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COWPEA YIELD GAIN FROM RESISTANCE TO *STRIGA GESNERIOIDES* PARASITISM IN SOUTHERN BÉNIN

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SUMMARY

Striga gesnerioides is a serious parasite of cowpea (*Vigna unguiculata*) on the Abomey plateau of southern Bénin. *S. gesnerioides* in southern Bénin has been characterized as a race that is different from those found in the dry savanna of West Africa. IITA breeding line IT93KZ-4-5-6-1-5 was used in a trial to study fertilizer response of cowpea on two farmers' fields in 1998. No emerged *S. gesnerioides* plants were observed on this breeding line while heavy parasite loads were observed on local cultivars growing in adjacent fields. In 1999, IT93KZ-4-5-6-1-5 was grown again on seven fields and no emerged *S. gesnerioides* plants were observed. In 2000 the same line was grown on 18 farmers' fields with local cowpea cultivars in adjacent control plots. The mean number of *S. gesnerioides* plants on the local cultivars was 0.92 per cowpea plant (*s.d*. 0.72) while the improved line carried none. The mean yield gain from the improved cowpea line was 156 % and varied from 20 to 680 kg pods ha^{-1}. Thus it appears that progress has been made in developing cowpea lines that are resistant to *S. gesnerioides* and the potential impact of adoption of resistant cowpea is high.

INTRODUCTION

Striga gesnerioides [Willd.] Vatke is a parasite of cowpea (*Vigna unguiculata*), usually found in West Africa in the dry savanna zone, which has one rainy season lasting less than five months. In a survey of *S. gesnerioides* in West Africa, Cardwell and Lane (1995) found an incidence of more than 60 % in seven out of 153 sites. One of those sites was on the Abomey plateau of southern Bénin. This report and that of Agbobli (1991) are the only ones that place *S. gesnerioides* far south of where it is usually found in West Africa.

The race of *S. gesnerioides*, found initially at Za'Kpota in southern Bénin, is thought to be a different one from that found in much of West Africa. Lane *et al*. (1994) found it to be virulent on the cowpea cultivar B301 from Botswana, which was resistant to most West African *S. gesnerioides* races. They found that 58-57, a local line from Senegal, and IT81D-994 were resistant to the Za'Kpota race of *S. gesnerioides*.

The International Institute of Tropical Agriculture developed *Striga gesnerioides*-resistant lines. Various sources of resistance were crossed and screened at Kano (Nigeria) and Za'Kpota. One parent was IT90K-76, which is derived from a backcross,

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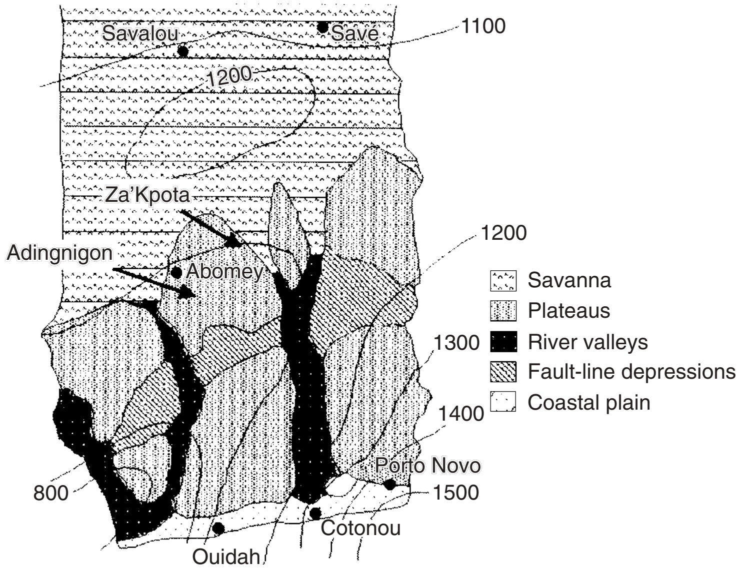

Figure 1. Location of Adingnigon on the Abomey plateau dominated by 'terre de barre' soils, a major physiographic unit of southern Bénin. Source: base map of physiographic units and annual rainfall in derived/coastal savanna benchmark area (Raunet, 1977).

(B301 × IT84S-2246-2) × IT84S-2246-4. It has the gene for *S. gesnerioides* resistance from B301 (landrace from Botswana), which confers resistance to four *S. gesnerioides* strains (Burkina Faso, Mali, Nigeria/Niger, and Cameroon) but is susceptible to the Za'Kpota, Bénin strain. The other parent was 58-57, which is resistant to three strains (Burkina Faso, Za'Kpota, and Cameroon) but susceptible to the Mali and Nigeria/Niger strains. IT93KZ-4-5-6-1-5 is a true-breeding progeny derived from the cross involving IT90K-76 and 58-57 and selected during several seasons at Kano and Za'Kpota. Thus, IT93KZ-4-5-6-1-5 has the combined resistance to all the five strains of *S. gesnerioides*. It is also resistant to viruses and other major diseases.

Though the new cowpea lines with resistance to *S. gesnerioides* had not yet been released in southern Bénin, permission was granted for their use in studies of soil amendments for cowpea. An additional objective of the activity, therefore, was to confirm their resistance in infested farmers' fields. When it became apparent that IT93KZ-4-5-6-1-5 was indeed resistant, a trial was designed with the twin objectives of confirming the resistance of the improved cowpea line against *S. gesnerioides* and estimating the yield increase from using the new variety.

MATERIALS AND METHODS

The trials were conducted at Adingnigon (lat. 7°08′N; long. 02°02′E; 150 m asl), which is approximately 25 km from Za′Kpota (lat. 7°14′N; long. 2°13′E; 150 m asl) on the Abomey plateau (Figure 1). The soils are classified as Nitosols (FAO/UNESCO, 1990) or *sols ferralytiques moyennement désaturés appauvris* (Raunet, 1977).

S. gesnerioides-resistant cowpea lines provided by the International Institute of Tropical Agriculture (IITA) were (i) IT93KZ-4-5-6-1-5 with reddish-brown seed colour, semi-erect plant type, and 75 to 80 days to maturity; and (ii) IT93KZ-8-21-23-6-35 with similar characteristics except for tan seed colour. In 1998, cowpea was grown on plots of 200 m^2 for soil fertility trials. Seed availability allowed two replications of IT93KZ-4-5-6-1-5 and five replications of IT93KZ-8-21-23-6-35. Cowpea density was similar in researcher-managed to that in nearby farmers' fields with 0.7 to 0.75 m between rows, 0.34 to 0.42 m between planting hills, and two to three plants per hill.

At 60 to 70 days after planting, all cowpea and emerged *S. gesnerioides* plants were counted in each plot. The entire plot was counted regardless of soil fertility amendments because almost no *S. gesnerioides* plants were observed. If *S. gesnerioides* plants were found in one of the breeding line plots, then the plant was tagged and the seedpod was opened to observe size and colour of the seed. *S. gesnerioides* plants were also counted in two sections of three linear meters each, as close as possible to the trials. In all cases this was done within five meters of the trial blocks.

In 1999, seven replications of IT93KZ-4-5-6-1-5 cowpea were grown with local cultivars in close proximity. The cowpea and *S. gesnerioides* were counted as before in the IT93KZ-4-5-6-1-5 plots. Counts of local cowpea and *S. gesnerioides* plants were made on 20 randomly selected hills in close proximity to the IT93KZ-4-5-6-1-5 plots.

In 2000, 18 farmers each planted one replication of a new trial. Plot size was approximately 400 m^2 and distance between the rows was approximately 0.75 m. Collaborating farmers chose the local cultivars and at least three different ones were used. Seed of IT93KZ-4-5-6-1-5 was sown for comparison. Rainfall started relatively late in the growing season but it was nevertheless sufficient for a crop of cowpea. Planting was done between 29 April and 17 May, 2000 after clearing the vegetation of the dry-season fallow. Further weeding was done approximately two to three weeks after planting. A recommended insecticide regime of three sprays of Primex at 0.6 l ha^{-1}, was followed. Despite this, insect damage was observed. Fertilizer was applied at 9 kg P ha^{-1} as triple super phosphate.

The emerged *S. gesnerioides* and cowpea plants were counted between 29 June and 10 August 2000 (between 43 and 90 days after planting cowpea) in all fields. To minimize the effect of potential gradients in the *S. gesnerioides* seed bank at field level, counts were made in the borders of the local and IT93KZ-4-5-6-1-5 cowpea plots nearest to each other. The first border row on the side of the IT93KZ-4-5-6-1-5 was not counted. This was to avoid the risk of counting emerged *S. gesnerioides* plants in the plot of IT93KZ-4-5-6-1-5 that may have been germinated by the roots of a local cultivar one row away. All cowpea plants, cowpea hills, and *Striga* plants (alive and dead) were counted in three rows of approximately 20-m length. At maturity, cowpea pods were collected from each plot in a quadrat measuring between 46 and 90 m^2, and weighed.

In 1998 and 1999, the number of emerged *S. gesnerioides* plants was divided by the number of cowpea hills planted. Means and standard deviation were calculated. In 2000, the number of emerged *S. gesnerioides* plants was divided by the number of cowpea hills, and these data were subjected to ANOVA as were the fresh pod yields.

Table 1. Density of *S. gesnerioides* on cowpea in soil fertility trials and nearby fields of local cowpea at Adingnigon (Abomey plateau) in 1998 and 1999.

Year	Variety	n	Sg/cowpea	*s.d.*
1998	IT93KZ-4-5-6-1-5	2	0.000	–
	IT93KZ-8-21-23-6-35	5	0.003	0.005
	Local cultivars	7	4.72	2.91
1999	IT93KZ-4-5-6-1-5	7	0.000	–
	Local cultivars	7	5.69	7.25

n = number of fields observed.
Sg/cowpea = number of *Striga gesnerioides* plants per cowpea planting hill.
s.d. = standard deviation.

Table 2. Mean number of *S. gesnerioides* plants per cowpea hill and cowpea pod yield (kg ha^{-1}) on 18 farmers' fields at Adingnigon, 2000.

Cowpea	Sg/cowpea	Pod yield	Cowpea density (plants ha^{-1})
IT93KZ-4-5-6-1-5	0.002	297	77 300
Local cultivars†	2.24	116	64 600
s.e.d.	0.473	59.3	7030

s.e.d. = standard error of the difference between means.
† Local cultivars included Kpeyikoun, Gboto and Gbogboe.

RESULTS

In 1998, emerged *S. gesnerioides* plants were not observed on IT93KZ-4-5-6-1-5 while a small number were observed on IT93KZ-8-21-23-6-35. On nearby farmers' plots, the mean emerged *S. gesnerioides* density was 4.7 per cowpea hill (Table 1). The farmers were in favour of continuing trials with IT93KZ-4-5-6-1-5 so this line was used on all fields in 1999. No *S. gesnerioides* plants were observed on IT93KZ-4-5-6-1-5 in 1999 while an average of 5.7 *S. gesnerioides* plants per cowpea hill were observed on the local cultivars (Table 1).

In 2000, virtually no emerged *S. gesnerioides* plants were visible on the IT93KZ-4-5-6-1-5 while there were 2.2 *S. gesnerioides* plants per cowpea hill (Table 2). Variability in the incidence of *S. gesnerioides* plants on local cowpea was high, ranging from 0 to 8.1 per hill. The density of *S. gesnerioides* plants was not related to any of the several local cultivars used. Nor was *S. gesnerioides* density related to the age of the cowpea at the time of counting although age of the crops varied from 43 to 90 days old.

The average yield of fresh cowpea pods was approximately 300 kg ha^{-1} for the improved line and 120 kg ha^{-1} for the local cultivars, while plant density was not significantly different (Table 2). On nine of the more-productive fields, the yield of IT93KZ-4-5-6-1-5 was approximately 449 kg ha^{-1}, whereas the mean of local varieties was 162 kg ha^{-1} (data not shown). The yield gain from using the improved line ranged from 20 to 680 kg pods ha^{-1} (Figure 2). Over all replications, the yield gain was not related to the number of emerged *Striga* plants.

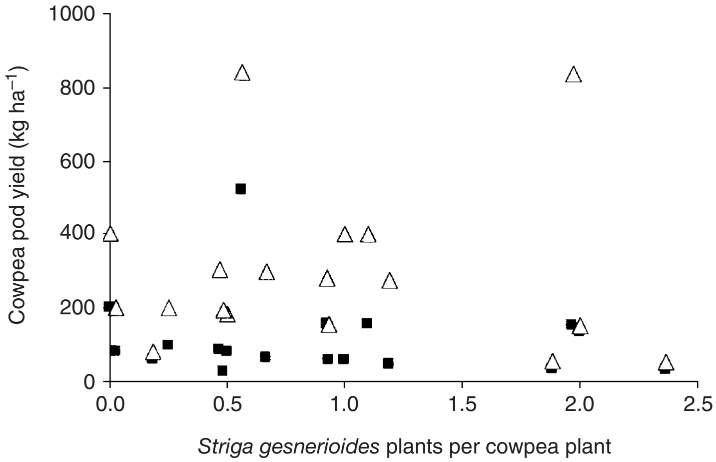

Figure 2. Pod yield of IT93KZ-4-5-6-1-5 cowpea and local cultivars on 18 fields as a function of *S. gesnerioides* density. ■ = local cultivars; Δ = IT93KZ.

DISCUSSION

That no *Striga* occurred on IT93KZ-4-5-6-1-5 in 1998 and 1999, provided preliminary confirmation of observations (B. B. Singh, personal communication, 1997) that some IT93KZ lines in on-station screening trials were resistant to the strain of *S. gesnerioides* found on the Abomey plateau. This led to a direct comparison of the new variety IT93KZ-4-5-6-1-5 with existing local varieties in a farmer/researcher-managed trial in 2000; resistance of the new variety was confirmed. The resistant line had been developed by crossing known sources of resistance with adapted varieties, followed by several generations of screening at Kano in northern Nigeria, and Za'Kpota on the Abomey plateau.

The practice of observing surrounding farmers' fields for comparison with experimental fields proved useful. Though the trials were set up for tests of soil fertility amendments for cowpea, this should not preclude observations on adjacent farmers' plots. This experience is provided here to encourage researchers to include this kind of observation in their reports.

Striga gesnerioides parasitism of cowpea on the Abomey plateau appears to be coupled with severe soil degradation and a precarious situation of food availability. A survey of food storage facilities (Floquet and Mongbo, 1998) has shown that the village of Adingnigon, chosen as representative of the Abomey plateau, had an average of 7.9 months during which granaries were empty. In contrast, grain stores are empty for only 1.4 months in the year on the Allada plateau where *S. gesnerioides* is not found. It can be speculated that *Striga* spp. were brought to the area in seed lots imported from the dry savanna to the north. How long ago this might have occurred, is not known. A maize-trade model by van den Akker and Hauser (1999) showed substantial annual fluxes of maize grain from the north of Bénin to the Abomey plateau, and Berner *et al.* (1994) reported data suggesting that dispersal of *Striga* seed over long distances occurs through crop seeds. It is not known why the strain of *S. gesnerioides* in southern Bénin is different from that found in northern Bénin (Lane *et al*., 1977).

Currently, soil fertility on the Abomey plateau is so low that only grain legumes are viable crops. Floquet and Mongbo (1998) recorded average maize seed yields of 280 kg ha^{-1} in 1994 and 1995. The major grain legumes are groundnut (*Arachis hypogaea*) and cowpea, while indigenous grain legumes such as Kersting's groundnut (*Kerstingiella geocarpum*), Bambara groundnut (*Voandzeia subterranea*), and others are often encountered. Cowpea is a crop that generally gives moderate yields on small plots that relatively recently have been brought out of fallow. Floquet and Mongbo (1998) reported average yields of approximately 500 kg ha^{-1} on plot sizes of approximately 0.35 ha. Cowpea is a preferred grain legume in the area, but its importance appears to have decreased as a result of *S. gesnerioides* parasitism. On land that has been cropped for many years, cowpea occupies less than 10% of the cropped land area (Floquet and Mongbo, 1998). The introduction of *S. gesnerioides*-resistant cowpea may, therefore, allow cowpea to become an important enterprise again on the Abomey plateau.

A preliminary estimate of the potential impact of introducing *S. gesnerioides*-resistant cowpea on the Abomey plateau can be estimated from (i) yield increases on land where cowpea is currently grown, plus (ii) the amount of land which could be allotted to cowpea as a result of resistance to *S. gesnerioides*. This will depend on adoption rates of the new line as it is introduced on a larger scale. An additional impact from this work is that crop rotation with grain legumes such as cowpea can also contribute to soil fertility if they accumulate substantial biomass. Carsky *et al*. (2001) found that growing cowpea in the first half of the rainy season allows the N requirement for maize planted immediately after, to be reduced by 30 kg ha^{-1}.

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