In the Introduction section paragraph one and the rest have different line spacing, this should be corrected

In results section after table five (Few lines before table 6) there is still a sentence "decreasing order" this too should be changed, I thank the Author for considering a choice of a word that will not bring debate so that everyone will understand it perfectly well.

The author also needs to read the document very careful making sure that all typos are corrected, e.g. there are some double spaces between words and in some instance i found two full stops after a sentence, these are minor details but they are also very important.

proof reading is important

Influence of cropping pattern systems on incidence of Scab and Septoria leaf spot disease of cowpea (*Vigna unguiculata*)

Mbong GA[1], FokunangCN[5*], Alabi O[2], TEMBE-FOKUNANG[5] EA. Emechebe M[3], M. D. Alegbejo MD[2], Akem CN[4],

[1]Department of Plant Biology, University of Dschang, B.P. 67, Dschang, Cameroon; [2]Department of Crop Protection, Institute for Agricultural Research, Ahmadu Bello University, Samaru, PMB 1044, Zaria, Nigeria;

[3]International Institute of Tropical Agricultural, Kano, Nigeria;

[4]Horticulture and Forestry Science, Department of Primary Industries and Fisheries, P. O. Box 15, Ayr, Queensland 4807, Australia

[5] Department of Pharmaceutical Sciences, University of Yaoundé 1

[*]Corresponding author: Prof Charles FOKUNANG

Aims: Scab caused by *Sphaceloma* sp and Septoria leaf spot caused by *Septoria vignae* were evaluated on one variety (Ife Brown) of cowpea: in this study. Ife Brown is highly susceptible to scab and moderately susceptible to Septoria leaf spot. Cowpea (*Vignia unguiculata* L.Walp) was planted simultaneously with maize (intercrop) and sorghum (intercrop). The scientific importance of intercropping pattern in this study was to develop an information based system on how crop pattern can influence disease incidence and severity and thus improve crop yield within an agro ecological zone

Study design: The field layout was factorial concept in Randomized Complete Block Design (RBCD) with four replications

Place and Duration of Study: The two cereals used for this study were, maize variety TZEEW, and sorghum variety ICSV111. The investigations were carried out during three cropping seasons of 2004, 2005 and 2006 at Samaru and Shika in Zaria, Nigeria.

Methodology: Five cropping patterns: interrow, intrarow, doublerow, strip and sole cropping on the incidence and severity of scab and Septoria leaf spot fungi isolated from infected field plants, were studied. Disease incidence and severity for scab and Septoria leaf spot were recorded at weekly intervals starting from the first appearance of the symptoms. Data for the different plant parts (leaf, stem, peduncle, flower cushion and pod) infected by scab and leaves infected by Septoria leaf spot were recorded from four middle ridges for each plot. The data obtained was subjected to analyses of variance (ANOVA) and mean separation was by Student Newman Keuls Test (SNK).

.

Results: Infection of the cowpea and severity of scab and Septoria leaf spot on the crop significantly increased with increase in age of the variety tested. Symptoms of infection resulting from scab were seen on all the aerial parts of the crop from seedling stage to maturity, depending on the time of infection. Cropping patterns

significantly affected the incidence and severity of the two fungi on cowpea in the order of sole<double-row<strip<inter-row<intra-row for scab and sole<intra-row<double-row<strip<inter-row for Septoria leaf spot. However, the reaction of the crop to the individual pathogens was different across the various cropping patterns with the rate of infection of scab higher compared with that of Septoria leaf spot. Cowpea sole cropping proves better for both pathogens compared to the other cropping patterns.

Conclusion: This study showed that sole cropping system was more ideal for disease managements and incidence of Scab and Septoria leaf spot diseases of cowpea with respect to cropping systems studied.

Keywords:: Cropping patterns, Cowpea scab, Septoria leaf spot, incidence, severity,

INTRODUCTION

In Nigeria, cowpea (*Vigna un*guiculata L. Walp (Fabaceae) is traditionally grown by small holder farmers whose traditional methods do not produce enough for the country's need. Most of the crop is grown during the shorter raining season (late July to October) in the Northern Guinea Savanna Zones of Nigeria. Farmers in these regions traditionally grow cowpea as an intercrop with maize, sorghum and pearl millet [1,2,3]. Some farmers in the region only grow cowpea, after they have harvested their cereals. Although there is a wealth of literature on the effect of intercropping cowpea with cereals and other crops, literature is lacking on the effect of diseases, especially under farmers condition.

The most common diseases of cowpea variety Ife Brown are scab (*Elsinoe phaseoli* Jenkins.), Septoria leaf spot (*Septoria vignae* P. Henn.), bacterial blight (*Xanthomonas campestria* pv.v*ignicola* Burkholder) [4]. Ife Brown is a high yielding variety commonly used in Nigeria, butis very susceptible to fungal diseases.

Scab caused by the fungus *Sphaceloma* sp. is one of the most destructive diseases of cowpea in the Northern Guinea Savanna Zones of Nigeria. The conidium of *Sphaceloma* sp. are usually regarded as the anamorph of the perfect species, *Elinoe phaseoli* Jenkins. which is responsible for inducing scab on cowpea [4]. The disease is seed-borne and can be spread by rain splash, run-off and wind-blown moisture. It attacks plants at all stages of growth [4, 5, 6].

Septoria leaf spot is a foliar disease of cowpea [7]. The disease is caused by *Septoria vignae* P. Henn. and it is seed-borne and seed transmitted [8]. It is hypothesized that different cowpea varieties intercropped with cereals in different cropping arrangements may offer a microenvironment that can alter the level of disease development on their host crops. However, this hypothesis has not been established on scab and Septoria spot diseases of cowpea. The objectives of this study were to determine the effect of cowpea and cropping pattern on the level of infection by two fungi pathogens. The scientific importance of intercropping pattern in this study was to develop an information based system on how crop pattern can influence disease incidence and severity and thus improve crop yield within an agro ecological zone

MATERIALS AND METHODS

Field Disease incidence and severity measurement

Field experiments were conducted thrice (each running through three separate growing seasons) in 2004, 2005 and 2006 at the Institute for Agricultural research (IAR), Samaru, Zaria, Nigeria. One variety of cowpea (Ife Brown-highly susceptible to scab and moderately susceptible to Septoria leaf spot) and two varieties of cereals (maize, TZEEW and sorghum, ICSV111-) were chosen for this study. Two separate experiments were set up for cowpea/maize and cowpea/sorghum intercrop. The field layout was factorial concept in Randomized Complete Block Design (RBCD) with four replicates. Five cropping patterns; sole-cropping (sole) with all rows in the plot sown to cowpea only; inter-row mixed cropping (inter-row) with rows of cowpea alternatively sown with rows of maize or sorghum; intra-row mixed cropping (intra-row) with cowpea and maize or sorghum seeds sown in alternate hills, respectively within each row; double

row cropping (double row) with two rows of cowpea sown between two rows of maize or sorghum; Strip cropping (strip) with four rows of cowpea sandwiched between two rows of maize or sorghum on either sides were used (Figure 1).

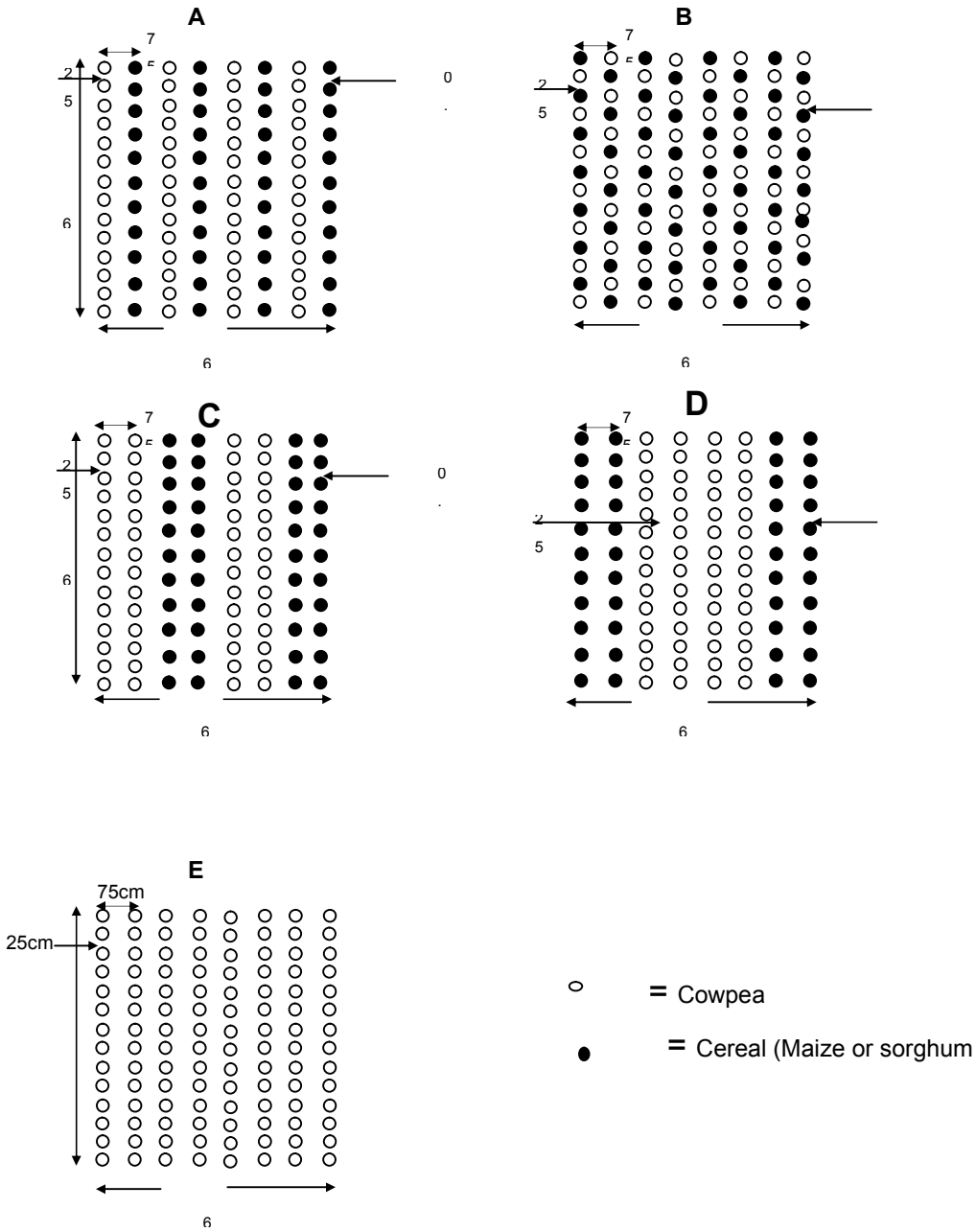

Figure 1. A schematic diagram showing the cropping patterns used in cowpea: (A) inter-row, (B) intra-row, (C) double row, (D) strip and (E) sole cowpea.

Each treatment plot consisted of eight, 75 cm ridges, and 6 m long. The plots were separated by border rows consisting of one ridge along the length and 2 m along the width. Cowpea and maize were sown at two seeds per stand and sorghum at eight seeds per stand and were later thinned to two plants per stand two weeks after germination to give approximately the same population of plants/ha in the various plots. Plant spacing for inter-row mixed cropping of maize and sorghum was 0.5 m and cowpea was 25 cm. Plant spacing for intra-row mixed cropping of maize and sorghum was 1 m and cowpea was 25 cm in-between the maize and sorghum respectively. Plant stand establishment was taken at 14 DAS and fertilizer was applied 14 DAS for both cowpea and cereals. A second dose of fertilizer was applied on the cereals two weeks after the first application. All plots were weeded thrice and cowpea plants were protected from insect damage by spraying biweekly with insecticide (Uppercott- Cypermethrin + Dimethoate at 1 litre/ha) until 75 % podding. Disease incidence and severity for scab and Septoria leaf spot were recorded at weekly intervals starting from the first appearance of the symptoms. Data for the different plant parts (leaf, stem, peduncle, flower cushion and pod) infected by scab and leaves infected by Septoria leaf spot were recorded from four middle ridges for each plot.

Statistical analysis: The data obtained from the field for disease incidence, severity for scab and septoria leaf spots were subjected to analyses of variance (ANOVA) and mean separation was by Student Newman Keuls Test (SNK).

RESULTS

The incidence of the scab and septoria leaf spot progressively increased with increase in crop maturity, irrespective of the cropping patterns used (Tables 1 and 2). The same trend was observed for disease severity for both pathogens (Tables 3, 4, 5 and 6). In 2004 and 2006 at 42-49 days after sowing (DAS), the effects of cropping patterns on scab incidence were not significantly different for both cowpea intercropped with maize (cowpea: maize) and cowpea intercropped with sorghum (cowpea: sorghum). However, at 42 DAS, the lowest scab incidence was recorded in the interrow pattern involving the association of cowpea and maize and cowpea and sorghum. Scab incidence on cowpea was also low in sole cropping. In the same period, the highest scab incidence occurred on intrarow of cowpea intercrop with maize and with sorghum. In 2006 at 42 DAS, Strip cropping recorded the highest scab incidence on cowpea intercrop with maize.

In 2005 at 42 DAS, the rate of scab incidence for the different cropping patterns showed no significant differences for cowpea:maize. At 49 DAS, significant differences were observed on scab incidence on cowpea intercrop with maize and with sorghum respectively. The effect of cropping patterns on scab incidence of cowpea:maize was statistically similar for inter-row, double row and strip but a significant ($P \leq 0.05$) difference was observed for intra-row that showed a higher scab incidence compared to the other cropping patterns. For cowpea intercrop with sorghum, scab incidence was lower on strip cropping and on sole cropped cowpea than the other cropping patterns, which were statistically similar (Table 1).

Table 1. Incidence of scab as affected by cropping patterns on cowpea variety Ife brown.

Cropping patterns	Scab Incidence							
	2004		2005		2006		**Combined**	
	42 DAS	49 DAS	42 DAS	49 DAS	42 DAS	49 DAS	*42 DAS*	49 DAS
				Cowpea: Maize				
Inter-row	8.35a	18.85a	3.02a	26.83bc	1.99a	7.78a	6.95a	19.27ab
Intra-row	15.83a	23.20a	6.36a	48.69a	2.00a	9.69a	5.57a	25.75a
Double row	13.16a	19.16a	3.24a	25.15bc	2.96a	8.86a	6.45a	17.72ab
Strip	13.59a	20.09a	3.19a	20.64bc	4.63a	15.47a	7.14a	18.73ab
				Cowpea: Sorghum				
Inter-row	10.63a	21.38a	1.97a	21.30bc	4.68a	7.54a	5.76a	16.74ab
Intra-row	13.55a	20.25a	5.85a	37.63ab	2.12a	4.51a	7.17a	20.80ab
Double row	13.87a	18.85a	2.77a	20.43bc	1.42a	5.65a	6.02a	14.98b
Strip	14.65a	16.88a	2.16a	17.47c	2.61a	15.16a	6.48a	16.50ab
Sole cowpea	10.70a	17.45a	2.78a	16.48c	3.54a	15.21a	5.57a	16.38ab

∗ Values in column followed by the same letters are not significantly different at $P \leq 0.05$(SNK test).

DAS = days after sowing.

The effect of cropping patterns on the incidence of Septoria leaf spot on cowpea showed no significant differences for cowpea intercrop with maize and with sorghum at 42-49 DAS in 2004 and 2006. Interrow had a high Septoria leaf spot incidence at 49 DAS compared to the other cropping pattern. In 2006, at 49 DAS strip cropping (cowpea: maize) and double row (cowpea: sorghum) had a high Septoria leaf spot incidence. A significant ($P \leq 0.05$) difference was observed in 2005 at 42-49 DAS with Septoria leaf spot incidence on the different cropping patterns. Strip cropping and sole cowpea had the least incidence (Table 2).

Table 2. Incidence of Septoria leaf spot as affected by cropping patterns on cowpea variety Ife brown

Cropping patterns	Septoria leaf spot Incidence							
	2004		2005		2006		Combined	
	42 DAS	49 DAS	42 DAS	49 DAS	42 DAS	49 DAS	42 DAS	49 DAS
				Cowpea: Maize				
Inter-row	1.02a	6.83a	1.56ab	7.74ab	0.19a	13.65a	0.92a	9.41a
Intra-row	1.07a	3.30a	4.01a	12.76a	3.03a	3.99a	2.70a	6.68ab
Double row	1.12a	5.27a	1.21ab	6.95ab	0.83a	1.87a	1.06a	3.87b
Strip	1.09a	4.25a	0.65b	3.34b	8.77a	16.19a	3.54a	7.93ab
				Cowpea: Sorghum				
Inter-row	1.87a	5.57a	1.23ab	5.49ab	2.30a	8.71a	1.80a	6.65ab
Intra-row	1.65a	4.49a	1.77ab	9.10ab	1.28a	3.40a	1.56a	5.66ab
Double row	2.47a	5.35a	1.12ab	5.64ab	6.65a	23.11a	3.41a	11.32a
Strip	2.12a	5.23a	0.31b	4.78b	4.09a	13.34a	2.18a	7.82ab
Sole cowpea	0.68a	3.00a	0.16b	3.83b	2.24a	9.62a	1.03a	5.48ab

∗ Values in a column followed by the same letters are not significantly different at $P \leq 0.05$ (SNK Test)
DAS = days after sowing.

The incidences of Septoria leaf spot on the other cropping patterns were statistically similar.

When the three years were combined, it was observed that scab incidence at 49 DAS was significantly ($P \leq 0.05$) higher for inter-row and intra-row compared to double-row, strip cropping and sole cowpea. Intra-row intercrop had the highest incidence for cowpea intercropped with maize and sorghum respectively. The general range of scab incidence on the different cropping patterns for the five practices was in the order of sole<double-row<strip<inter-row<intra-row.Septoria leaf spot incidence at 49 DAS was significantly ($P \leq 0.05$) higher on inter row and lower on double row for cowpea: maize but double row had a higher incidence for cowpea: sorghum. The general range of Septoria leaf spot incidence was in the order of sole<intra-row<double- row<strip<Inter-row (Table 1 and 2).

In 2004, the severity of scab infected plant parts and Septoria leaf spot on the different cropping patterns were not significantly different from each other but inter-row and intra-row had a higher scab severity on the leaves, stems and peduncles for cowpea: maize and cowpea: sorghum compared to double row and strip cropping. Significant ($P \leq 0.05$) differences were observed on peduncle scab for cowpea: maize and cowpea: sorghum with intra-row having a higher scab severity compared to the other cropping patterns (Table 3).

Table 3. Severity of scab and Septoria leaf spot on the different plant parts as affected by cropping patterns in 2004.

Cropping Patterns	Scab disease severity scores											
	Leaf		Stem		Peduncle		Flower cushion		Pod		Septoria leaf spot at:	
	70 DAS	77 DAS	70 DAS	77 DAS	70 DAS	77 DAS	70 DAS	77 DAS	70 DAS	84 DAS	70 DAS	77 DAS
Cowpea:Maize												
Inter-row	7.50ab	8.50a	8.00a	8.50a	5.50ab	6.00ab	1.00a	1.30a	2.00a	3.50a	6.00a	8.00a
Intra-row	8.00a	8.50a	7.50a	9.00a	4.50ab	8.00a	1.00a	1.50a	1.25a	2.00a	3.50a	7.50a
Double row	7.50ab	7.50a	5.50ab	7.00a	5.00ab	6.00ab	1.00a	2.00a	1.75a	3.00a	4.50a	8.00a
Strip	7.00ab	8.00a	8.00a	6.50a	4.00ab	5.50ab	1.00a	1.30a	1.75a	2.00a	3.50a	7.50a
Cowpea:Sorghum												
Inter-row	8.00a	8.50a	8.00a	8.50a	4.50ab	7.00ab	1.00a	1.80a	1.75a	2.50a	4.50a	7.50a
Intra-row	8.00a	8.50a	8.00a	9.00a	6.50a	8.00a	1.00a	1.80a	1.75a	2.50a	5.50a	7.50a
Double row	6.00b	6.00a	5.00ab	8.00a	2.00b	5.00b	1.00a	1.50a	1.30a	3.50a	4.00a	7.50a
Strip	7.50ab	8.00a	7.50a	8.00a	5.00ab	6.00ab	1.00a	1.30a	1.50a	2.50a	3.50a	7.00a
Sole cowpea	7.50ab	8.00a	6.00ab	7.50a	2.50b	6.50ab	1.00a	1.30a	1.50a	2.50a	3.50a	6.50a

Values in a column followed by the same letters are not significantly different at $P \leq 0.05$ SNK Test).
DAS = days after sowing.

The leaves and stems at 70 DAS and sole cowpea at 70 and 77 DAS showed significant ($P \leq 0.05$) differences in scab severity for cowpea: maize and cowpea: sorghum and these differences were statistically similar but higher for intra-row for cowpea: maize and cowpea: sorghum compared to the other cropping patterns and double-row showed a lower scab severity at 70 and 77 DAS and sole cowpea at 70 DAS.

No scab severity was recorded on flower cushion for all the different cropping patterns at 70 DAS. Significant differences were not observed on flower cushion (77 DAS) and pod scab at 70 DAS and 77 DAS but inter-row and intra-row (cowpea; sorghum) showed a high flower cushion (77 DAS) and pod (70 DAS) scab severity compared to double-row, strip cropping and sole cowpea. The different plant parts for cowpea: maize and cowpea: sorghum on double-row and sole cowpea proved better for scab severity. The severity of Septoria leaf spot at 70 and 77 DAS for cowpea: maize and cowpea: sorghum on the different cropping patterns was not significantly different from each other but its effect was higher on all the cropping patterns compared to sole cowpea. Sole cropped and strip cropping proved better for Septoria leaf spot severity (Table 4).

Table 4. Severity of scab and Septoria leaf spot on the different plant parts as affected by cropping patterns in 2005.

Cropping Patterns	Scab disease severity scores											
	Leaf		Stem		Peduncle		Flower cushion		Pod		Septoria leaf spot at:	
	70 DAS	77 DAS	70 DAS	77 DAS	70 DAS	77 DAS	70 DAS	77 DAS	70 DAS	84 DAS	70 DAS	77 DAS
						Cowpea:Maize						
Inter-row	5.00a	6.50a	6.00a	7.00a	5.00a	6.50a	1.25a	2.25a	2.00a	3.50ab	3.50a	7.00a
Intra-row	6.00a	7.50a	6.00a	8.00a	5.50a	8.00a	1.25a	3.50a	3.00a	5.00ab	4.00a	8.00a
Double row	5.00a	7.00a	5.50a	7.50a	5.00a	7.50a	1.25a	3.00a	2.25a	4.50ab	3.50a	7.50a
Strip	4.50a	6.50a	4.50a	7.00a	4.50a	7.00a	1.00a	3.00a	1.75a	4.00ab	3.00a	6.50a
						Cowpea:Sorghum						
Inter-row	4.00a	7.50a	5.00a	7.00a	4.50a	7.00a	1.00a	3.00a	1.75a	5.00ab	3.00a	7.00a
Intra-row	5.00a	5.50a	5.50a	7.00a	5.00a	7.00a	1.00a	3.50a	2.50a	6.00a	4.00a	7.50a
Double row	4.00a	7.50a	4.50a	7.50a	4.50a	7.50a	1.00a	3.00a	2.50a	5.00ab	4.50a	6.50a
Strip	3.50a	7.00a	3.50a	7.00a	4.00a	7.00a	1.00a	2.50a	2.00a	4.00ab	3.50a	6.00a
Sole cowpea	3.50a	6.50a	3.50a	6.50a	3.50a	5.50a	1.00a	1.75a	1.50a	3.00b	2.50a	6.00a

∗ Values in a column followed by the same letters are not significantly different at $P \leq 0.05$ (SNK Test).
DAS = days after sowing.

In 2005, the severity of scab and Septoria leaf spot on the different cropping patterns were not significantly different from each other but pod scab showed significant ($P \leq 0.05$) differences at 84 DAS for cowpea: maize and cowpea: sorghum with intra-row having a higher severity compared to the other cropping patterns which were statistically similar (Table 4). Generally, strip cropping had the lowest scab and Septoria leaf spot severity on the different plant parts for both cowpea: maize and cowpea: sorghum for all the DAS, followed by inter-row, double-row and intra-row. Sole cowpea recorded the least scab severity on the different plant parts for all the DAS.

In 2006, the severity of scab on the different plant parts and Septoria leaf spot also showed no significant differences for all the cropping patterns (Table 5).

Table 5. Severity of scab and Septoria leaf spot on the different plant parts as affected by cropping patterns in 2006.

Cropping Patterns	Scab disease severity scores											
	Leaf		Stem		Peduncle		Flower cushion		Pod		Septoria leaf spot at:	
	70 DAS	77 DAS	70 DAS	77 DAS	70 DAS	77 DAS	70 DAS	77 DAS	70 DAS	84 DAS	70 DAS	77 DAS
Cowpea:Maize												
Inter-row	4.0oa	5.33a	4.67a	5.33a	5.33a	6.00a	1.33a	2.00a	1.33a	2.00a	2.67a	5.33a
Intra-row	3.33a	4.67a	3.33a	4.67a	4.00a	5.33a	1.67a	2.67a	2.67a	3.33a	2.67a	5.33a
Double row	3.33a	5.33a	4.00a	5.33a	4.00a	4.67a	1.33a	2.00a	2.00a	2.67a	3.33a	6.00a
Strip	2.70a	5.33a	4.67a	5.33a	4.00a	4.67a	1.00a	1.67a	1.33a	2.00a	4.00a	4.67a
Cowpea:Sorghum												
Inter-row	2.67a	4.00a	1.67a	4.00a	4.00a	4.67a	1.00a	2.00a	2.00a	2.67a	4.00a	6.00a
Intra-row	2.33a	4.67a	1.33a	5.33a	2.67a	5.33a	1.00a	2.00a	2.00a	2.67a	1.67a	4.00a
Double row	4.67a	6.00a	4.67a	5.33a	4.67a	5.33a	1.33a	2.00a	2.33a	3.33a	4.00a	5.33a
Strip	4.67a	6.67a	4.00a	4.67a	4.00a	4.67a	1.00a	1.67a	1.33a	2.00a	4.00a	4.67a
Sole cowpea	4.67a	7.33a	4.00a	6.00a	4.00a	4.67a	1.00a	1.67a	1.33a	2.00a	4.00a	5.33a

∗ Values in a column for each treatment followed by the same letters are not significantly different at $P \leq 0.05$ (SNK Test).
DAS = days after sowing

Scab severity on the different plant parts and Septoria leaf spot severity for cowpea: maize was lower on intra row (leaf scab and stem scab) at 70 and 77 DAS compared to the other cropping patterns. The severity of scab on flower cushions and pods were lower on strip cropping compared to the other cropping patterns. At 70 and 77 DAS, inter-row and intra-row (cowpea: maize) had a lower leaf and stem scab severity compared to double-row, strip cropping and sole cowpea. This was in contrast to what was reported for 2004 and 2005. Flower cushion and pod scab severity showed the same pattern of arrangement as cowpea: maize with strip cropping giving the least scab severity.

Generally cropping patterns showed significant differences ($P \leq 0.05$) on the severity of scab on the stems (70 DAS), peduncles, flower cushions, sole cowpea (70 and 77 DAS) and pods (77 and 84 DAS) for both cowpea: maize and cowpea: sorghum intercrop. These differences were statistically similar but higher than that of sole cowpea in all the years combined (Table 6). The trend was in the order of sole<double-row< strip <inter-row<intra-row. Septoria leaf spot showed significant differences ($P \leq 0.05$) for the different cropping patterns at 77 DAS for cowpea: maize and cowpea: sorghum in the order of sole<intra-row<double-row<strip<inter-row (Table 6).

.

Table 6. Severity of scab and Septoria leaf spot on the different plant parts as affected by cropping patterns in 2004, 2005 and 2006 combined.

Cropping Patterns	Scab disease severity scores											
	Leaf		Stem		Peduncle		Flower cushion		Pod		Septoria leaf spot at:	
	70 DAS	77 DAS	70 DAS	77 DAS	70 DAS	77 DAS	70 DAS	77 DAS	70 DAS	84 DAS	70 DAS	77 DAS
Cowpea: Maize												
Inter-row	5.50a	6.75a	6.17a	6.92a	5.33a	6.17ab	1.17ab	1.83ab	1.75ab	3.00ab	4.08a	6.75ab
Intra-row	5.75a	6.83a	5.50ab	7.25a	4.67ab	7.08a	1.33a	2.50a	2.25a	3.33ab	3.33a	6.92ab
Double row	5.33a	6.67a	5.00ab	6.58a	4.67ab	6.08ab	1.17ab	2.33ab	2.00ab	3.33ab	3.83a	7.17a
Strip	4.67a	6.58a	5.67ab	6.25a	4.17ab	5.75ab	1.00b	2.00ab	1.58ab	2.67ab	3.50a	6.25ab
Cowpea: Sorghum												
Inter-row	4.83a	5.58a	4.92ab	6.50a	4.33ab	6.25ab	1.00b	2.25ab	1.83ab	3.33ab	3.75a	6.83ab
Intra-row	5.17a	6.17a	4.92ab	6.92a	4.67ab	6.75ab	1.17ab	2.42ab	2.08ab	3.67ab	3.75a	6.33ab
Double row	4.92a	6.75a	4.67b	6.92a	3.75ab	6.00ab	1.08ab	2.17ab	2.00ab	3.83a	4.17a	6.42ab
Strip	5.25a	7.00a	5.00ab	6.50a	4.25ab	5.83ab	1.00b	1.83ab	1.58ab	2.83ab	3.67a	5.92ab
Sole cowpea	5.25a	7.25a	4.58b	6.67a	3.42b	5.58b	1.00b	1.58b	1.42b	2.50b	3.33a	5.67b

∗ Values in a column for each treatment followed by the same letters are not significantly different at $P \leq 0.05$ (SNK Test).
DAS = days after sowing.

DISCUSSION

Cropping patterns (inter-row, intra-row, double row, strip and sole cowpea) showed significant effect on the incidence and severity of scab on the different plant parts and Septoria leaf spot on cowpea variety Ife Brown with increase in age of the plant.. Generally, scab incidence at 49 DAS (days after sowing) was higher on inter-row and intra-row compared to double-row, strip and sole cowpea. Septoria leaf spot incidence was lower on intra-row compared to the other cropping patterns. The increase or decrease may depend on the location and season. These results corroborate those of Boudreau [9] and Lanter [10] who reported that maize intercropped with bean (*Phaseolus vulgaris*) could increase or decrease angular leaf spot severity depending on the location and season. The specific factors and interactions, which lead to such variable results, are difficult to determine but moisture may play a key role. Accordingly, the data collected from the meteorological centre of the Institute for Agricultural Research (IAR) on the micro-climate at Samaru may have differed with respect to intercropping which in turn might have caused variation in the results obtained in the different years of this study with higher incidence and severity in some of the cropping patterns and lower incidence and severity in others. It is also possible that the small changes in rainfall, temperature and relative humidity obtained in this region may show some variations in cowpea: maize and cowpea: sorghum intercrops compared with the conditions elsewhere. However, the reaction of cowpea variety Ife Brown to the individual pathogen was different across the various cropping patterns. In general, the range of scab and Septoria leaf spot incidences on the five cropping patterns were in the order of sole<double row<strip<inter-row<intra-row for scab incidence and for Septoria leaf spot, the incidence was in the order of sole<intra-row<double row<strip<inter-row for. Sole cowpea had a lower incidence for both diseases compared to the other cropping patterns. Results of the present study differ from that of Van Rheenen *et al*. [11], who reported that bean: maize intercrop showed a decrease in disease incidence than bean monoculture (sole-cropped bean). Edema *et al*. [12] also reported that except for viral diseases, disease incidence was generally lower in intercropped than in sole cowpea.

The severity of scab infected plant parts and Septoria spot in some of the different cropping patterns in the three years of study showed some variations for the different practices. The results obtained in 2004 and 2005 showed some similarities in disease severity on double-row and strip cropping with sole cowpea having a lower scab and Septoria leaf spot severity than inter-row and intra-row cropping for cowpea: maize and cowpea: sorghum. A reverse of this was observed in 2006 for cowpea: sorghum with inter-row and intra-row having a lower scab severity than improved practices. This was also similar to reports by Edema *et al*. [12] that except for viral diseases, disease severities were generally lower in intercropped than in sole cropped cowpea. Intra-row intercrop had a lower

Septoria leaf spot severity for cowpea: sorghum compared to the other cropping patterns. However, results of the present study showed some variations on the effect of cropping patterns on the two pathogens compared with experiments conducted by Adebitan *et al*. [13] at three different locations in Ibadan which showed that cropping patterns significantly affected the incidence and severity of anthracnose and brown blotch on cowpea, increasing generally in the order of sole>strip>intra-row>double-row>inter-row. In their report, they confirmed that the reaction of the cowpea genotypes to anthracnose and brown blotch was different across the different cropping patterns. A lower Septoria leaf spot severity on intra-row for cowpea: sorghum confirms previous reports by Edema *et al*. [12, 14] that disease severities were lower in cowpea intercropped than sole cowpea. The decrease of Septoria leaf spot on intra-row could be attributed to plant spacing. This confirms studies on cowpea by Gurama *et al*. [15] that inter-row spacing had higher scab severity than cowpea grown at wider spacing. Overcrowding of plant was apparently responsible for high relative humidity in the crop microenvironment, which thus favoured spore germination for subsequent infection and disease development. This is in agreement with previous work by Gurama *et al*. [15, 16], who reported an increase in scab incidence and severity on cowpea grown at closer spacing. Therefore, decreased scab and Septoria leaf spot severity on cowpea variety Ife Brown due to intercropping itself may result, with double-row and strip cropping proving better for scab infection and intra-row and double-row cropping proving better for Septoria leaf spot infections. Sole cropping was more profitable in terms of in disease control for both pathogens and it is also easy to spray against insects.

CONCLUSION.

This study shows that intercropping pattern is very important to enhance alley cropping in a developing economy like Nigeria where subsistent farming is common. Intercropping enhance reduction of inoculum pressure of pathogenic diseases and therefore reduce cost of fungicide and pest management within the framework of integrated pest and disease management system. However, sole and strip cropping have been shown to be more profitable in terms of disease management and economic productivity for large scale crop production where integrated pest management is very applicable to reduce crop failure.. This study showed that sole cropping system was more ideal for disease managements of incidence of Scab and Septoria leaf spot diseases of cowpea with respect to the other tested cropping systems.

ACKNOWLEDGEMENTS

We thank the International Institute of Tropical Agriculture (IITA), Nigeria for material and technical support. Our appreciation to Mr Anyanwu Andrew of the Institute of Agricultural

Research, Ahmadou Bello University, Zaria, Nigeria for technical assistance, the Ministry of Higher Education of Cameroon for research mobilization grant.

COMPETING INTERESTS

The authors do not have any conflict of interest.

AUTHORS' CONTRIBUTIONS

MBONG GA AND C:N: FOKUNANG designed the study, wrote the protocol conducted field and laboratory experiment, performed the statistical analysis, , and wrote reviewed the drafts of the manuscript.
O. ALABI, A. M. EMECHEBE review and editing of manuscript drafts
M. D. ALEGBEJO, C. N. AKEM, managed the analyses of the study, data mining of literature searches. All authors read and approved the final manuscript."

CONSENT

This paper does not require ethical approval.

REFERENCES

1. Henriet, JGA.,. Van EK, Blade SF,. Singh BB. Quantitative assessment of traditional cropping system in the Sudan savanna of Northern Nigeria. 1. Rapid survey of prevalent cropping systems. *Samaru J.Agric. Re*s. 1997. 14: 37-45.

2. Mortimore, MJ., Singh BB, Harris F, Blade SF. Cowpea in traditional cropping systems. Pages 99-113 in Advances in cowpea research, edited by B B. Singh, D. R. Mohan Raj, K. E. Dashiell and L. E. N. Jackai. Co-publication of International Institute of Tropical Agriculture (IITA) and Japan International Research Centre for Agricultural Science (JIRCAS). IITA, Ibadan, Nigeria. 1997 pp 213..

3. Subbarao, GV,. Renard CR, Payne WA,.. Bationo, AB. Long-Term of Tillage, P Fertilization and Crop Rotation on Pearl Millet/Cowpea Productivity in West Africa. Expl. Agric. 2000.36: 243-264.

4. Emechebe, AM. Scab disease of cowpea (*Vigna unguiculata*) caused by a species of the fungus *Sphaceloma*. Ann. Appl.Biol. 1980. 96:11-16.

5. Singh, SR, Rachie KO. *Cowpea Research Production* and Utilization. John Wiley and Sons. New York, 1985.406 pp.

6. Mbong, GA., Akem CN., Alabi O, Emechebe AM., Alegbejo MD.. Effect ofsowing date on the incidence, apparent infection rate and severity of scab on cowpea. Asian J. Agric Sc. 2010. 2(2): 63-68.

7. Emechebe, AM,. Shoyinka SA.. Fungal and bacterial diseases of cowpea in Africa in: Singh, S. R. and K. O. Rachie (eds), *Cowpea Research*, *Production* and Utilization. John Wiley and Sons, Chichester, UK, 1985. pp. 173-192.

8. Emechebe, AM. McDonald, D.. Seedborne pathogenic fungi and bacteria of crop in northern Nigeria. *PANS* 1979. 25: 401-404.

9. Boudreau, MA.. Effect of intercropping bean with maize on the severity of angular leaf spot of bean in Kenya. *Plant pathol*. 1993. 42: 16-25.

10. Lanter, JM. Epidemiology of angular leaf spot of bean in monoculture and in bean: maize intercrops. Ph.D. Thesis, university of California-Berkeley.
11. Van Rheenen, H. A., O. E. Hasselbach and S.G.S. Muigai. 2005. The effect of growing bean together with maize on the incidence of bean diseases and pest. *Eur.J Plant Pathol.*1990... 87 (5): 193-199.

12. Edema, RE. Adipala CI,. Florini DA. Influence of season and cropping systems on occurrence of cowpea diseases in Uganda. *Plant Dis .* 1997.81:465-468.

13. Adebitan, TT, Ikotun T, Fawole B, Dashiell KE. The influence of cowpea genotype and cropping pattern on two *Colletotrichum* diseases of cowpea. Paper presented at the 22nd Annual Conference of the Nigerian Society for Plant Protection at the University of Agriculture, Abeokuta on April 6-9, 1992.pp 32.

14. Zinsou VK, Wydra B, Ahduendou BH.. Effect of soil ammendment, intercropping and planting time in combination on the severity of cassava bacterial blight and yield in two ecozones of West Africa. Plant Pathol, 2004. 53 (5)-585-595.

15. Gurama, AU,. Adebitan SA,. Wacka CM. Effects of plant spacing and sowing date on cowpea scab caused by *Sphaceloma* sp. Int. J. Tropical Plant Dis. 1998..16:81-90.

16. Adebitan, SA,. Ikotun T. Effect of Plant spacing and crop pattern on anthracnose (*Colletotrichum lindernuthianum*) of cowpea *Fitopatologia Brasileira* 1996. 21 (1): 512.

.