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Yield depression in cowpea cultivars infected with *Xanthomonas campestris* pv. *vignicola* in Sudan savanna of Nigeria

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ABSTRACT

Two field trials were conducted in the Sudan savanna site of IITA Experimental Station, Minjibir, Kano State, Nigeria to assess the effect of bacterial blight on pod, grain and fodder yield of two cowpea varieties artificially inoculated with *Xanthomonas campestris* pv. *vignicola*. One hundred percent disease incidence was recorded in inoculated plants both in 1996 and 1997. High disease severity scores of 59 and 56 were recorded in inoculated IT82D-889, and 67 and 63 for inoculated IAR-48, in 1996 and 1997 respectively. In the 1996 trial, IAR-48 had depressions of 42%, 43% and 34% in pod, seed and fodder yields respectively. In the same year, pod, seed and fodder yields of IT82D-889 were depressed by 67%, 64% and 29%, respectively. In 1997, pod, seed and fodder yields of IAR-48 were depressed by 46%, 45% and 34%, respectively while in IT82D-889, higher depressions of 71.0%, 68.0% and 53.0% were recorded.

Key words: Bacterial blight, cowpea, disease severity, *Vigna unguiculata*, *Xanthomonas campestris*, yield

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.) is an important crop grown mainly in the savanna zones in the tropics and subtropics. It is grown for its grains, green pods and leaves and is also used for forage in Nigeria (Oyekan 1977). Cowpea contains about 24% protein, 62% soluble carbohydrates and small amounts of other nutrients (Elias *et al.* 1964). World cowpea production in 1994 was estimated at 3.53 million metric tonnes of which 1.75 million metric tonnes was produced in Nigeria (FAO 1994 as cited by Adejumo 1997). Unfortunately, in Africa, most of the cowpea is produced under small scale subsistence agriculture where low grain yield of about 88 kg ha^{-1} may be the maximum obtained in the lowland tropics of west Africa (Summerfield *et al.* 1985).

Cowpea production is severely constrained by a large number of pests and diseases (Singh and Allen 1979; Emechebe and Shoyinka 1985). There are about 12 major diseases of cowpea, of which one is bacterial blight caused by *Xanthomonas campestris* pv. *vignicola* (Patel 1981). The symptoms of bacterial blight of cowpea do not vary although the description may sound a little different from different authors (Preston 1949; Patel and Jindal 1970; Williams 1975; Emechebe and Shoyinka 1985; Saettler 1991). Preston (1949) described three types of symptoms: blight, pod symptoms and canker. In the blight phase, water-soaked spots appear on the cotyledon and primary leaves of young seedlings. They begin to turn reddish brown after a few days and then to light yellow-brown as the infected parts dry out. The spots range from the size of a pinpoint to nearly half an inch (1.25 cm) in diameter. Spots can enlarge and cover more of the surface of the older leaves. Severely blighted leaves usually drop from the plant. In pod phase, spots appear on pods raised or swollen, reddish-brown and distorted. Symptoms may be masked on pods with dark colouration. In severe cases there is poor pod development, most of the seeds are shriveled and will not germinate. In the canker phase, reddish-brown swollen cankers or elongated cracks appear anywhere from the ground line to the top of the plant. It is very common for severely cankered stems to break just above the crown. Stem cankers are usually found on older plants, but may be present on stems of younger plants as well in which case the plants seldom reach maturity.

Ekpo (1978) reported yield depressions of 26.4% and 18.1% in "Ife Brown" and 23.6% and 19.2% in "New Era" in 1975 and 1976 respectively. Complete defoliation of susceptible plants can result under heavy epiphytotics of bacterial blight (Emechebe and Shoyinka 1985). The yield loss estimate of Ekpo (1978) is about the only detailed report of yield depression in literature. However, this experiment was performed in a rain forest region and not in the savanna where the disease is endemic.

The objective of this study therefore was to estimate depressions caused by bacterial blight in seed yield, pod yield and fodder yield in cowpea grown in the Sudan savanna of Nigeria.

MATERIALS AND METHODS

Experimental site, land preparation and experimental design

Two field experiments were conducted at the IITA experimental research station in Minjibir, Kano State of Nigeria, in 1996 and 1997 cropping seasons. Kano is in the Sudan savanna, on longitude 08° 31' E, latitude 12° 03' N and an altitude of 1500m (Kowal and Knabe 1972). The soil texture is generally sandy, dominated by a fine sand subfraction. Clay content in most of the surface horizons and some subsoils is generally low. The amounts of organic carbon, total nitrogen and available phosphorus are low (IAR 1980).

The experiment was set up in a randomized complete block design with three replications. The treatments were: inoculation with sterile distilled water (control) and inoculation with bacterial inoculum at concentration 10^6 colony forming units ml^{-1} ($CFUml^{-1}$). Cultivars IAR 48 and IT 82D-889 were selected for the study because they are released lines commonly grown by farmers in Kano.

Land preparation involved ploughing, disc harrowing and ridging followed by basal fertilizer application of N:P:K 15:15:15 at 200 kg ha^{-1}. The total field area was 224 m^2. The field was divided into 12 plots of 6m^2 separated from one another by 1 m alley. Each plot was 2 m long and consisted of 4 rows spaced 75 cm apart. Seeds were planted on 24 July for the 1996 season and on 15 July for the 1997 season. Two weeks prior to these dates, alleys surrounding plots that would contain bacteria-inoculated plants were sown with 2 rows of a disease spreader variety IT 84S-2246-4, susceptible to bacterial blight. Alleys around plots that would contain controls had no disease spreader line but two rows of millet. The millet prevented inter-plot interference. The spreader line was artificially inoculated with bacterial inoculum two weeks after emergence to guarantee high disease pressure in test plots. Seeds of test lines were sown by hand (three per hill), about 2.5 cm deep at in-row spacings of 20 cm. A mixture of pre-emergence herbicides (Gramoxone® + Galex®) was applied immediately after planting at a concentration of 100 ml herbicide/20 litres water. Subsequent weed control was carried out manually at 3 and 6 weeks after plant emergence. A week after emergence, seedlings were thinned to two per hill, leaving 20 plants per row.

Inoculation of plants

Test seedlings were artificially inoculated 14 days after emergence, by spraying the abaxial surface of two youngest fully expanded trifoliate leaves (4-leaf-stage) until water-soaked spots were obtained using a hand operated sprayer (Hills Master spray, Hills industries Ltd., Pontygwindy Industrial Estate, Caerphilly, Mid Glamorgan, U.K.). Bacterial inoculum was prepared from 24-hr nutrient agar culture plates. The bacteria were washed off the cultures with sterile normal saline (0.85 g of NaCl in 1 litre of sterile distilled water) into a conical flask and were diluted to approximately 10^6 $CFUml^{-1}$. The prepared inoculum was stored in a 600-ml conical flask in the refrigerator immediately after preparation and later transferred to the field in ice-cooled containers to inhibit proliferation of bacterial cells prior to inoculation of plants. Inoculation was done within 35 minutes of calibration of the inoculum. Control plants were sprayed with sterile distilled water. Insect damage was controlled by spraying plants with Sherpa plus® (an insecticide) at a concentration of 80 ml of insecticide/20 litres of water (two sprays after flowering at 2-weeks interval). In addition, control plants were sprayed with Macuprax, a copper-based bactericide, (2 gl^{-1} of sterile distilled water) at 8, 15 and 22 days after seedling emergence.

Disease assessment

Disease assessment was carried out in the two middle rows of each plot. This area consisted of 20 plant stations (40 plants). Disease assessment was a visual rating which started from the time of first appearance of disease symptoms until mid stage of development. Severity per plot was assessed by selecting four leaves per station at random and visually estimating the area of bacterial necrosis on them using a 0-75 scale, where 0 = no symptom on leaf; 5 = >0 to 5% of leaf area blighted; 25 = 6 to 25% of leaf area blighted; 50 = 26 to 50% of leaf area blighted; and 75 = 51 to 100% of leaf area blighted. The final score was the mean of the four leaves scored per 20 plant hills. Disease incidence per plot was obtained by calculating the proportion of hills in the assessment area in a plot that were infected to the total number of hills present.

Yield analysis

At maturity all pods were manually harvested from the two centre rows of each plot. The harvested pods were put into cloth bags and left to sun-dry for 5 days. These pods were manually threshed after the weight and number of pods per plot were obtained. The seed weight of each plot was obtained by weighing all the

seeds obtained from pods within the two middle rows of each plot. Fodder in the two middle rows per plot were rolled into a bundle and weighed to obtain the fodder weight per plot. Yield depression was calculated by dividing the difference in yield values between control and infected plots by the yield value from control plot and multiplying the quotient by 100. To verify if there was any genetic difference in the yield potential of the two varieties used in the experiment, equivalent yield was calculated as a ratio of mean yield of inoculated plants to mean yield of control plants multiplied by 100 (Fisher *et al.* 1976 as cited by Ekpo 1978).

Statistical analysis

Data obtained from experiments were analysed using SAS (1996) statistical package, version 6.12. Analysis of variance (ANOVA) was used to test hypothesis that there was no difference in yields of cowpea infected with bacterial blight and uninfected cowpea. Means separation was by least significant difference test (LSD).

RESULTS AND DISCUSSION

In 1996 and 1997 foliar symptoms of bacterial blight first occurred as water-soaked spots 11 and 8 days, respectively, after inoculation and generally increased in severity with time. All plants in inoculated plots developed blight symptoms (100% disease incidence) in both years (Table 1). The disease incidence in uninoculated control plots was generally, significantly ($P \leq 0.05$) lower than that of inoculated plots in both years (Table 1). The disease severity scores in inoculated plots were significantly ($P \leq 0.05$) higher than corresponding scores recorded for uninoculated plots of both varieties. For variety IT82D-889, the disease severity scores in inoculated plots were 58.7% and 56.0% compared to 19.0% and 19.0% in control plots in 1996 and 1997, respectively. In variety IAR-48, the severity scores were 67.0% and 63.0% in inoculated plots while scores in uninoculated plots were 25.0% and 29.3%, in 1996 and 1997 respectively (Table 1). Rather high disease incidence and severity recorded in the control plots indicates either (i) a high level of seed-borne bacterial inoculum in the seed lot used for planting; (ii) poor insecticidal control of insect pests that resulted in intra- and inter-plot spread of the disease; (iii) ineffectiveness of Macuprax as a bactericide; (iv) all of the above possibilities.

The calculated equivalent yields for pod, seed and fodder of IT82D-889 were not significantly ($P \leq 0.05$) different from those of IAR-48 in

Table 1. Disease incidence and severity for bacterial blight inoculated plants and control plants for two cowpea varieties in 1996 and 1997.

	1996				1997			
	Incidence		Severity		Incidence		Severity	
Variety	Control	Inoculated	Control	Inoculated	Control	Inoculated	Control	Inoculated
IT82D-889	96.7	100.0^{ns}	19.0	58.7*	56.0	100.0*	19.0	56.0*
IAR-48	73.3	100.0*	25.0	67.0*	83.3	100.0*	29.3	63.0*

LSD for incidence 8.96
LSD for severity 19.87

*Significant at $P \leq 0.05$; ^{ns} Not significant at $P \leq 0.05$.

corresponding yield components (Table 2). The similarity in equivalent yields supports the observed comparable disease responses recorded for both varieties under natural infection in control plots and under artificial infection in inoculated plots (Table 1). The results indicate that the two cowpea varieties are similar in their yield potential under the same bacterial disease pressure and agronomic practices.

There was a significant ($P \leq 0.05$) difference in pod and seed yields of infected and control plants of both varieties in 1996 and 1997. However, there was no significant difference ($P \leq 0.05$) between the fodder yields of infected and control plants except for variety IT82D-889 in 1997 (Table 3).

Table 2. Equivalent yields for two cowpea varieties infected with bacterial blight.

	1996			1997		
Variety	Pod	Seed	Fodder	Pod	Seed	Fodder
IT82D-889	38.0	39.8	80.7	33.6	36.1	59.5
IAR-48	57.9	56.5	65.9	54.2	55.0	66.4
LSD	23.6	23.7	41.6	23.6	23.7	41.6

Table 3. Effect of bacterial blight on yield (kilogram per hectare) of cowpea in 1996 and 1997 in the sudan savanna of Nigeria.

		1996			1997		
Yield component	Variety	Control	Inoculated	Depression (%)	Control	Inoculated	Depression(%)
Pod	IT82D-889	925.0	307.1	66.8*	1183.3	344.8	70.8*
	IAR-48	930.8	539.0	42.0*	948.7	514.0	45.8*
	LSD for mean yield 344.6						
Seed	IT82D-889	689.8	251.5	63.54*	872.8	282.8	67.6*
	IAR-48	669.7	380.3	43.2*	679.8	374.8	44.86*
	LSD for mean yield 214.3						
Fodder	IT82D-889	877.0	619.6	29.4^{ns}	1337.4	624.6	53.3*
	IAR-48	1040.9	685.3	34.2^{ns}	1047.3	694.1	33.7^{ns}
	LSD for mean yield 469.79						

*Significant at $P \leq 0.05$; ^{ns}Not significant at $P \leq 0.05$.

In general, yield depressions from inoculated plots were higher in 1997 than 1996. In 1996 trial, artificial inoculation with blight pathogen resulted in depressions of 42.0%, 43.2% and 34.2% in pod, seed and fodder yields of IAR-48 respectively. In the same year depressions of 66.8%, 63.5% and 29.4% were recorded for pod, seed and fodder yields of IT82D-889, respectively. In 1997 trial bacterial blight caused depressions of 45.8%, 44.9% and 33.7% in pod, seed and fodder yields of IAR-48, respectively. In IT82D-889 yield depressions of 70.8%, 67.6% and 53.3% were recorded for pod, seed and fodder respectively (Table 3).

Overall there were no significant differences

($P \leq 0.05$) between yield values obtained in 1996 and those obtained in 1997 for comparable treatments within and between varieties.

The implication of the results obtained in this work is that bacterial blight is a serious threat in cowpea production, particularly if the cowpea lines or varieties cropped are not resistant to the disease. An appreciable loss in yield will occur any time a susceptible variety is grown in an infested site. The yield loss reported herein confirms the reports of Allen *et al.* (1981), and Kishun *et al.* (1980) who stated that grain yield loss due to bacterial blight may exceed the 18-26% yield loss as reported by Ekpo (1978). The loss in foliage due to bacterial blight seriously affects farmers in northern Nigeria who need these leaves as fodder. The higher yield depression found in 1997 though not significantly different from that of 1996 indicates the potential for inoculum build-up and increased disease severity as a result of successive cropping of susceptible varieties at the same site.

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