Response of cowpea to sowing date and maize plant population in a Sudan savannah environment

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Maize cultivation has recently expanded to the West African Sudan savannah and has the potential to play a key role in the cropping systems of the region where intercrop yields have been low. Staggering planting date and manipulating plant population of component crops are potential ways to improve yields of intercrops. A field trial was conducted to investigate the performance of contrasting cowpea cultivars when sown at different dates under varying maize plant populations at Minijibir in the Sudan savannah of Nigeria in 2008 and 2009. The trial was laid out in a randomized complete block design with split-split-plot arrangement and replicated four times. Planting date (four and six weeks after sowing maize) formed the main plot; plant population (0, 17,777, 26,666 and 53,333 plants ha^{-1}) was assigned to subplots and cowpea cultivars to sub-sub-plots. Results showed that the best grain yield potential for intercropped cowpea was achieved by sowing early in low to moderate maize plant populations. Early sowing was more conducive to achieving a higher number of branches, higher number of peduncles, higher number of pods, and higher fodder and grain yields. Cowpea performance reduced progressively with increase in maize plant population because of increased shading from maize plants. Growing cowpea under high maize population was more favourable for indeterminate cowpea cultivar whereas, growing under zero to moderate maize populations favoured semi-determinate cowpea cultivar most in grain production. Thus, when planning to grow cowpea with maize at full maize crop, farmers may need to seed indeterminate cowpea cultivar early under maize. At reduced maize plant populations, growing maize with semi-determinate cowpea cultivar will do. However, choice of maize plant population to use may depend on the income, food nutrition and feed needs of the farmer.

Keywords: maize, cowpea, intercrop, planting date, plant population, crop value

Millet (*Pennisetum glaucum* L.)/ cowpea (*Vigna unguiculata* (L.) Walp.) and sorghum (*Sorghum bicolor* L. Moench)/ cowpea intercrops are the most widespread intercrop combinations in the Sudan Savannah of Nigeria (NAERLS and NPAFS 2010; Stoop 1986, 301-319). Maize (*Zea mays* L.), which is the most important cereal crop in Sub-Saharan Africa has recently expanded to the Sudan Savannah (IITA 2009). In cereal-cowpea intercropping, the usual objective of the farmer is to have high yields in the cereal crop, which is the main crop and additional grain and fodder from the secondary cowpea crop. The cowpea provides a cheap source of protein. In this system, the cereals are usually sown at wide spacing which limits the productivity of the cereal crop. Yields of intercropped cowpea are also limited, estimated at about 350 kg ha^{-1}, as a result of shading from the dominant cereal crop among other factors (IITA 2009; Olufajo and Singh 2002, 267-277; Terao et al. 1997, 129-140).

Staggering the date cowpea is sown in a cereal crop is a potential way to reduce the negative shading effect of the cereal on cowpea (Olufajo and Singh 2002, 267-277). Relative sowing dates of component crops can contribute significantly to the yield of intercrop systems as it modifies the relative periods of complementarity

0041-3216/2015/010080-12

and competitiveness of component crops (Midmore 1993, 357-380). It also affects the extent to which plants of component crops can reach their yield potential. Planting date effect on component cowpea is even more significant with cultivars of diverse growth habits. For example, in an experiment to assess the effect of different dates of sowing cowpea as an intercrop with millet in the Sudan savannah of Nigeria, Singh and Ajeigbe (2002, 278-286), found a significant genotype × date of sowing interaction for grain and fodder yields. In that trial, the early and medium maturing cowpea genotypes had highest grain and fodder yields when simultaneously sown with millet, whereas the late maturing genotypes had highest yields when sown three weeks after millet. All the genotypes however, showed drastic yield reduction when sown six and nine weeks after millet.

Other ways to improve cowpea yield through shade reduction is by manipulating the plant population of the cereal crop. In Nigeria, sole maize is typically grown at a population of 53,333 plants ha^{-1}. But it is not known how varying plant populations of maize would affect the understorey cowpea of diverse growth habits in the Sudan savannah. Research information on cowpea performance when sown at different dates and under varying plant populations of maize is scarce as maize has only recently been introduced to this region. Such information would guide farmers in planning their farm enterprise to achieve set goals such as meeting their financial and nutritional needs through target outputs involving individual crops in the cropping system. Therefore, this paper presents the performance of cowpea cultivars with contrasting growth habits sown at different dates under varying plant populations of maize.

Material and methods

Experimental site

The study was conducted at the research farm of the International Institute of Tropical Agriculture, Minjibir (latitude 12^o 08'N, longitude 08^o 32'E, elevation 500 m asl), 40 km north-east of Kano, during the growing seasons (June-November) of 2008 and 2009. Minjibir is in the Sudan savannah and has an average annual rainfall of 690 mm and a growing period of about 120 days. The soil was typic Utipsamments and had 825 g kg^{-1} sand, 80 g kg^{-1} silt and 100 g kg^{-1} clay containing 2.8 g kg^{-1} organic carbon, 0.23 g kg^{-1} total nitrogen, 18.35 ug g^{-1} Mehlich phosphorus, 0.26 cmol kg^{-1} potassium, and a pH (H_2O)1:1 of 5.7. The area had an average total rainfall of 727.7 mm, monthly minimum temperature of 23.0^{o}C and maximum temperature of 32.1^{o}C for the June-November period, during the two-year field experimentation.

Planting materials, experimental design and treatments

One maize cultivar (TZE COMP.5-W, early-maturing, 90-100 days and Striga tolerant) and two cowpea cultivars (IT97K-499-35, medium maturing, semi-determinate and semi-spreading and IT89KD-288, late maturing, indeterminate and full spreading), developed at IITA (2009) were evaluated in this study. The experimental design was a four-replicate split-split-plot, with cowpea sowing dates (4 and 6 weeks after sowing maize (WASM)) as main plots, four maize populations (0, 17,777, 26,666 and 53,333 plants ha^{-1}) as subplots and the two cowpea cultivars (IT97K-499-35 and IT89KD-288) as sub-subplots. A sub-subplot measured 3.0 m × 5.0 m and contained four ridges. Plant spacing for maize was 75 cm between ridges and 25 cm within ridges to obtain 53,333 plants ha^{-1}, 75 cm between ridges and 50 cm within ridges to obtain 26,666 plants ha^{-1} and 75 cm between ridges and 75 cm within ridges to obtain 17,777 plants ha^{-1}. Plant spacing for cowpea was 75 cm between ridges, and 25 cm within ridges.

Agronomic management

The land was disc-harrowed and ridged. Maize seeds were sown on the 24 June and 01 July in 2008 and 2009 respectively. Three maize seeds were sown per hole and later thinned to one plant per stand at two weeks after sowing. Cowpea was seeded at 4 or 6 WASM. Four seeds of cowpea were sown and later thinned to two plants per stand at two weeks after sowing. For maize having a ridge spacing of 25 cm, one stand of cowpea was maintained between the 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.

Nitrogen, phosphorus and potassium were applied basally at the rate of 60 kg ha^{-1}of each nutrient as NPK 15:15:15. A second dose of nitrogen from urea was side-dressed at a rate of 60 kg N ha^{-1} three weeks later. For cowpea, single super phosphate at a rate of 30 kg P ha^{-1} were applied by side placement at the time of sowing cowpea seeds. The seeds of maize and cowpea were treated with Apron star (20% w/w thiamethoxam, 20% w/w metalaxyl-M and 2% w/w difenoconazole, Syngenta Crop Protection AG, Basle, Switzerland) at a rate of 4 kg of seed to 10 g of Apron Star, before sowing. During the vegetative, flowering and podding stages, cowpea plants were sprayed with Karate (50 g/l lamda-cyhalothrin, Syngenta Crop Protection AG, Basle, Switzerland) at a rate of 1.0 L ha^{-1} when the first few insects were noticed. Plots were kept weed-free manually.

Measurement

At cob maturity, maize plants from the two middle rows in a plot (less a distance of 50 cm at the ends of each middle row) forming the net plot, were hand-cut at the soil surface. Maize ears were removed, sun-dried for one week and shelled. Grains were weighed and final grain yield was expressed in kg ha^{-1}, adjusted to 12% moisture content using a Farmex MT-16 grain moisture tester.

At pod maturity, number of branches m^{-2}, number of peduncles m^{-2} and number of pods m^{-2} were determined using all the plants in a quadrat measuring 1.5 m^{2} placed across the two middle rows that made the net plot. Grain yield was determined from seeds obtained from all pods harvested in each net plot. The moisture content of grain samples from each net plot was determined using the Farmex MT-16 grain moisture tester and final grain yield ha^{-1} adjusted to 14% moisture content was calculated. Fodder yield in kg ha^{-1} was calculated from harvested and sun-dried plants in each net plot. For maize and cowpea, the value of production was calculated using the expression below.

Production × unit price = crop value,
where production = grain yield in kilogram ha^{-1}

Statistical analysis

Pooled statistical analysis of the two-year data was performed using SAS (SAS Institute, 2008, SAS Institute Inc., Cary, NC, USA.). Data were pooled because year and the interaction between year and other factors were not significant for all traits, meaning that data for both years were similar. The SAS procedure used for the ANOVA was a mixed model. Replication was treated as random effect and sowing date and maize cultivar as fixed effects (Random = Rep Rep*Cowpea sowing date Rep*Cowpea sowing date*Maize plant population) in determining expected mean square and appropriate F-tests in the ANOVA. Differences between two treatment means were compared using LSD at the 5% level of probability as calculated by LSMEANS statement of PROC MIXED code of SAS with option pdiff.

Results

Grain yield of maize

Grain yield of maize was affected by maize plant population (Table 1). In contrast, maize grain yield did not differ with cowpea sowing date and cowpea cultivar. Interactions among all the factors did not influence this trait. Grain yield increased progressively with increase in maize plant population (Table 2). When compared with maize population of 17,777 plants ha^{-1}, there was a 30 and 68% increase for 26,666 and 53,333 plants ha^{-1}, respectively.

Number of branches m^{-2} in cowpea

The number of branches differed with cowpea sowing date, maize plant population and cowpea cultivar (Table 1). The two-way interaction between cowpea sowing date and maize plant population and the three-way interaction among cowpea sowing date, maize plant population and cowpea sowing date did not affect the number of branches. However, interactions between cowpea sowing date and cowpea cultivar and between maize plant population and cowpea cultivar influenced this trait. The number of branches increased with increase in cowpea maturity duration at each cowpea sowing date (Table 3). But the magnitude of increase was higher for sowings at 4 than at 6 WASM. Similarly, the number of branches increased with an increase in cowpea maturity duration at each maize plant population (Table 3). The magnitude of increase progressively decreased with an increase in maize plant population. On average, the number of branches was 45% higher when cowpea was sown at 4 than at 6 WASM. In relation to maize population of 0 plants ha^{-1}, number of branches decreased by 18, 35 and 63% under a maize population of 17,777, 26,666 and 53,333 plants ha^{-1}, respectively. IT89KD-288 was 67% higher than IT97K-499-35 in branch production

Table 1. Probability of F values from analysis of variance for grain yield of maize and yield and yield-related traits of cowpea as affected by cowpea sowing date, maize plant population and cowpea cultivars at Minjibir in Nigerian Sudan savannah

Effect	Maize grain yield	Number of branches	Number of peduncles	Number of pods	Fodder yield	Cowpea grain yield
Cowpea sowing date (D)	0.5125	0.0284	0.0408	0.0796	<.0001	0.0007
Maize plant population (P)	0.0008	0.0002	<.0001	<.0001	<.0001	<.0001
D × P	0.165	0.1562	0.53	0.2574	0.1163	0.5351
Cowpea cultivar (C)	0.5175	<.0001	<.0001	<.0001	<.0001	<.0001
D × C	0.9732	0.009	0.0063	0.1244	<.0001	<.0001
P × C	0.6418	0.0088	<.0001	<.0001	<.0001	<.0001
D × P × C	0.2246	0.3007	<.0001	0.0145	0.0003	<.0001

Table 2: Grain yield of maize when intercropped with cowpea cultivars sown at different dates under varying maize plant populations at Minjibir in the Nigerian Sudan savannah

Effect	kg ha^{-1}
Cowpea sowing date (D)	
4 WASM[a]	3248.2
6 WASM	3428.8
Maize population (P, plants ha^{-1})	
53,333	4225.7
26,666	3266.7
17,777	2523.1
0	nil
Cowpea cultivar (V)	
IT97K-499-35	3373.6
IT89KD-288	3303.3
Mean	3338.5
SED D	ns
SED P	269.28
SED V	ns

[a]WASM, weeks after sowing maize; ns, not significant at P = 0.05

Table 3: Number of branches of cowpea cultivars sown at different dates under varying maize plant populations at Minjibir in the Nigerian Sudan savannah

		Cowpea cultivar (C)		
Cowpea sowing date (D)	Maize population (P, plants ha^{-1})	IT97K-499-35	IT89KD-288	Difference
		no. m^{-2}		
4 WASM[a]	53,333	10.5	12.6	-2.1^{ns}
	26,666	16.3	24.6	-8.3^{ns}
	17,777	20.2	25.7	-5.5^{ns}
	0	19.4	27.4	-8.0^{ns}
	Mean	16.6	22.6	
6 WASM	53,333	3.4	8.2	-4.8^{ns}
	26,666	5.5	13.9	-8.4^{ns}
	17,777	8.5	22	-13.5^{ns}
	0	15.6	31	-15.4^{ns}
	Mean	8.2	18.8	
SED D × C		1.2		
SED P × C		1.7		
SED D × P × C		ns		

[a]WASM, weeks after sowing maize; ns, not significant at P = 0.05

Table 4: Number of peduncles of cowpea cultivars sown at different dates under varying maize plant populations at Minjibir in the Nigerian Sudan savannah

Cowpea sowing date (D)	Maize population (P, plants ha^{-1})	Cowpea cultivar (C) IT97K-499-35	IT89KD-288	Difference
		no. m^{-2}		
4 WASM	53,333	15.3	21.4	-6.2^{ns}
	26,666	29	31.4	-2.3^{ns}
	17,777	44.7	48.2	-3.5^{ns}
	0	103.5	24.5	79.0***
	Mean	48.1	31.4	
6 WASM	53,333	9.9	12.8	-2.9^{ns}
	26,666	16.6	25.6	-9.0^{ns}
	17,777	30.4	30.2	0.2^{ns}
	0	83.3	43.6	39.7***
	Mean	35	28.1	
SED D × C		2.44		
SED P × C		3.46		
SED D × P × C		4.89		

[a]WASM, weeks after sowing maize; ns, not significant at P = 0.05; *** = significant at P = 0.001

Number of peduncles m^{-2} in cowpea

The number of peduncles was significantly affected by all factors studied and by most of their interactions (Table 1). At either cowpea sowing date, the number of peduncles did not differ between cowpea cultivars under maize populations of 17,777, 26,666 and 53,333 plants ha^{-1} (Table 4). However, under a maize population of 0 plants ha^{-1}, differences occurred between cowpea cultivars: the number of peduncles decreased with an increase in cowpea maturity duration. On average, the number of peduncles was 26% higher at 4 than at 6 WASM. Mean number of peduncles decreased by 40, 60 and 77% under a maize population of 17,777, 26,666 and 53,333 plants ha^{-1}, respectively, when compared with 0 maize plants ha^{-1}. IT97K-499-35 was 40% higher than IT89KD-288 in peduncle production.

Number of pods m^{-2} in cowpea

The number of pods was influenced by maize plant population and cowpea cultivar, and by the interactions between maize plant population and cowpea cultivar and among cowpea sowing date, maize plant population and cowpea cultivar (Table 1). When sown at 4 WASM, differences did not occur between cowpea cultivars grown under a maize population of 26,666 and 53,333 plants ha^{-1} (Table 5). However, when grown under a maize population of 0 and 17,777 plants ha^{-1}, IT97K-499-35 had higher number of pods than IT89KD-288. When sown at 6 WASM, differences did not occur between cowpea cultivars grown under a maize population of 17,777, 26,666 and 53,333 plants ha^{-1}. There were however, differences between cowpea cultivars when grown under a maize population of 0 plants ha^{-1}; IT97K-499-35 had a higher number of pods than IT89KD-288. The mean number of pods was 26% higher when cowpea was sown at 4 than at 6 WASM. There was a decrease in the mean number of pods with an increase in maize plant population. The decrease was 48, 72, and 84% for cowpea grown under a maize population of 17,777, 26,666 and 53,333 plants ha^{-1} respectively, compared with 0 maize plants ha^{-1}. Overall, IT97K-499-35 was 72% higher than IT89KD-288 in the number of pods.

Fodder yield in cowpea

Fodder yield of cowpea was influenced by all factors studied and by most of their interactions (Table 1). At either cowpea sowing date and for each maize plant population, fodder yields of cowpea increased with increase in cowpea maturity duration (Table 6). The magnitude of increase reduced with late sowing. On average, fodder yield was 32% higher when cowpea was sown at 4 than at 6 WASM. In relation to a maize population of 0 plants ha^{-1}, fodder yield decreased by 30, 47 and 67% under maize populations of 17,777, 26,666 and 53,333 plants ha^{-1}, respectively. IT89KD-288 was 143% higher than IT97K-499-35 in fodder production.

Table 5: Number of pods of cowpea cultivars sown at different dates under varying maize plant populations at Minjibir in the Nigerian Sudan savannah

		Cowpea cultivar (C)		
Cowpea sowing date (D)	Maize population (P, plants ha^{-1})	IT97K-499-35	IT89KD-288	Difference
			no. m^{-2}	
4 WASM[a]	53,333	6.2	24.1	-17.8[ns]
	26,666	25.7	24.8	0.90[ns]
	17,777	66.1	30.7	35.5***
	0	105.1	35	70.1***
	Mean	50.8	28.6	
6 WASM	53,333	4	11.2	-7.1[ns]
	26,666	16.3	15.2	1.1[ns]
	17,777	31.3	24.2	7.1[ns]
	0	105.7	44.7	61.0***
	Mean	39.3	23.8	
SED D × C		ns		
SED P × C		4.26		
SED D × P × C		6.03		

[a]WASM, weeks after sowing maize; ns, not significant at P = 0.05; *** = significant at P = 0.001.

Table 6: Fodder yield of cowpea cultivars sown at different dates under varying maize plant populations at Minjibir in the Nigerian Sudan savannah

Cowpea sowing date (D)	Maize population (P, plants ha^{-1})	Cowpea cultivar (C) IT97K-499-35	IT89KD-288	Difference
		kg ha^{-1}		
4 WASM[a]	53,333	654.7	1391.1	-736.4***
	26,666	887.6	2700.8	-1813.2***
	17,777	1264.1	3678.5	-2414.4***
	0	1835.7	4503.9	-2668.2***
	Mean	1160.5	3068.6	
6 WASM	53,333	558.3	1187.9	-629.6***
	26,666	700.7	1921	-1220.3***
	17,777	1190.2	2045.2	-855.0***
	0	1589.5	3669.7	-2080.2***
	Mean	1009.7	2205.9	
SED D × C		56.66		
SED P × C		113.32		
SED D × P × C		160.26		

[a]WASM, weeks after sowing maize; ns, not significant at P = 0.05; *** = significant at P = 0.001

Grain yield in cowpea

Grain yield of cowpea was affected by all factors studied and most of their interactions (Table 1). When sown at 4 WASM, cowpea grown under maize population of 53,333 plants ha^{-1} had yield that increased with increase in maturity duration of cowpea (Table 7). At this time, there was no difference in grain yield between both cowpea cultivars when grown under a maize population of 26,666 plants ha^{-1}. However, when cowpea was grown under a maize population of 0 and 17,777 plants ha^{-1}, grain yield increased with decrease in maturity duration of cowpea. For sowings at 6 WASM and under a maize population of 53,333 plants ha^{-1}, cowpea grain yield increased with increase in maturity duration of cowpea. At this time and under maize populations of 17,777 and 26,666 plants ha^{-1}, differences did not occur between the cowpea cultivars. In contrast, under a maize plant population of 0 plants ha^{-1}, grain yield increased with decrease in maturity duration of cowpea. Mean grain yield was 42% higher at 4 than at 6 WASM. There were 37, 59 and 81% decreases in mean grain yield for cowpea grown under a maize population of 17,777, 26,666 and 53,333 plants ha^{-1} respectively, compared with 0 maize plants ha^{-1}. IT89KD-288 was 40% higher than IT97K-499-35 in grain production.

Crop value

Crop values are summarized in Table 8. When cowpea was sown at 4 WASM, crop value increased with increase in maize plant population. The increase was 138.1, 147.8 and 160.1% under a maize population of 17,777, 26,666 and 53,333 plants ha^{-1} respectively, compared with a maize population of 0 plants ha^{-1}. Similarly, when cowpea was sown at 6 WASM, crop value increased with an increase in maize plant population. The increase was 127.1, 177.9 and 257.5% under a maize population of 17,777, 26,666 and 53,333 plants ha^{-1} respectively, compared with a maize population of 0 plants ha^{-1}.

Table 7: Grain yield of cowpea cultivars sown at different dates under varying maize plant populations at Minjibir in the Nigerian Sudan savannah

Cowpea sowing date (D)	Maize population (P, plants ha^{-1})	Cowpea cultivar (C) IT97K-499-35	IT89KD-288	Difference
		kg ha^{-1}		
4 WASM[a]	53,333	107.2	309.3	-202.0***
	26,666	440.6	422.8	17.8ns
	17,777	796.8	516.5	280.3***
	0	1382.8	462.5	920.3***
	Mean	681.9	427.8	
6 WASM	53,333	29.4	209.6	-180.2***
	26,666	256.5	272.5	-15.9ns
	17,777	417.6	399.9	17.7ns
	0	983.3	568.1	415.2***
	Mean	421.7	362.5	
SED D × C		42.2		
SED P × C		37.71		
SED D × P × C		53.33		

[a]WASM, weeks after sowing maize; ns, not significant at P = 0.05; *** = significant at P = 0.001

Table 8: Mean crop values of maize-cowpea intercrops and sole cowpea over two years at Minjibir in Nigerian Sudan savannah

Cowpea sowing date	Maize population (P, plants ha^{-1})	Maize + cowpea IT97K-499-35	IT89KD-288	Mean
		US Dollar ($) equivalent ha^{-1}		
4 WASM[a]	53,333	1786.8	1813.5	1800.1
	26,666	1755.7	1674.3	1715.0
	17,777	1699.1	1595.8	1647.4
	0	1037.1	346.9	692.0
Mean		1569.7	1357.6	
6 WASM	53,333	1968.4	2191.2	2079.8
	26,666	1665.3	1567.8	1616.6
	17,777	1364.8	1278.0	1321.4
	0	737.5	426.1	581.8
Mean		1434.0	1365.8	

[a]WASM, weeks after sowing maize; mean price kg^{-1} for maize = $0.43, for IT97K-499-35 and IT89KD-288 = $0.75 each. Exchange rate of one US dollar ($) to one hundred and fifty Nigerian naira (₦) was used.

Discussion

This study focused on the performance of improved cowpea cultivars sown at different dates under varying maize plant populations in a maize-cowpea intercropping system in the Sudan savannah of Nigeria. Maize plant population affected grain yield of maize. Expectedly, grain yield of maize was more at higher plant populations because these plant populations would canopy sooner, intercept more light, and produce more dry matter and yield. Conversely, the higher maize plant populations would shade the understorey cowpea more, leading to a greater reduction in the growth and yield of the cowpea plants.

The significant interaction between maize plant population and cowpea cultivar for the number of branches, number of peduncles, and number of pods, fodder yield and grain yield suggests that the cowpea cultivar responded differently to maize plant populations for these traits. This means that variation occurs among the maize plant populations and between the cowpea cultivars, indicating that different cowpea cultivars have differing levels of tolerance to intercrop shading caused by the maize plants. IT89KD-288 performed better than IT97K-499-35 at higher maize plant population because of its tolerance to shading which corroborates the findings of several other researchers (Kamara et al.2011, 1763-1770; Olufajo and Singh 2002, 267-277; Terao et al. 1997, 129-140). IT89KD-288 was probably more tolerant because it has a full spreading growth habit which allows higher leaf area for greater radiation capture in the intercrop. The decline of cowpea yields from under full radiation at a maize plant population of 0 plants ha^{-1} to severe shading under maize population of 53,333 plants ha^{-1} would be due to reduced photosynthetically active radiation caused by shading from the taller maize crop (Ewansiha et al. 2014; 597-608, Fukai andTrenbath 1993, 247-271).

The interactions between cowpea sowing date and cowpea cultivar and among cowpea sowing date, maize plant population and cowpea cultivar for most of the attributes studied suggest that cowpea cultivars responded differently to cowpea sowing date for the traits. The higher growth and yield recorded for both cowpea cultivars at 4 WASM compared with 6 WASM may be due to the availability of sufficient moisture during the growing season, longer growth period and lesser competition with maize for light and other resources. Conversely, the shortening of the growing season plus intense competition for insufficient moisture, light and nutrients with the already established maize component may have accounted for the reduced cowpea performance when the cowpea cultivars were intercropped at 6 WASM (Ewansiha et al. 2014, 597-608; Singh and Ajeigbe 2002, 278-286).

These findings seem to suggest that for greater intercrop yield of cowpea under high maize plant population, indeterminate spreading cowpea such as IT89KD-288 could be grown at 4 WASM or earlier. Where a farmer has only the semi-determinate semi-spreading cowpea cultivar such as IT97K-499-35, it should be sown early in low to moderate maize plant populations because of its intolerance to severe shade. Apart from the fact that grain yield of maize was more at high plant population while yield of cowpea decreased with an increase in plant population of maize, crop value indicated that growing the cowpea cultivar under high maize plant population would be more profitable compared with low to moderate maize plant populations. Therefore, there are three possibilities with implication for farmers' income, food nutrition and feed for livestock. Firstly, farmers who would prefer more grains of cowpea with smaller yield of maize could intercrop cowpea with maize sown at a population of l7,777 plants ha^{-1}. This would meet the nutritional need of the rural poor farmers who cannot afford the more expensive meat and fish while providing more cowpea fodder as feed for their livestock. Secondly, farmers who would prefer more grains of maize with smaller yield of cowpea could intercrop cowpea with maize sown at a population of 53,333 plants ha^{-1}. This would meet the financial need of the farmers for better livelihoods. Finally, farmers that prefer average yield of maize and cowpea could grow their cowpea with maize sown at a maize population of 26,666 plants ha^{-1}. This would meet the need for both good nutrition and income.

Conclusion

The best grain yield potential for intercropped cowpea was achieved by sowing early in low to moderate maize plant populations. Early sowing was more conducive to achieving higher number of branches, higher number of peduncles, higher number of pods, and higher fodder yield with higher grain yield. Cowpea performance reduced with increase in maize plant population because of increase in shading and competition from maize plants. Growing cowpea under high maize population was more favourable for fully spreading cowpea cultivar whereas, zero to low maize populations favoured semi-spreading cowpea cultivar most, in grain yield. Fodder yield was better for the cultivar with indeterminate and full spreading growth habit when sown at four or six weeks after maize under low to high maize plant populations. Nevertheless, when planning to intercrop cowpea with maize at full maize crop, farmers may need to seed indeterminate spreading cowpea cultivar early in the intercrop. At reduced maize plant populations, intercropping maize with semi-determinate and semi-spreading cowpea cultivar will do. However, choice of maize plant population to use may depend on the income, food nutrition and feed needs of the farmer.

Acknowledgement

The authors would like to thank the International Institute of Tropical Agriculture (IITA), Nigeria, for providing institutional support.

References

Ewansiha, S.U., A.Y. Kamara and J.E. Onyibe. 2014. Performance of cowpea cultivars when grown as an intercrop with maize of contrasting maturities. *Archives of Agronomy and Soil Science*, **60(5):** 597–608, http://dx.doi.org/10.1080/03650340.2013.829565

Fukai, S., and B.R. Trenbath. 1993. “Processes determining intercrop productivity and yields of component crops.” *Field Crops Res*. **34:** 247–271.

IITA (International Institute of Tropical Agriculture). 2009. Crops [Internet]. Nigeria: International Institute of Tropical Agriculture; [cited 2013 Jan 13]. Available from: http://www.iita.org

Kamara, A.Y., L.O. Omoigui, S.U. Ewansiha, F. Ekeleme, D. Chikoye, and H. Ajeigbe. 2011. “Performance of semi-determinate and indeterminate cowpeas intercropped with maize in Northeast Nigeria.” *African J Agric Res.* **8:**1763–1770.

Midmore, D.J. 1993. “Agronomic modification of resource use and intercrop productivity.” *Field Crops Res*. **34:** 357-380.

NAERLS and NPAFS (National Agricultural Extension and Research

Liaison Services and National Programme for Agriculture and Food Security). 2010. National report of agricultural performance survey of 2010 wet season in Nigeria. Zaria: NAERLS Press.

Olufajo, O.O., and B.B. Singh. 2002. "Advances in cowpea cropping research." In *Challenges and opportunities for enhancing sustainable cowpea production. Proceedings of the World Cowpea Conference 111*; 4–8 September, 2000, edited by C.A. Fatokun, S.A. Tarawali, B.B. Singh, P.M. Kormawa, and M. Tamo, 267-277. Ibadan: IITA.

SAS Institute Inc. 2008. The SAS system for Windows. Release 9.2. Cary (NC): SAS Institute.

Singh, B.B., and H.A. Ajeigbe. 2002. "Improving cowpea-cereals based cropping systems in the dry savannahs of West Africa." In *Challenges and opportunities for enhancing sustainable cowpea production. Proceedings of the World Cowpea Conference 111*; 4–8 September, 2000, edited by C.A. Fatokun, S.A. Tarawali, B.B. Singh, P.M. Kormawa, and M. Tamo, 278-286, Ibadan, IITA.

Stoop, W.A. 1986. "Agronomic management of cereal/cowpea cropping systems for major toposequence land types in the West African savannah." *Field Crops Res*. **14**: 301-319.

Terao, T., I. Watanabe, R. Matsunaga, S. Hakoyama, and B.B. Singh. 1997. "Agro-physiological constraints in intercropped cowpea: an analysis." In *Advances in cowpea research*, edited by B.B. Singh, D.R. Mohan Raj, K.E. Dashiel, and L.E.N. Jackai, 129-140. Co-publication of International Institute of Tropical Agriculture (IITA) and Japan International Research Center for Agricultural Sciences (JIRCAS). Ibadan: IITA.