Effect of plant spacing and cropping pattern on brown blotch (*Colletotrichum truncatum*) of cowpea

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Field studies were conducted to determine the effect of plant spacing and cropping pattern on brown blotch, caused by *Colletotrichum truncatum*. A greater reduction of the disease occurred on intercropped compared to monocropped cowpea [*Vigna uniguiculata* (L.) Walp.]. Cowpea at wider spacings (between and within rows) showed lower disease incidence and severity in both monocrop and intercrop patterns than those at closer spacings. Fewer but more marketable yields were obtained from intercropped than monocropped cowpea, and from cowpea planted at wider row-spacings than those from closer spacings.

Keywords: Plant spacing; Cropping pattern; Brown blotch; Disease incidence; Disease severity; Cowpea

Brown blotch, caused by *Colletotrichum truncatum* (Schw.) Andrus & Moore, is one of the most widely spread diseases of cowpea [*Vigna unguiculata* (L.) Walp.] in Nigeria (Singh and Allen, 1979). Many control measures have been recommended for the control of this disease (Copeland *et al.*, 1975; Yen and Sinclair, 1980; Oladiran and Oso, 1983; Alabi *et al.*, 1986; Gomez *et al.*, 1986). However, most of these control measures lack application because of the indigenous intercropping system which is widely practised by the farmers.

Cowpea is rarely planted as a monocrop, especially in northern Nigeria where it is mainly grown (Litzinger and Moody, 1976). It is mostly intercropped with maize (*Zea mays* L.), sorghum [*Sorghum bicolor* (L.) Moench], pearl millet [*Pennisetum americanum* (L.) Leeke], and (or) cassava (*Manihot esculenta* Crantz), and occasionally with cotton (*Gossypium hirsutum* L.) or groundnut (*Arachis hypogaea* L.) (Baker and Norman, 1975). There is no record of any deliberate attempt to investigate the effect of intercropping cowpea with other crops or plant spacing on brown blotch. Therefore, the present study was conducted to quantify the incidence, spread, and severity of brown blotch on cowpea planted at different spacings and in maize and non-maize based stands.

Materials and Methods

Experimental conditions

The experiment was conducted at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Ibadan is located at 7°30′ N and 3°54′ E. The experimental site is in the tropical rain-forest zone and the rains there are bimodal with a monthly mean of 160 mm in April–June, usually designated as the long rains, and 150 mm in September–October, designated as the short rains.

The experiment was carried out in six separate seasons from 1987 to 1989. The first season was from April to July while the second was from August to November. The third season was the dry-off cropping season from December to March in the succeeding year. The field experiment conducted in the third season was irrigated with overhead sprinklers for 4 h per week. The rate of water supply was 8.6

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mm h^{-1} which was equivalent to 35 mm of rainfall per week. This adequately simulated the normal water requirement for the growth of both cowpea and maize plants in addition to other overall needs.

Land preparation, planting, and cultural management

The experimental plot was mowed, weeds were sprayed with paraquat at 5 L ha^{-1}, and zero tillage was adopted. Two seeds were sown per hole and later thinned to one plant. Subsequent weed control after the initial application of paraquat was by hoeing at three-week intervals. Routine three-weekly insect control with Sherpa Plus (a combination of dimethoate and cypermethrin) sprayed from a Knapsack sprayer at 5 mL L^{-1} of water was applied from 10 days after sowing until maturity.

Experimental plot size and design

A 2 × 3 × 4 factorial experiment in a completely randomised block of 24 plots was used with the following factors: two cropping patterns (monocrop and intercrop), three between- or inter-row spacings consisting of 50, 75, and 100 cm, and four within- or intra-row spacings which consisted of 10, 20, 30, and 40 cm. The experimental plots were 3 m long and 6 m wide. A clear border of 1.5 m was maintained between plots to prevent cross-contamination due to plant-to-plant contact from plants in one plot and others in an adjacent plot. There were three replications.

Ife brown, a cowpea variety that is high yielding but very susceptible to brown blotch, was used. It was intercropped with TZESR-Y variety of maize, which is also high yielding. Maize was chosen because it is predominantly intercropped with cowpea by most subsistence farmers in the rain forest and fringes of southern Guinea Savanna of West Africa as a surety against crop failure. Their different growth patterns and moisture requirements make it more likely that both crops will yield well. The beneficial advantages of cowpea in the intercrop for enriching the soil with nitrogen has been demonstrated (Agboola and Fayemi, 1972; Atkins, 1982).

In the sole cowpea plots 50-, 75-, and 100-cm between-row spacings gave 12, 8, and 6 rows per plot, respectively. Plant populations decreased in the order 30, 15, 10, and 7 cowpea plants per row approximately as a result of spacing 10, 20, 30, and 40 cm within rows in the plots, respectively. In the intercrop plots, the plant equivalence between the two crops was calculated according to the ratio of the estimated optimum plant populations of each component crop in pure stands (Karel *et al.*, 1980). This was considered necessary to remove any inherent disadvantage which may occur due to additive models, whereby plant populations used in the pure stand treatment result in a total population of the mixtures being greater than the monocrop causing an excess carrying capacity of the unit area (Evans, 1960). Therefore, every second row of maize was replaced by a pair of cowpea rows to keep the total population in both mono- and inter-crop constant.

Disease assessment

Ten plants randomly selected from each plot were examined for disease symptoms. A total of three disease assessments was made within a seasonal trial. Each plant showing signs of disease, no matter how slight or severe, was tagged each time disease incidence readings were taken. Data on the incidence and severity of anthracnose were recorded at intervals of two weeks, starting from 40 days after planting (DAP), when symptoms of infection appeared on the plant. Incidence was rated to be the number of plants affected, and severity was assumed to be the area of the plant that was affected (James and Shih, 1974).

Disease incidence was calculated from the total number of plants examined that had symptoms of brown blotch. The severity of the disease on cowpea in the plots was scored on the 0–5 modified scale of Mukunya and Keya (1978). A disease severity index was obtained by multiplying the proportion of plants in each disease category by the rating of their category, and adding the products together (Oladiran and Oso, 1983).

Seeds were harvested from all cowpea plants in the two central rows per plot to determine seed weight per plant which was later converted to obtain seed yield in kilograms per hectare. The seeds were sorted out into 'clean' [i.e. free from infection by not being discoloured and (or) disfigured] and 'unclean,' being otherwise described. They were reweighed and reconverted to estimate the relative yield losses due to various treatments.

Data analysis

Data collected were pooled together and averaged over the two years of the experiment for the three separate seasons because of their similarity. They were transformed using arcsine. Statistical analyses of variances (ANOVA) were carried out separately for each sampling date and season to evaluate the significance of differences for incidence and severity values with Duncan's New Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Symptoms of brown blotch disease were seen on cowpea in the monocrop and intercrop 35 DAP, about two weeks before the cowpea started flowering. These were initially tiny local-

ized tan lesions. They later became enlarged and merged together forming reddish, later brown, discolouration on all the aerial parts including petioles, leaves, and flower stalks from where pods were infected. These observations were similar with those previously described (Andrus and Moore, 1935; Emechebe, 1981).

Influence of cropping pattern on incidence and severity

In the first season, the number of cowpea plants infected (incidence) by brown blotch in the intercrop was significantly lower than that observed in the monocrop during the various sampling times (Table 1). A similar trend was observed in the other seasons except at 40 DAP, and at 54 DAP in the third season when values obtained on sole cowpea were statistically identical with those obtained on intercropped cowpea. At 68 DAP, there were reductions in the incidence of brown blotch on cowpea intercropped with maize of 62.7, 65.2, and 31.9% in the first, second, and third seasons, respectively, compared to the cowpea plants in the monocrop.

The effect of cropping pattern on the severity of brown blotch was not significant at 40 DAP during the three seasons (Table 1). This shows that at the onset of visible expression of symptoms, cowpea in both systems was equally infected by the disease, probably because of inocula which were carried over in the seeds from the previous seasons. It has been reported that the disease is seed-borne (Emechebe, 1981). However, further infection could be aided by rain-splashing and plant-to-plant contact (Westcotts, 1979). As secondary inocula were produced later in the cropping season, it is possible that rain-splashing and the proximity of neighbouring plants enhanced host infection more in the monocrop than in the intercrop stands later in the season. At 68 DAP, the disease was less severe in intercrop than in monocrop plots; with reductions of 65.9, 41.4, and 69.4% at 68 DAP during the first, second, and third seasons, respectively.

The effect of spacing on incidence and severity

Generally, the effect of inter-row spacing was significant on both incidence and severity of brown blotch on cowpea at all sampling periods except at 40 DAP in the first season when there was no significant effect on severity (Table 2). The disease was least prevalent and least severe on plants spaced at 100-cm rows apart, whereas it occurred most and became most severe on those spaced 50 cm between rows, especially at 68 DAP. This indicates that the probability of cowpea becoming infected and the disease being more severe increased as the spacing decreased.

Similar observations were made with respect to the effect of intra-row spacing on brown blotch of cowpea. Cowpea planted 10 cm apart within rows showed the highest values of incidence while those spaced at 40 cm showed the lowest, irrespective of the stage of the crop's growth and the seasons (Table 3). It has

Table 1 Mean per cent values for incidence and severity of *Colletotrichum* brown blotch of cowpea by two cropping patterns during the three seasons[1] across 1987–88 and 1988–89 cropping years

Cropping pattern	Incidence (%)			Severity (%)		
	40 DAP	54 DAP	68 DAP	40 DAP	54 DAP	68 DAP
First season						
Intercrop	24.5 ac	36.5 a	47.2 a	7.8 a	31.5 a	42.5 a
Monocrop	30.8 b	69.4 b	76.8 b	38.7 a	62.5 a	70.5 a
Second season						
Intercrop	38.9 a	37.9 a	55.8 a	13.8 a	23.9 a	48.6 a
Monocrop	44.7 a	61.7 b	92.2 b	14.1 a	77.0 b	83.7 b
Third season						
Intercrop	18.1 a	35.8 a	45.8 a	18.7 a	34.8 a	46.7 a
Monocrop	20.5 a	59.1 a	60.4 b	30.0 a	57.8 a	60.5 b

[1]Three seasons in 1987–88: first season, April–July 1987; second season, August–November 1987; and third season, December 1987 – March 1988
DAP, days after planting
Means followed by different letter(s) within a column for each season differ at $P \leq 0.05$ (Duncan's Multiple Range Test)

Table 2 Mean per cent values for incidence and severity of *Colletotrichum* brown blotch of inter-row spacing during the three seasons[1] across 1987–88 and 1988–89 cropping years

Inter-row spacing (cm)	Incidence (%)			Severity (%)		
	40 DAP	54 DAP	68 DAP	40 DAP	54 DAP	68 DAP
First season						
100	18.0 a	33.1 a	44.1a	13.5 a	21.2 a	42.5 a
75	19.4 a	43.1 b	55.7b	15.2 a	36.9 b	51.8 b
50	21.5 b	52.6 c	72.2c	18.3 a	58.2 b	77.6 c
Second season						
100	17.2 a	23.2 a	35.9 a	16.1 a	25.4 a	26.6 a
75	24.2 b	45.1 b	53.5 b	20.1 b	60.2 b	44.3 b
50	30.0 c	56.1 c	83.3 c	21.9 b	63.4 b	86.0 c
Third season						
100	13.9 a	27.5 a	40.6 a	6.6 a	9.0 a	13.0 a
75	20.3 ab	37.2 b	45.9 b	8.5 ab	12.5 b	26.5 b
50	23.7 b	47.7 c	67.7 c	9.6 b	24.6 b	42.0 c

[1]Three seasons in 1987–88: first season, April–July 1987; second season, August–November 1987; and third season, December 1987 – March 1988
DAP, days after planting
Means followed by different letter(s) within a column for each season differ at $P \leq 0.05$ (Duncan's Multiple Range Test)

Table 3 Mean per cent values for incidence and severity of *Colletotrichum* brown blotch by intra-row spacing during the three seasons[1] across 1987–88 and 1988–89 cropping years

Intra-row spacing (cm)	Incidence (%)			Severity (%)		
	40 DAP	54 DAP	68 DAP	40 DAP	54 DAP	68 DAP
First season						
40	17.5 a	33.6 a	37.5 a	12.4a	18.8 a	32.8 a
30	18.3 a	36.0 a	45.1 b	14.1a	25.2 b	51.9 b
20	21.4 b	49.3 b	63.9 c	14.6a	27.2 bc	55.6 b
10	21.3 b	52.9 c	69.1 d	14.7a	30.4 c	62.3 c
Second season						
40	17.5 a	21.3 a	28.3 a	13.9 a	24.5 a	26.5 a
30	19.0 a	33.2 b	37.4 b	19.9 b	34.5 b	36.8 b
20	26.4 b	41.7 c	49.6 c	21.8 b	40.0 c	42.5 c
10	32.2 c	43.2 c	60.6 d	21.8 b	46.2 d	48.6 d
Third season						
40	16.9 a	35.0 ab	38.6 a	6.2 a	7.7 a	10.7 a
30	17.9 a	32.9 a	47.1 b	9.0 ab	12.1 b	16.1 b
20	21.0 a	39.4 bc	51.3 bc	8.0 b	13.2 bc	18.7 bc
10	9.8 b	14.9 c	21.3 a	20.7 c	42.5 c	55.4 c

[1]Three seasons in 1987–88: first season, April–July 1987; second season, August–November 1987; and third season, December 1987 – March 1988
DAP, days after planting
Means followed by different letter(s) within a column for each season differ at $P \leq 0.05$ (Duncan's Multiple Range Test)

Table 4 Effect of cropping pattern × intra-row spacing interaction on the percentage incidence of brown blotch on cowpea at 54 and 68 DAP in the first growing season

Intra-row spacing (cm)	Cropping pattern					
	54 DAP			68 DAP		
	Mono-crop	Inter-crop	Differ-ence	Mono-crop	Inter-crop	Differ-ence
40	36.1 a	31.1 a	5.0 ns	41.9 a	33.1 a	8.8 ns
30	45.6 b	26.4 a	19.2**	52.8 b	37.5 a	15.3**
20	60.3 b	38.3 b	22.0**	74.4 c	53.3 b	21.1**
10	65.8 c	50.0 c	15.8*	80.9 c	63.0 c	17.9*

DAP, days after planting
Mean separation in a column at $P \leq 0.05$ (Duncan's Multiple Range Test)
ns, Not significant; *, significant at $P \leq 0.05$; **, highly significant at $P \leq 0.01$

Table 5 Effect of cropping pattern × spacing interaction on the severity of brown blotch at 68 DAP in the second seasons

Spacing (cm)	Cropping patterns		Difference
	Monocrop	Intercrop	
Inter-row			
100	32.8 a	4.2 a	28.6**
75	41.3 b	8.8 a	32.5**
50	50.9 c	11.7 b	39.2**
Intra-row			
40	28.1 a	2.9 ab	25.2**
30	33.2 a	2.3 a	30.9**
20	47.8 b	9.6 c	38.2**
10	57.7 c	18.1 d	39.6**

DAP, days after planting
Only means followed by different letter(s) within a column for each factor differ significantly at $P \leq 0.05$ (Duncan's Multiple Range Test)
**, Highly significantly at $P \leq 0.01$ (Duncan's Multiple Range Test)

been suggested that requisite factors for infection of cowpea by *Colletotrichum* species include humidity, moderate temperature, and heavy dew (Schwartz and Steadman, 1978). Schwartz and Steadman demonstrated that dense foliage favoured reduced air circulation, promoted higher humidity, prolonged dew periods, and allowed cooler soil-surface temperatures. Thus, closer plant spacing could enhance the incidence of brown blotch on cowpea, and open canopies resulting from wide spacing could inhibit plant-to-plant spread of the disease and colonization of the host crop by the disease. Although the effect of intra-row spacing was not significant on severity at 40 DAP in the first and third seasons, there was generally a significant increase in the level of severity at other sampling periods in the seasons as the distance between plant stands within a row was decreased.

Interaction effects on incidence and severity

Only the effects of inter-row spacing × cropping pattern and intra-row spacing × cropping pattern were significant on the incidence of brown blotch at 54 and 68 DAP, and on severity only at 68 DAP in the second season (Tables 4 and 5). The three-way interaction of cropping pattern and inter-row and intra-row spacing was not significant on either incidence or severity. At 40-cm intra-row spacing, there was no significant reduction in disease incidence on cowpea in mono- and inter-crop patterns. At other spacings, significant reductions occurred on intercropped cowpea compared to monocropped cowpea (Table 4). In the intercropped stands, there was no significant reduction in the incidence of brown blotch on cowpea planted at 30 and 40 cm within rows.

Severity consistently increased with decreasing levels of inter-row spacing of cowpea in the monocrop but not in the intercrop (Table 5). In both systems, severity was statistically identical with cowpea spaced 30 and 40 cm apart in the row, whereas there was an increase in severity on cowpea spaced 20 and 10 cm and also between 30 and 20 cm within rows.

Therefore, at closer spacings, there was an increase in the number (incidence) and plant area (severity) of cowpea plants infected in monothan in inter-crop stands. Reasons for this could be attributed to infection which could occur more readily among cowpea plants in a monocropped system than among those in the intercrop. Intercropping of cowpea with maize provided wider spacing among the host crop. At these spacings, the distance between adjacent plants could reduce the probability of successful spread. Thus, the wider the distance between the cowpea plants, the less likely the chances of new plants being infected (Chilvers and Brittain, 1972).

Influence of cropping pattern and spacing on seed yield

During the seasons, higher seed yields were obtained from cowpea in the monocrop plots than from the intercrop plots (Table 6). Lowest seed yields were produced by cowpea plants spaced 100 cm apart while the highest yields were produced by those spaced 50 cm apart. Also, lowest yields were obtained from the plants grown less closely together within the rows than those grown more closely spaced in the rows. However, seeds produced from intercropped cowpea were of better quality than those from monocropped cowpea. This therefore indicates that more seeds from the latter group were badly infected by brown blotch. Equally, seeds produced by plants closely spaced together were of poorer quality, most being disfigured and discoloured and rendered unmarketable and unsuitable for consumption. These results corroborate those from a similar experiment conducted on anthracnose of cowpea caused by *C. lindemuthianum* (Adebitan and Ikotun, 1996). As earlier suggested, the observation made could be attributable to lower disease incidence and severity on the intercropped cowpea and on cowpea less closely spaced together than it was, on the contrary, to the individual different cases (Adebitan and Ikotun, 1996).

Table 6 Seed yield of cowpea infected by brown blotch under different cropping patterns and inter-row and intra-row spacings during three seasons[1] from 1987 to 1989

Treatments	Seed yield[2] (kg ha^{-1})			
	First season	Second season	Third season	Mean
Cropping pattern				
Intercrop	397.3 a	441.2 a	302.6 a	380.4 a
Monocrop	633.8 b	673.9 b	471.3 b	593.0 b
Inter-row spacing (cm)				
100	490.1 a	532.9 a	306.9 a	433.3 a
75	524.9 b	560.9 b	419.0 b	501.6 b
50	531.6 b	578.9 c	445.2 b	525.2 c
Intra-row spacing (cm)				
40	498.3 a	526.6 a	344.9 a	456.6 a
30	501.2 a	559.8 b	381.8 ab	480.9 b
20	527.8 b	562.6 bc	389.8 bc	493.4 c
10	534.9 b	581.2 c	31.3 c	515.8 d

[1]First season, April–July; second season, August–November; and Third season, December–March
[2]Average of three replications
Means followed by different letter(s) within a column for each season differ at $P \leq 0.05$ (Duncan's Multiple Range Test)

Conclusion

Brown blotch establishment on cowpea is more enhanced in the monocrop than in the cowpea–maize intercrop. Closely spaced cowpea plants appeared to favour disease spread. Intercropped cowpea produced fewer but better quality seeds than monocropped cowpea. Also, fewer but better quality seeds were obtained from cowpea widely spaced together than from those which were closely planted. Thus, wide spacing should be allowed among the stands of monocrop cowpea or it should be intercropped with maize to reduce the incidence and severity of brown blotch disease on cowpea.

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