 076e P. 17-18.

Chobe, S.M. 1987. Productivity of maize/ sorghum/mixture as affected by crop proportion, stand, arrangement and maize variety. Unpublished M.Sc. Thesis. Ahmadu Bello University, Zaria 76 P.

Eddowes, M. 1969. Physiological Study of competition in *Zea mays* L III. Competition in maize and its practical implications for forage maize production *Journal of Applied Science Cambridge,* 72: 203-215.

Elemo, K.A., Kumar, V., Olukosi, J.O., Ogungbile, A.O. 1988. Review of research work on mixed cropping in the Nigerian savanna. *Samaru Miscellaneous Paper,* 127: 130.

Fisher, N.M. 1984. Fertilizer Use on mixed crops in northern Nigeria. A seminar paper presented at the Department of Agronomy. Institute for Agricultural Research Ahmadu Bello University, Zaria, Nigeria 19 P.

Haizel, K.A., Twumasi-Afriyie. 1977. The agronomic significance of mixed cropping 2.Maize interplanted with sorghum. *Ghana Journal of Agricultural Science,* 10: 87-98.

Lere, G.A., 1985. The effect of plant population and plant arrangement on the performance of maize and sorghum in mixed crop Unpublished M.Sc. Thesis. Ahmadu Bello University, Zaria 85 P.

Norman, D.W. 1968. Why practice intercropping? *Samaru Agricultural News Letter,* 10(6): 107-116.

Norman, D.W. 1974. Rationalizing mixed cropping under indigenous conditions. The example of Northern Nigeria. *Journal of Development Studies,* 11(1): 3-21.

Stoop, W.A. 1987. Adaptation of sorghum/ maize and sorghum/pearl millet intercrop systems to the toposequence land type in the northern sudanian zone of the West African savanna *Field Crops Research,* 15(3): 255-272.

Willey, R.W., Osiru, D.S.O., 1972. Studies on the mixture of maize and beans (*Phaseolus vulgaris*) with particular reference to plant population. *Journal of Agricultural Science Cambridge,* 79: 517-529.

Willey, R.W. 1979. Intercropping: Its importance and research needs. Part 2. Agronomy and research approaches. *Field Crop Abstracts,* 32: 73-85.

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