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PERFORMANCE OF COWPEA GROWN AS AN INTERCROP WITH MAIZE OF DIFFERENT POPULATIONS

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ABSTRACT

Cereal-cowpea intercrops have a record of low yields in the West African savannah. Two potential ways to improve the yield of cowpea (*Vigna unguiculata* Walp), when grown with maize (*Zea mays* L.), is by manipulating the plant population of maize and using adapted cowpea cultivars. A field trial was conducted at Samaru in northern Guinea savannah of Nigeria, to determine the performance of semi-determinate and indeterminate cowpeas grown under maize populations of 0, 17,777, 26,666, and 53,333 plants ha^{-1}. The radiation transmitted into cowpea was reduced by 50, 30 and 15% for a maize population of 53,333, 26,666 and 17,777 plants ha^{-1} respectively, compared with 0 plants ha^{-1}. Maize population of 0 to 26,666 plants ha^{-1} favoured better cowpea performance compared with 53,333 plants ha^{-1} because at these lower plant populations, maize plants had lower leaf area indices which allowed maize canopy to transmit more light into the understorey cowpea. The negative effects of shade were more pronounced in the semi-determinate cowpea than in the indeterminate. Therefore, in high maize populations, indeterminate spreading cowpeas should be grown; while semi-determinate cowpeas should be planted in low to moderate maize populations because of their intolerance to severe shade.

Key Words: *Vigna unguiculata, Zea mays*

RÉSUMÉ

La culture des céréales en association avec le niébé a souvent été associée à un faible rendement dans les savanes Ouest-Africaines. Il existe deux façons probables d'améliorer le rendement du niébé (*Vigna unguiculata* Walp) cultivé en association avec le maïs (*Zea mays* L.) ; la manipulation de la densité populationnelle du maïs et l'utilisation des variétés de niébé adaptées. Un essai en plein champ a été réalisé à Samaru dans la partie nord de la savane de Guinée au Nigeria, afin de déterminer la performance de niébés semi-déterminé et indéterminé cultivés en association avec différentes densités de maïs (0, 17,777, 26,666, and 53,333 plants ha-1). Comparé à un champ semé seulement au niébé, la radiation solaire transmise au niébé était réduite de 50, 30 et 15% respectivement pour des densités de maïs de 53,333, 26,666 and 17,777 plants ha-1. Une densité de maïs allant de 0 à 26,666 plants ha-1 favorisait mieux la performance du niébé qu'une densité de 53,333 plants de maïs par ha. Ceci parce qu'à cette faible densité, les plants de maïs avaient une faible surface foliaire et pouvaient ainsi transmettre un rayonnement solaire suffisant au niébé. L'effet négatif de l'ombre causé par la couverture foliaire du maïs était plus prononcé sur le niébé semi-déterminé que sur le niébé indéterminé. Il apparait alors, que le niébé indéterminé devrait être cultivé en association avec une forte densité de maïs, tandis que le niébé semi-déterminé devrait être cultivé en association avec une densité de maïs faible ou modéré.

Mots Clés: *Vigna unguiculata, Zea mays*

INTRODUCTION

Maize (*Zea mays* L.) is among the most important cereal crop in sub-Saharan Africa (IITA, 2009), which is becoming widely cultivated in the northern Guinea savanna of Nigeria (Fakorede *et al.*, 2003). It is grown widely with cowpea (*Vigna unguiculata* (L.) Walp.) in the West African savannah (Stoop 1986; NAERLS and NPAFS, 2010). Intercropping cowpea with maize, as with millet (*Pennisetum glaucum* L.) and sorghum (*Sorghum bicolor* L. Moench), is characterised by a very low cowpea and cereal yields (Mortimore *et al.*, 1997; Terao *et al.*, 1997; Olufajo and Singh, 2002), which cannot meet the food demand of the rapidly increasing population in the region. The low productivity of cowpea in intercropping systems is due, among other reasons, to shading by cereals; whereas cereal yields are low mainly due to lack of fertiliser (Mortimore *et al.*, 1997; Terao *et al.*, 1997; Olufajo and Singh, 2002; Singh and Ajeigbe, 2002). However, intercropping would be more productive if the effect of maize shade was reduced.

The manipulation of plant population and use of adapted cultivars are potential ways to reduce the negative shade effect of cereal on cowpea (Ofori and Stern, 1987; Olufajo and Singh, 2002). Appropriate plant population will permit a planned sharing of natural resources and manipulation of competitiveness to suit targeted yields (Midmore, 1993). Ofori and Stern (1987) reported that an increase in the population of either crop in a maize-cowpea mixture resulted in increases in total yield. Thus, the identification and use of improved cowpea cultivars that are tolerant to shade have high prospects to further increase the grain yield of cowpeas and the overall productivity of the intercropping system. With a growing bank of improved and diverse cowpea cultivars developed by the International Institute of Tropical Agriculture (IITA) (IITA, 2009), it is necessary to identify those genotypes that are adapted to intercropping and amenable to management options that suit the farmers' objectives of achieving high intercrop yields and satisfying the protein content of their meals. Interaction between maize population and cowpea cultivar may help to identify the cultivar appropriate for a given maize population to achieve higher yields. Therefore, the objective of this study was to determine the effect of maize population on the performance of contrasting cowpea cultivars in a maize-cowpea intercrop.

MATERIALS AND METHODS

Study site. The study was conducted during the rainy seasons (June –November) of 2008 and 2009 at the research farm of the Institute for Agricultural Research (IAR), Ahmadu Bello University, Samaru, Zaria (11° 11'N, 07° 38'E, 686 m asl), in the northern Guinea savannah of Nigeria. It has an average annual rainfall of 1000 mm, with a crop growing period of 151-180 days; and a daily mean temperature of 20 °C during the growing season.

The daily rainfall and minimum and maximum temperature during the study were recorded (Table 1). The study site had a previous history of *Centrosema pascuorum* (Benth.) cultivation, and was under fallow of this legume and other weeds before the trial was established.

Plant material, experimental design and treatments. Maize cultivar TZE COMP. 5 W (early-maturing, 90-100 d and Striga tolerant) and cowpea cultivars IT97K-499-35 (medium-maturing, semi-determinate and semi-spreading) and IT89KD-288 (late-maturing, indeterminate and spreading), developed at IITA (IITA, 2009), were evaluated in this study. The experiment was laid out in a randomised complete block design, in a split plot arrangement. The treatments were maize population (0, 17777, 26666 and 53333 plants ha^{-1}) and cowpea cultivar (IT97K-499-35 and IT89KD-288). Maize population formed the main plot and cowpea cultivar the subplot.

The experiment had three replications with a subplot measuring 3.0 × 5.0 m. Plant spacing for maize was 75 cm × 25 cm, 75 cm × 50 cm and 75 × 75 cm to achieve 53333, 26666 and 17777 plants ha^{-1}, respectively. Plant spacing for cowpea was 75 cm × 25 cm and there were four ridges per plot.

Agronomic practices. Maize seeds were sown on 18 June and 22 June in 2008 and 2009,

TABLE 1. Rainfall and temperature at Samaru, Nigeria, during the trial period

Month	2008			2009		
	Rainfall (mm)	Minimum °C (min.)	Maximum °C (max.)	Rainfall (mm)	Minimum °C (min.)	Maximum °C (max.)
January	0	13.6	29.0	0	14.1	33.8
February	0	15.7	32.0	0	16.9	36.3
March	0	19.9	38.6	0	19.6	38.0
April	72.6	21.8	37.4	20.3	23.2	38.4
May	95.2	21.9	35.0	85.1	22.2	35.5
June	111.7	20.9	33.1	89.5	21.0	33.2
July	201.3	20.0	30.5	285.0	20.0	32.3
August	352.6	19.5	29.7	439.7	20.4	30.0
September	217.5	25.5	31.4	206.7	20.0	31.9
October	89.0	18.2	33.2	151.7	20.3	32.8
November	0	12.8	33.8	0	14.8	32.4
December	0	14.6	32.1	0	13.3	33.5
Total	1139.9			1278		
Average		18.7	33.0		18.8	34.0

respectively. Three maize seeds were sown per hole and later thinned to one plant per stand at two weeks after planting (WAP). Cowpea seeds were sown at six weeks after maize was sown. Four seeds of cowpea were sown and later thinned to two plants per stand at two WAP. For maize having within ridge spacing of 25 cm, one stand of cowpea was maintained between two stands of maize. For maize having within ridge spacing of 50 cm, two stands of cowpea were maintained between two stands of maize. For maize having within ridge spacing of 75 cm, three stands of cowpea were maintained between two stands of maize. With this arrangement, cowpea spacing corresponded to 25 cm within a ridge.

At planting, 60 kg N, P_2O_5 and K_2O ha^{-1}, respectively, in the form of NPK 15:15:15 was applied. Urea was side-dressed at about 10 cm to the maize stand at a rate of 60 kg N ha^{-1} at three WAP and covered with soil. For cowpea, SSP at a rate of 30 kg P ha^{-1} was applied by side placement at the time of cowpea planting.

Plots were kept weed-free using hand hoes. During vegetative, flowering and podding stages, cowpea plants were sprayed with Karate (50 g L^{-1} lamda-cyhalothrin, Syngenta Crop Protection AG, Basle, Switzerland). This was applied at a rate of 1.0 L ha^{-1} at the time the first few insects were noticed.

Leaf area index and radiation. Leaf area index of maize (LAI) and maize canopy radiation (transmitted photosynthetically active radiation (TPAR), and the photosynthetically active radiation intercepted by cowpea (IPAR), were measured at full maize tasselling, using AccuPAR model LP-80 PAR/LAI Ceptometer (Decagon Devices, Inc., Pullman, USA). Incident PAR was measured in the open, without vegetation interception, above the maize and cowpea canopies in each plot. Five above-canopy measurements were taken and the displayed average recorded.

Two profiles of measurement were taken; the radiation under maize, but above cowpea canopy, and the radiation under maize and cowpea canopies for maize populations of 17,777, 26,666 and 53,333 plants ha^{-1}, and radiation under cowpea for maize population of 0 plants ha^{-1}. The sensor was placed diagonally across the two inner rows, so that the ends of the sensor coincided with the line of plants in each row. Five measurements were taken for each profile and the displayed average recorded. LAI of maize was simultaneously recorded.

Observations were taken under cloud-free conditions, between 12 and 2 o'clock in the afternoon. The proportion of PAR intercepted by the maize canopy and proportion of transmitted PAR (TPAR) by maize were calculated as shown in Ewansiha *et al.* (2014). The proportion of intercepted PAR by cowpea was calculated by subtracting proportion of TPAR under cowpea from that above cowpea.

Agronomic measurement. At maturity, maize plants from the two middle rows were hand-cut at the soil surface level. Maize ears were removed, sun-dried for one week, shelled and grain adjusted to 12% moisture content using Farmex MT-16 grain moisture tester. For cowpea, number of branches, number of peduncles and number of pods per unit area of 1.5 m^2 within a net plot were counted at cowpea harvest. These were calculated as number of branches, number of peduncles and number of pods m^{-2}, respectively. Harvested pods were sun-dried for one week and threshed. Grains were weighed and percentage moisture content of grains was determined using Farmex MT-16 grain moisture tester. Grain yield adjusted to 14% moisture was computed from the grain. Crop residue (fodder) from the net plot were rolled up together and left on the plot to sun-dry to a constant weight. Dried fodder was weighed on the field using Salter top loading scale to obtain fodder yield per plot. This was expressed as cowpea fodder yield ha^{-1}. For maize and cowpea, crop values were calculated using the expression given in Ewansiha *et al.* (2014).

Statistical analysis. Statistical analysis was performed using SAS for Windows (SAS Institute, 2011). The SAS procedure used for the ANOVA was the mixed model. Replication was treated as random effect and maize population as fixed effect in determining expected mean square and appropriate F-tests in the ANOVA. Differences between two treatment means were compared using LSD at 5% level of probability calculated by LSMEANS statement of PROC MIXED code of SAS with option pdiff. Pearson's correlation coefficient was used to test for a correlation among the variables using PROC CORR of SAS.

RESULTS AND DISCUSSION

Variance analysis. Year significantly influenced proportion of TPAR and cowpea grain yield (Table 2). Maize population influenced the agronomic performances of maize and cowpea. Significant varietal differences occurred in number of branches, number of peduncles and cowpea fodder yield.

There were significant interactions between year and maize population for proportion of IPAR, number of peduncles, number of pods and cowpea grain yield. Significant interactions also occurred between year and cultivar for number of branches, number of peduncles, number of pods and cowpea fodder yield. The three-way interaction among year, maize population and cowpea cultivar for cowpea fodder and grain yields was significant. These interactions might have been due to the differences in rainfall both in amount and distribution between the two years (Table 1). The rainfall differences may have caused cross ranking of maize populations and cultivars between the two years. Moreover, the year-to-year variation in temperature may have influenced varietal performance in the two different years. Kamara *et al.* (2011a) reported similar significant interaction between year and cultivar for fodder and grain yields in cowpea. Interaction between season and cultivar has been reported in bean (Francis *et al.,* 1978; Santalla *et al.,* 2001) for period of flowering and grain yield. Such significant year/season × cultivar interactions limit the breeder's desire for stable genetic progress.

There was lack of significant maize population × cowpea cultivar interaction for all traits except number of pods and grain yield, suggesting that cowpea cultivars responded similarly to maize population for these variables. This may mean that the intercropping conditions were favourable for the growth of the component crops prior to the time of pod production and grain filling and that cowpea did not significantly influence the companion maize or that there were no differences in the influence of the cowpea cultivars on maize. Olufajo and Singh (2002) have

TABLE 2. Probability of F values for physiological and agronomic responses of maize and cowpea to maize population and cowpea cultivar in northern Guinea savanna of Nigeria

Effect	Maize LAI[a]	Maize grain yield	Proportion of maize TPAR[b]	Proportion of cowpea IPAR[c]	Number of branches	Number of peduncles	Number of pods	Cowpea grain yield	Cowpea fodder yield
Year (Y)	0.2801	0.2664	0.0277	0.3019	0.2424	0.0063	0.001	<.0001	0.4225
Maize population (P)	<.0001	0.0002	<.0001	0.0004	<.0001	0.001	<.0001	<.0001	<.0001
Y × P	0.7476	0.6021	0.4029	0.0285	0.8042	0.0409	<.0001	0.0021	0.6166
Cultivar (C)	0.5703	0.0767	0.6816	0.122	0.0311	0.0027	0.1936	0.0772	<.0001
Y × C	0.6282	0.9658	0.5732	0.2591	0.0469	<.0001	0.0024	0.2429	0.0006
P × C	0.9613	0.1556	0.7868	0.5845	0.4771	0.5968	0.0316	0.0211	0.055
Y × P × C	0.8377	0.3229	0.8357	0.7732	0.1393	0.7493	0.1925	0.0046	0.0465

[a]LAI, leaf area index; [b]TPAR, transmitted photosynthetically active radiation; [c]IPAR, intercepted photosynthetically active radiation.

reported that cowpea does not significantly affect maize in intercrop. Therefore, the IPAR, number of branches, number of peduncles and fodder yield of the cowpea cultivars were comparable in high maize populations as in low maize populations in the stress-free environment.

Maize LAI and grain yield. Maize LAI and grain yield significantly increased with increase in maize population (Table 3). This may be so because higher plant populations achieved earlier canopy closure and intercepted more light for higher dry matter accumulation than lower plant populations. The optimum plant population for pure maize was adopted for the ceiling plant population of the component maize in this study. Thus, the LAI and grain yield of maize in the intercropping system may not be predicted beyond the plant populations studied.

Proportion of maize TPAR and cowpea IPAR. The proportion of maize TPAR significantly decreased with increase in maize population (Table 4). This was because at higher populations, maize canopy became denser and so diminished the amount of light penetration. The reduction in TPAR was by 50, 30 and 15% for maize populations of 53,333, 26,666 and 17,777 plants ha^{-1}, respectively, compared with the lowest population.

At a maize population of 0 plants ha^{-1}, cowpea IPAR did not significantly differ from that recorded at a maize population of 17,777 plants ha^{-1} (Table 4). Similarly, the proportion of IPAR at a maize population of 53,333 plants ha^{-1} did not significantly vary with that at maize population of 26,666 plants ha^{-1}. However, proportions of IPAR recorded at maize populations of 53,333 and 26,666 plants ha^{-1} were significantly lower than those obtained at maize populations of 0 and 17,777 plants ha^{-1}. The reductions may be due to high leaf area indices and high canopy closure of the dominant maize achieved at the higher maize populations, which intercepted more light, leaving less for the understory cowpea.

Branches and peduncles. The number of branches decreased with increase in maize population (Table 5). The decreases were only significant at a maize population of 26,666 and 53,333 plants ha^{-1}. Numbers of peduncles were

TABLE 3. Effect of maize population and cowpea cultivar on maize leaf area index and maize grain yield in northern Guinea savanna of Nigeria

Maize population (P, plants ha^{-1})	Maize leaf area index (LAI)			Maize grain yield (kg ha^{-1})		
	Cowpea cultivar (C)					
	IT97K-499-35	IT89KD-288	Mean	IT97K-499-35	IT89KD-288	Mean
53,333	1.37	1.42	1.4	5709.9	4705	5207.5
26,666	0.82	0.85	0.83	3659.9	3914.8	3787.3
17,777	0.29	0.39	0.34	2707.2	1934.6	2320.9
0	-	-	-	-	-	-
Mean	0.83	0.89		4025.7	3518.2	
$LSD_{0.05}$ P	0.384			1431.84		
$LSD_{0.05}$ C	ns[a]			ns		
$LSD_{0.05}$ P × C	ns			ns		

[a]ns, not significant

TABLE 4. Effect of maize population and cowpea cultivar on proportions of transmitted photosynthetically active radiation by maize canopy and intercepted photosynthetically active radiation by cowpea canopy in northern Guinea savanna of Nigeria

Maize population (P, plants ha^{-1})	Proportion of maize TPAR[a]			Proportion of cowpea IPAR[b]		
	Cowpea cultivar (C)					
	IT97K-499-35	IT89KD-288	Mean	IT97K-499-35	IT89KD-288	Mean
53,333	0.5	0.5	50	0.1	0.19	0.14
26,666	0.7	0.71	0.7	0.23	0.23	0.23
17,777	0.88	0.83	0.83	0.43	0.46	0.45
0	1.00	1.00	1.00	0.42	0.47	0.45
Mean	0.77	0.76		0.3	0.33	
$LSD_{0.05}$ P	0.095			1.91		
$LSD_{0.05}$ C	ns[c]			ns		
$LSD_{0.05}$ P × C	ns			ns		

[a]TPAR, transmitted photosynthetically active radiation; [b]IPAR, intercepted photosynthetically active radiation; [c]ns, not significant

similar at maize populations of 0 and 17,777 plants ha^{-1}; it then decreased significantly with increase in maize population. These findings suggest that branching and peduncle production are depressed by the higher shade experienced under the higher maize populations. The late maturing cultivar IT89KD-288 produced significantly more branches and peduncles than the medium maturing IT97K-499-35. This may be due to the longer growth period and the fully spreading habit of IT89KD-288 which enabled the production of more nodes for branch and peduncle attachment. With the production of more branches and peduncles, the cultivar is able to produce more pods and grains. Therefore, for higher system productivity, late maturing

TABLE 5. Effect of maize population and cowpea cultivar on number of branches and number of peduncles in northern Guinea savanna of Nigeria

Maize population (P, plants ha^{-1})	Number of branches (no. m^{-2})			Number of peduncles (no. m^{-2})		
	Cowpea cultivar (C)					
	IT97K-499-35	IT89KD-288	Mean	IT97K-499-35	IT89KD-288	Mean
53,333	7.2	8.2	7.7	26.2	34.1	30.2
26,666	6.9	10.7	8.8	30.8	51.2	41
17,777	10.9	14.3	12.6	47.4	60.6	54
0	14.2	14.5	14.3	50.2	58.9	54.5
Mean	9.8	11.9		38.6	51.2	
$LSD_{0.05}$ P	2.87			16.55		
$LSD_{0.05}$ C	2.03			10.66		
$LSD_{0.05}$ P × C	ns[a]			ns		

[a]ns, not significant

cultivars with spreading habits will be more appropriate for intercropping with maize.

Number of pods, grain yield and fodder yield. The number of pods and grain yield depended on maize population (Table 6). When averaged across the cowpea cultivars, the number of pods decreased by 17.2%, 34.6%, and 44.0% at a maize population of 17,777, 26,666 and 53,333 plants ha^{-1} respectively, compared with 0 plants ha^{-1}. At maize populations of 26,666 and 53,333 plants ha^{-1}, the late maturing cultivar IT89KD-288 produced more pods than the medium maturing IT97K-499-35. However, at maize populations of 0 and 17,777 plants ha^{-1}, the medium maturing cultivar produced more pods than the late maturing cultivar. The magnitude of the difference between these two cultivars was higher and significant at lower maize populations compared with the higher maize populations.

Mean grain yield decreased by 4.6% at 17,777, 37.2% at 26,666 and 63.9% at 53,333 maize plants ha^{-1} compared with 0 plants ha^{-1}. The response of grain yield to plant population varied with cowpea cultivar, suggesting that cowpea cultivars have different tolerance levels to shade. For example, at a maize population of 0 plants ha^{-1}, both cowpea cultivars performed similarly. However, at a maize population of 53,333 plants ha^{-1}, IT89KD-288 produced significantly higher grain yield than IT97K-499-35. This may be due to the fact that IT89KD-288 is fully spreading, late-maturing and indeterminate and so produces more leaves with greater soil cover in mixture, and continues to grow and flower even after the removal of the shade effects of the maize component. These results are consistent with earlier reports by Terao *et al.* (1997), Kamara *et al.* (2011b) and Ewansiha *et al.* (2014) that in light-limited intercrop conditions, cowpea cultivars with a spreading growth habit have potential to harvest more light, produce more leaves, branches, pods and grain than those with an erect growth habit. Thus, these results seem to suggest that for greater intercrop yield of cowpea, indeterminate spreading cowpea could be grown in high maize population. This becomes very reasonable when the primary objective of the farmer is to produce more cereal grain. Where a farmer has only the semi-determinate cowpea cultivar such as IT97K-499-35, it should be planted in low to moderate maize populations because of its intolerance to severe shade.

Fodder yield decreased with increasing maize population (Table 6). These decreases were 16.3, 49.5, and 58.1% at a maize population of 17,777, 26,666, and 53,333 plants ha^{-1}, respectively, compared with 0 plants ha^{-1}. Cultivar IT89KD-

TABLE 6. Effect of maize population and cowpea cultivar on number of pods and cowpea grain yield in northern Guinea savanna of Nigeria

Maize population (P, plants ha^{-1})	Number of pods (no. m^{-2})			Cowpea grain yield (kg ha^{-1})			Cowpea fodder yield (kg ha^{-1})		
	Cowpea cultivar (C)								
	IT97K-499-35	IT89KD-288	Mean	IT97K-499-35	IT89KD-288	Mean	IT97K-499-35	IT89KD-288	Mean
53,333	39.3	44.1	41.7	404.1	635.1	519.6	1178.3	1546.2	1362.2
26,666	46.5	51.8	49.1	881.2	927.3	904.2	1291.7	1991.2	1641.5
17,777	68.2	56.3	62.2	1335.5	1411.6	1373.6	2457.2	2985.3	2721.2
0	81.5	68.8	75.2	1491	1387.6	1439.3	2670.9	3834.9	3252.9
Mean	58.9	55.2		1027.9	1090.4		1899.5	2589.4	
$LSD_{0.05}$ P	11.62			204.65			443.55		
$LSD_{0.05}$ C	ns[a]			ns			291.54		
$LSD_{0.05}$ P × C	16.43			198.46			ns		

[a]ns, not significant

288 produced significantly higher fodder yield than IT97K-499-35. The higher fodder yield of IT89KD-288 may be due to its lateness in maturity, which does allow high biomass production.

Relationship among variables. Cowpea grain yield was positively and significantly related with TPAR (r = 0.817***), IPAR (r = 0.658***), number of branches (r = 0.497***), number of peduncles (r= 0.425**), number of pods (r = 0.777***) and fodder yield (r = 0.740***). It negatively and significantly related with LAI (r =- 0.679***) and grain yield (r = -0.636***) of maize. Similarly, maize LAI negatively and significantly related with TPAR (r = -0.950***), IPAR (r = -0.752***), number of branches (r = -0.409*), number of peduncles (r = -0.404*), number of pods (r = -0.411*) and fodder yield (r = -0.588***). This is why higher maize populations of 26,666 and 53,333 plants ha^{-1} reduced the performance of associated cowpea crop since higher maize population corresponded with higher shade. Higher shade affected the growth of cowpea during the critical stages of growth leading to smaller plants with fewer branches and peduncles that carried the fewer pods that bore the grain (Mariga, 1990; Ntare and Williams, 1992; Terao *et al.*, 1997).

Crop values of maize and cowpea. Crop values of maize plus cowpea are summarized in Table 7. Crop value increased with increase in maize population. These increases were 82.8, 95.0 and 131.9% at a maize population of 17,777, 26,666 and 53,333 plants ha^{-1} respectively, compared with 0 plants ha^{-1}. Although high maize population of 53,333 plants ha^{-1} significantly reduced cowpea yield, this population had higher crop value in financial terms for the two cowpea cultivars. However, the decision on the maize population to adopt goes beyond financial considerations. Where the objective of the farmer is primarily to increase total household income, it would be more profitable to adopt maize-cowpea intercrop at 53333 plants ha^{-1}. Where the objective of the farmer is to improve nutritional status and health of household members, it may be advisable to use lower maize populations. Cowpea is a leguminous crop, high in cheap protein which is

TABLE 7. Mean crop values of maize plus cowpea under different maize populations over two years in northern Guinea savanna of Nigeria

Maize population (plants ha^{-1})	IT97K-499-35	IT89KD-288	Mean
	US$[a] equivalent ha^{-1}		
53,333 plants + Cowpea	2429.1	2578.4	2503.8
26,666 plants + Cowpea	2102.6	2108.3	2105.5
17,777 plants + Cowpea	1897.6	2049.7	1973.6
0 plants + Cowpea	1118.2	1040.7	1079.5
Mean	1886.9	1944.3	

[a]Mean price kg^{-1} for maize = US$0.43, for IT499K-35 and IT89KD-288 = $0.75 each. Exchange rate of one US$ to one hundred and fifty Nigerian naira (₦) was used.

very valuable to poor households that cannot afford meat or fish.

CONCLUSION

Growing cowpea with high maize population densities reduces the intercepted photosynthetically active radiation, number of branches, peduncles and pods and fodder and grain yields of cowpea. Crop value of maize plus cowpea is higher at high maize populations. In high maize populations, indeterminate spreading cowpeas should be grown; semi-determinate cowpeas should be planted in low to moderate maize populations because of their intolerance to shade.

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