

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

ABSTRACT

Scab caused by *Sphaceloma* sp and Septoria leaf spot caused by *Septoria vignae* were evaluated on one variety of cowpea: Ife Brown in this study. Ife Brown is highly susceptible to scab and moderately susceptible to Septoria leaf spot. The cowpea (*Vigna unguiculata* L.Walp) was planted simultaneously with maize (intercrop) and sorghum (intercrop) respectively. The two cereals used were all extra early varieties. The investigations were carried out during three cropping seasons of 2004, 2005 and 2006 at Samaru and Shika in Zaria, Nigeria. The field layout was factorial concept in Randomized Complete Block Design (RBCD) with four replications. Five cropping patterns: interrow, intrarow, doublerow, strip and sole cropping on the incidence and severity of scab and Septoria leaf spot, were studied. 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 decreasing 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 monocrop proves better for both pathogens compared to the other cropping patterns.

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

INTRODUCTION

In Nigeria, cowpea (*Vigna unguiculata* L. Walp (Fabaceae) is traditionally grown by small holder's 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 region

traditionally grow cowpea as an intercrop with maize, sorghum and pearl millet (Henriet *et al.*, 1997; Mortimore *et al.*, 1997; Subbarao *et al.*, 2000). 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 farmer conditions.

The most common diseases of cowpea variety Ife Brown are scab (*Elsinoe phaseoli* Jenkins.), Septoria leaf spot (*Septoria vignae* P. Henn.), bacterial blight (*Xanthomonas campestris* pv.*vignicola* Burkholder.). Scab caused by the fungus *Spaceloma* sp is one of the most destructive diseases of cowpea variety the Northern Guinea Savanna Zones of Nigeria. The conidium of *Sphaceloma* sp are usually regarded as the anamorph of the perfect species, *Elsinoe phaseoli* Jenkins. which is responsible for inducing scab on cowpea (Emechebe, 1980). 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 (Emechebe, 1980; Singh and Rachie, 1985; Mbong *et al.*, 2010). Septoria leaf spot is a foliar disease of cowpea (Emechebe and Shoyinka, 1985). The disease is caused by *Septoria vignae* P. Henn. and it is seed-borne and seed transmitted (Emechebe and McDonald, 1979). 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.

MATERIALS AND METHODS

Collection, isolation and identification of the fungus

Cowpea leaf showing scab and septoria leaf spot symptoms with dark brown lesions were collected from infected field plots. The diseased leaf were washed with running tap water and small pieces of infected materials were cut from the edges of the leaf, surface-sterilized for 3 minutes in 10% sodium hypochlorite solution and rinsed five times in sterile distilled water. The leaf pieces were dried on sterilized filter paper and placed on solidified Potato Dextrose Agar (PDA) containing 100mg/l sodium novobiocin as antibiotics to inhibit bacterial growth. The material was incubated at 25±2°C for 7 days. Observation was made

67 daily for any mycelial growth. Identification of the fungus was done under the microscope
68 and confirmation made using the procedure of Barnett and Hunter,(1972). Pure cultures
69 were obtained by sub-culturing onto fresh plates. Stock cultures were maintained on agar
70 slants in McCartney bottles.

71 *Preparation of spore suspension*

72 Spore suspensions were prepared from 8-day-old cultures of the isolated fungus by
73 flooding with sterile distilled water and dislodging the spores with small brush. The
74 suspension was clarified by centrifugation at 2000 rpm for 3 min and the supernatant was
75 filtered through 2 layers of sterile muslin cheesecloth. The spore concentration was
76 determined with a haemocytometer and adjusted to 2.0×10^6 spores/ml of distilled water.

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78 Field Disease incidence and severity measurement

79 Field experiments were conducted thrice (each running through three separate
80 growing seasons) in 2004, 2005 and 2006 at the Institute for Agricultural research (IAR),
81 Samaru, Zaria, Nigeria. One variety of cowpea (Ife Brown-highly susceptible to scab and
82 moderately susceptible to Septoria leaf spot) and two varieties of cereals (maize, TZEED-
83 extra early and sorghum, ICSV111-extra early) were chosen for this study. The field layout
84 was factorial concept in Randomized Complete Block Design (RBCD) with four replicates.
85 Five cropping patterns; sole-cropping (sole) with all rows in the plot sown to cowpea only;
86 inter-row mixed cropping (inter-row) with rows of cowpea alternatively sown with rows of
87 maize or sorghum; intra-row mixed cropping (intra-row) with cowpea and maize or
88 sorghum seeds sown in alternate hills, respectively within each row; double row cropping
89 (double row) with two rows of cowpea sown between two rows of maize or sorghum; Strip
90 cropping (strip) with four rows of cowpea sandwiched between two rows of maize or
91 sorghum on either sides were used (Figure 1).

92 Each treatment plot consisted of eight, 75 cm ridges, and 6m long. The plots were
93 separated by border rows consisting of one ridge along the length and 2 m along the width.
94 Cowpea and maize were sown at two seeds per stand and sorghum at eight seeds per stand
95 and were later thinned to two plants per stand two weeks after germination to give
96 approximately the same population of plants /ha in the various plots. Plant spacing for
97 inter-row mixed cropping of maize and sorghum was 0.5 m and cowpea was 25 cm. Plant
98 spacing for intra-row mixed cropping of maize and sorghum was 1 m and cowpea was 25
99 cm in-between the maize and sorghum receptively. Plant stand establishment was taken at

100 14 DAS and fertilizer was applied 14 DAS for both cowpea and cereals. A second dose of
101 fertilizer was applied on the cereals two weeks after the first application. All plots were
102 weeded thrice and cowpea plants were protected from insect damage by spraying biweekly
103 with insecticide (Uppercott- Cypermethrin + Dimethoate at 1 litre/ha) until 75% podding.
104 Disease incidence and severity for scab and Septoria leaf spot were recorded at weekly
105 intervals starting from the first appearance of the symptoms. Data for the different plant
106 parts (leaf, stem, peduncle, flower cushion and pod) infected by scab and leaves infected
107 by Septoria leaf spot were recorded from four middle ridges for each plot. The data
108 obtained was subjected to analyses of variance (ANOVA) and mean separation was by
109 Student Newman Keuls Test (SNK).

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111 RESULTS

112 The incidence and severity of the individual fungi progressively increased
113 with increase in the age of the crop, irrespective of the cropping patterns and the
114 cowpea variety used. (Tables 1, 2, 3, 4, 5 and 6). In 2004 and 2006 at 42-49 days after
115 sowing (DAS), the effects of cropping patterns on scab incidence were not significantly
116 different for both cowpea intercropped with maize (cowpea: maize) and cowpea
117 intercropped with sorghum (cowpea: sorghum). However, at 42 DAS, the lowest scab
118 incidence was recorded in the interrow pattern involving the association of cowpea and
119 maize and cowpea and sorghum. Scab incidence on cowpea was also low in sole cropping.
120 In the same period, the highest scab incidence occurred on intrarow of cowpea intercrop
121 with maize and with sorghum. In 2006 at 42 DAS, Strip cropping recorded the highest scab
122 incidence on cowpea intercrop with maize.

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

132 The effect of cropping patterns on the incidence of Septoria leaf spot on cowpea
133 showed no significant differences for cowpea intercrop with maize and with sorghum at

134 42-49 DAS in 2004 and 2006. Interrow had a high Septoria leaf spot incidence at 49 DAS
135 compared to the other cropping pattern. In 2006, at 49 DAS strip cropping (cowpea: maize)
136 and doublerow (cowpea: sorghum) had a high Septoria leaf spot incidence. A significant
137 ($P \leq 0.05$) difference was observed in 2005 at 42-49 DAS with Septoria leaf spot incidence
138 on the different cropping patterns. Strip cropping and sole cowpea had the least incidence
139 (Table 2). The incidences of Septoria leaf spot on the other cropping patterns were
140 statistically similar.

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

151 In 2004, the severity of scab infected plant parts and Septoria leaf spot on the
152 different cropping patterns were not significantly different from each other but inter-row
153 and intra-row had a higher scab severity on the leaves, stems and peduncles for cowpea:
154 maize and cowpea: sorghum compared to double-row and strip cropping. Significant
155 ($P \leq 0.05$) differences were observed on peduncle scab for cowpea: maize and cowpea:
156 sorghum with intra-row having a higher scab severity compared to the other cropping
157 patterns (Table 3). The leaves and stems at 70 DAS and sole cowpea at 70 and 77 DAS
158 showed significant ($P \leq 0.05$) differences in scab severity for cowpea: maize and cowpea:
159 sorghum and these differences were statistically similar but higher for intra-row for
160 cowpea: maize and cowpea: sorghum compared to the other cropping patterns and double-
161 row showed a lower scab severity at 70 and 77 DAS and sole cowpea at 70 DAS.

162 No scab severity was recorded on flower cushion for all the different cropping
163 patterns at 70 DAS. Significant differences were not observed on flower cushion (77
164 DAS) and pod scab at 70 DAS and 77 DAS but inter-row and intra-row (cowpea;
165 sorghum) showed a high flower cushion (77 DAS) and pod (70 DAS) scab severity
166 compared to double-row, strip cropping and sole cowpea. The different plant parts for
167 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 3).

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, doublerow and intrarow. 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). Scab severity on the different plant parts and Septoria leaf spot severity for cowpea: maize was lower on intrarow (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 significantly ($P \leq 0.05$) differences 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 and these differences were statistically similar but higher than that of sole cowpea in all the years combined (Table 6). The general decrease was in order of sole < double-row < strip < inter-row < intra-row. Septoria leaf spot showed significant ($P \leq 0.05$) differences for the different cropping patterns at 77 DAS for cowpea: maize and cowpea: sorghum with a general decrease in order of sole < intra-row < double-row < strip < inter-row (Table 6).

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199 DISCUSSION

Cropping patterns (inter-row, intra-row, double row, strip and sole cowpea) showed significant effect on the incidence, severity of scab on the different plant parts and Septoria

leaf spot on cowpea variety Ife Brown with increase in age of the plant. One might expect intercropping to either increase disease incidence or severity or at any rate reduce it, which was what was observed in this study. 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 (1993) and Lanter (1990) 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 some. 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 decreasing order sole<double row<strip<inter-row<intra-row if scab incidence and sole<intra-row<double row<strip<inter-row for Septoria leaf spot incidence. 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.* (2005), who reported that bean: maize intercrop showed a decrease in disease incidence than bean monoculture (sole-cropped bean). Edema *et al.* (1997) 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 similar

to reports by Edema *et al.* (1997) 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.* (1992) at three different locations in Ibadan which showed that cropping patterns significantly affected the incidence and severity of anthracnose and brown blotch on cowpea, decreasing generally in 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.* (1997) and Zinsou *et al.* (2004) 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.* (1998) that inter-row spacing had higher scab severity than cowpea grown at distance contact. 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.* (1998) and Adebitan and Ikotun (1996), 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 in disease control for both pathogens and it is also easy to spray against insects.

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

312 Ife brown.

Cropping patterns	Scab Incidence in:							
	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

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315 * Values in column followed by the same letters are not significantly different at

316 $P \leq 0.05$ (SNK Test).

317 * DAS = days after sowing.

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330 Table 2. Incidence of Septoria leaf spot as affected by cropping patterns on cowpea

331 variety Ife brown

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Cropping patterns	Septoria leaf spot Incidence in:							
	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

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335 * Values in a column followed by the same letters are not significantly different at
336 P≤0.05 (SNK Test).

337 * DAS = days after sowing

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 on:											
	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
<u>Cowpea:Maize</u>												
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
<u>Cowpea:Sorghum</u>												
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.

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

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Scab disease severity scores on:

Cropping Patterns	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
<u>Cowpea:Maize</u>												
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
<u>Cowpea:Sorghum</u>												
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

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353 * Values in a column followed by the same letters are not significantly different at $P \leq 0.05$ (SNK Test).

354 * DAS = days after sowing.

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

Scab disease severity scores on:												
Cropping Patterns	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
<u>Cowpea:Maize</u>												
Inter-row	4.00a	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
<u>Cowpea:Sorghum</u>												
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

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* 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

368 Table 6. Severity of scab and Septoria leaf spot on the different plant parts as affected by cropping patterns in 2004, 2005 and 2006
 369 combined.
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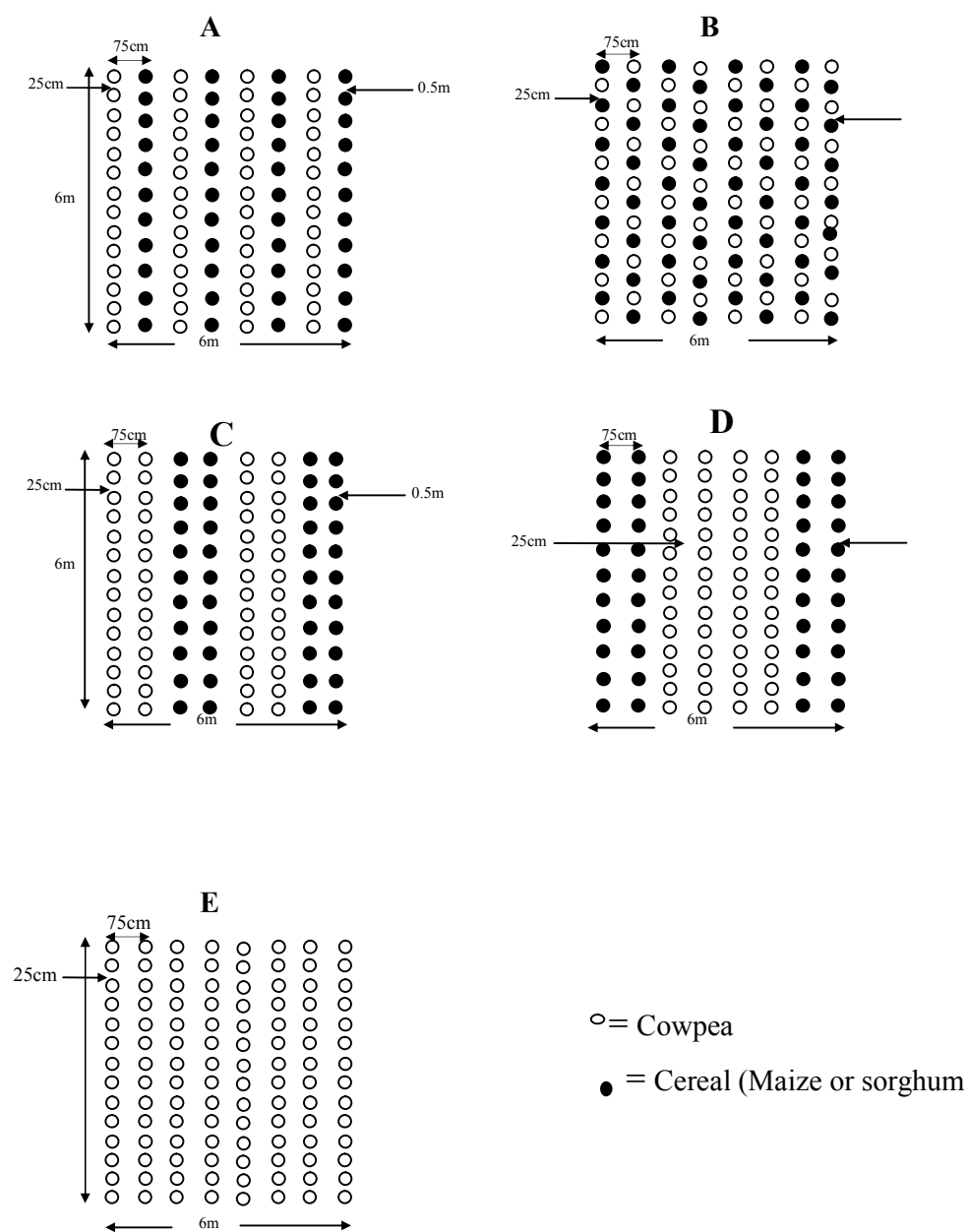
Cropping Patterns	Scab disease severity scores on :											
	Leaf		Stem		Peduncle		Flower cushion		Pod		Septoria leaf spot at:	
	70 DAS	77 DAS	70 DAS	77 DAS	70 DAS	77 DAS	70 DAS	77 DAS	70 DAS	84 DAS	70 DAS	77 DAS
<u>Cowpea: Maize</u>												
Inter-row	5.50a	6.75a	6.17a	6.92a	5.33a	6.17ab	1.17ab	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
<u>Cowpea: Sorghum</u>												
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

374 * Values in a column for each treatment followed by the same letters are not significantly different at $P \leq 0.05$ (SNK Test).

375 * DAS = days after sowing.

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379 Figure 1. A schematic diagram showing the cropping patterns used in cowpea: (A) inter-row, (B)

380 intra-row, (C) double row, (D) strip and (E) sole cowpea.

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