Reaction of cowpea (*Vigna unguiculata*) cultivars to *Striga gesnerioides* races from Mali and Niger

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Touré, M., Olivier, A., Ntare, B. R., Lane, J. A. and St-Pierre, C.-A. 1998. **Reaction of cowpea (*Vigna unguiculata*) cultivars to *Striga gesnerioides* races from Mali and Niger**. Can. J. Plant Sci. **78**: 477–480. Field, pot and laboratory experiments were performed to evaluate the resistance of 12 cowpea (*Vigna unguiculata* [L.] Walp.) accessions to two races of the parasitic weed *Striga gesnerioides* (Willd.) Vatke (witchweed) from Cinzana, Mali and Maradi, Niger. Cultivar IT82D-849 showed resistance to either *S. gesnerioides* race in field, pot and laboratory experiments. IT81D-994 and Suvita-2 were both resistant to *S. gesnerioides* from Cinzana, but were susceptible to *S. gesnerioides* from Maradi. The occurrence of distinct varietal specificity among *S. gesnerioides* races may indicate the existence of significant interpopulation genetic divergence. These results highlight the possibility that varietal resistance could be overcome by some races of the parasitic weed, emphasizing the necessity to perform cowpea selection for resistance to various *S. gesnerioides* races.

Key words: Cowpea, parasite races, resistance, selection, *Striga gesnerioides*, varietal specificity

Touré, M., Olivier, A., Ntare, B. R., Lane, J. A. et St-Pierre, C.-A. 1998. **La réaction de cultivars de niébé (*Vigna unguiculata*) à des races de *Striga gesnerioides* du Mali et du Niger**. Can. J. Plant Sci. **78**: 477–480. Des essais au champ, en pots et en laboratoire ont été réalisés afin d'évaluer la résistance de 12 cultivars de niébé (*Vigna unguiculata* [L.] Walp.) à deux races de la mauvaise herbe parasite *Striga gesnerioides* (Willd.) Vatke provenant de Cinzana, au Mali et de Maradi, au Niger. Le cultivar IT82D-849 s'est montré résistant à chacune des races de *S. gesnerioides* dans les essais au champ, en pots et en laboratoire. IT81D-994 et Suvita-2 se sont avérés résistants au *S. gesnerioides* de Cinzana, mais sensibles au *S. gesnerioides* de Maradi. L'existence de spécificités variétales distinctes parmi les races de *S. gesnerioides* pourrait indiquer l'existence d'une divergence génétique significative entre les populations. Ces résultats indiquent qu'il est possible que certaines races de la mauvaise herbe parasite viennent à bout de la résistance variétale du niébé, ce qui souligne la nécessité de réaliser la sélection du niébé pour sa résistance aux diverses races de *S. gesnerioides*.

Mots clés: Niébé, races de parasites, résistance, sélection, *Striga gesnerioides*, spécificité variétale

Cowpea (*Vigna unguiculata* [L.] Walp.) is an important source of protein for many farmers in the semi-arid tropics of West Africa. Unfortunately, the parasitic witchweed *Striga gesnerioides* (Willd.) Vatke (Scrophulariaceae) causes considerable yield losses in this crop (Aggarwal and Ouedraogo 1989).

The extent of the damage in cowpea is related to the close interaction between the host and the parasitic weed. Germination of *S. gesnerioides* seed occurs in response to specific stimulants exuded by host roots (Muller et al. 1992). The extremity of the germinated radicle then turns into a haustorium (Okonkwo and Nwoke 1978), which attaches itself to the host root and penetrates the host vascular tissue, establishing vascular connections (Ba 1983) that allows the parasitic weed to absorb water, minerals and organic compounds which are essential for parasitic development (Graves et al. 1992).

The development of appropriate methods for the control of *S. gesnerioides* has been the focus of considerable interest. Resistant cultivars are potentially an appropriate method to control *S. gesnerioides* infestation in small-scale farmers' fields, as they require only low purchase of inputs. Breeding for resistance to *S. gesnerioides* has provided several resistant cowpea cultivars (Parker and Polniaszek 1990; Aggarwal 1991). At the same time, *S. gesnerioides* races exhibiting differential virulence on various cowpea cultivars have been identified, with most cultivars being only resistant to the races from Burkina Faso and Mali, while being susceptible to the race from Niger (Parker and Polniaszek 1990). Cultivar B301, however, showed resistance to all races. Thus, it has been widely used as a resistant genitor in breeding programmes (Singh and Emechebe 1991). Other *S. gesnerioides* races have been identified later, however (Lane et al. 1996), including a race from Benin able to attack B301 (Lane et al. 1994). This highlights the possibility that varietal resistance would be overcome by some races of the parasitic weed that would show a distinct varietal specificity. This would result in the need to select cowpea cultivars for resistance to several *S. gesnerioides* races. The present study discusses the susceptibility of cowpea cultivars to specific *S. gesnerioides* races in Mali and Niger.

MATERIALS AND METHODS

Field Experiments

A variety trial was conducted at two locations in fields infested with *S. gesnerioides* at Cinzana, Mali and Maradi, Niger in 1989. The 11 cowpea cultivars used were Suvita-2, KVX61-1, KVX61-2, KVX61-74, KVX65-114 and KVX183-1 from Burkina Faso, B301 from Botswana, IT82D-849 and IT81D-994 from Nigeria, Dan Illa from Niger and TVU 7607 from Mali. Seeds were supplied by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Niger.

Planting occurred on 19 July in Cinzana and on 20 July in Maradi. Plots were 3 m long, and included four rows spaced 60 cm apart. The seeds were spaced 30 cm apart along the rows. Three seeds were planted in each seed hole, and cowpeas were thinned to one plant per seed hole 15 d after planting. All observations were made on the two central rows.

Fertilizer was applied before planting at the rate of 21 kg ha^{-1} P_2O_5. Plots were hand-weeded when necessary, starting 15 d after planting in Cinzana and 25 d after planting in Maradi. Insecticides were applied every 15 d from the date of flowering of cowpea. In Cinzana, the first treatment consisted of deltamethrin (Decis, 25 g a.i. L^{-1}) applied at the rate of 12.5 g a.i. ha^{-1}, and the two other treatments consisted of endosulfan (Thiodan, 375 g a.i. L^{-1}) applied at the rate of 750 g a.i. ha^{-1}. In Maradi, the first treatment consisted of pirimicarb (Pirimor) applied at the rate of 200 g a.i. ha^{-1}, and the two other treatments consisted of Cymbush applied at the rate of 15 and 20 g a.i. ha^{-1} of cypermethrin and dimethoate, respectively. Insecticides were applied using Tecnoma T-15 and Electrodyn pulverisators in Cinzana and Maradi respectively.

The number of emerged *S. gesnerioides* stems was recorded for each plot. A randomized complete block design with four replicates was used in both experiments.

Pot Experiments

Pot experiments were performed in Sotuba, Mali and Sadoré, Niger in 1990. The trial included the same 11 cultivars that were tested in fields, except for the addition of cultivar TN88-63. Seeds were supplied by ICRISAT.

Three cowpea seeds were sown, on 18 June in Sotuba, and on 24 August in Sadoré, in each 3.5 L pot filled with a mixture of about 3 kg of sandy soil and 1 kg of farmyard manure. About 100 mg of *S. gesnerioides* seeds collected during October 1988 either in Cinzana, Mali, for the Mali experiment (*S. gesnerioides* race 2, according to Lane et al. 1996), or in Maradi, Niger, for the Niger experiment (*S. gesnerioides* race 3, according to Lane et al. 1996), were mixed in the top third of the soil 1 wk prior to sowing. Pots were placed outside and watered daily in order to allow *S. gesnerioides* seed preconditioning. After the sowing of cowpea, pots were watered twice a week in order to prevent water stress. Cowpeas were thinned to two plants per pot 15 d after sowing. The number of days from sowing to the first emergence of *S. gesnerioides* stems was recorded for each pot in addition to the number of emerged *S. gesnerioides* stems per pot at cowpea maturity. A randomized complete block design with four replicates was used in both experiments.

Laboratory Experiment

The same 12 cultivars that were tested in pots were assessed for their reaction to *S. gesnerioides* using the technique developed by Lane et al. (1991). Cowpea plants were sown in vermiculite in a glasshouse at a temperature of 25°C and a 16 h daylength. After 5 d, cowpea roots were washed and placed in shallow plastic trays lined with two layers of tissue paper and glass fibre filter paper (GF/A, Whatman). Nutrient solution, with a double concentration of Fe, was supplied daily (Drew and Saker 1986). The trays were wrapped in polyethylene and surrounded with aluminium foil. Cowpea plants were maintained in a growth chamber at a temperature of 30°C/25°C day/night and a 16 h daylength.

Striga gesnerioides seeds from each race were sterilized in a sodium hypochlorite solution (1% available chlorine) for 5 min, rinsed in distilled water, placed on moist glass fibre filter paper in a Petri dish and imbibed in the growth chamber for 14 d. Imbibed seeds were transferred to 6 mm discs of glass fibre filter paper, which were placed over the tips of lateral roots of cowpea plants growing in trays (Moore et al. 1995). After germination, approximately 50 *S. gesnerioides* seeds were transferred to the roots of each cowpea plant using a fine brush.

Four plants of each cultivar were observed 3 and 14 d after direct contact between *S. gesnerioides* germinated seeds and cowpea roots. Cowpea plants supporting *S. gesnerioides* plants more than 1 cm long were classified as susceptible and others as resistant (Singh and Emechebe 1990).

Statistical Analysis

The data from field and pot experiments were subjected to standard analysis of variance using SAS GLM. Cultivars were compared using the Waller-Duncan test of multiple comparison at $k = 100$ (Waller and Duncan 1972). Cultivars showing no visible sign of infection (i.e. supporting no emergence of *S. gesnerioides*) were excluded from the statistical analysis as they were considered resistant.

RESULTS

Field Experiments

No emergence of either *S. gesnerioides* race occurred on cultivar IT82D-849 (Table 1). Based on numbers of emerged *S. gesnerioides* stems, cultivar B301 showed resistance to the race from Maradi only, while Suvita-2, IT81D-994, KVX 61-2 and KVX 65-114 showed resistance to the race from Cinzana. Significant ($P < 0.05$) differences were observed among susceptible cultivars for numbers of emerged *S. gesnerioides* stems per plot.

Pot Experiments

Based on numbers of emerged *S. gesnerioides* stems, cultivars B301 and IT82D-849 showed resistance to both races from Cinzana and Maradi, while Suvita-2 and IT81D-994 only showed resistance to the race from Cinzana (Table 2). Significant ($P < 0.05$) differences were observed among susceptible cultivars for both numbers of emerged *S. gesnerioides* stems per pot and numbers of days from sowing to first emergence of *S. gesnerioides* with the race from

Table 1. Mean numbers of emerged *S. gesnerioides* stems per plot on 11 cowpea cultivars in fields infested with *S. gesnerioides* races from Cinzana, Mali and Maradi, Niger

	No. *S. gesnerioides* per plot	
Cultivar	Race from Cinzana	Race from Maradi
TVU 7607	18.3*a*	15.0*a*
Dan Illa	2.5*c*	13.8*a*
KVX 183-1	6.3*b*	3.8*cd*
KVX 61-74	3.3*c*	7.5*bc*
KVX 65-114	0	9.3*b*
KVX 61-2	0	2.5*d*
KVX 61-1	1.0*c*	4.0*cd*
Suvita-2	0	3.0*d*
IT81D-994	0	6.0*bcd*
IT82D-849	0	0
B301	2.3*c*	0
Mean	5.6	7.2
Standard error	1.7	3.0

*a–d*Mean values followed by the same letter in a column do not differ significantly according to the Waller-Duncan test at $k = 100$. Cultivars with 0 values were excluded from the statistical analysis as they were considered resistant.

Table 2. Mean numbers of emerged *S. gesnerioides* stems per pot and mean numbers of days from sowing to first emergence of two races of *S. gesnerioides* on 12 cowpea cultivars grown in pots

	Race from Cinzana		Race from Maradi	
Cultivar	No. *S. gesnerioides* per pot	No. days to *S. gesnerioides* emergence	No. *S. gesnerioides* per pot	No. days to *S. gesnerioides* emergence
TVU 7607	19.8*a*	42.0*ab*	35.0*b*	39.8*a*
Dan Illa	12.3*bc*	41.0*a*	31.0*bc*	34.3*a*
KVX 183-1	24.8*a*	42.0*ab*	31.0*bc*	43.3*a*
KVX 61-74	13.8*b*	51.8*c*	32.3*b*	31.3*a*
KVX 65-114	11.5*bc*	56.3*c*	38.0*ab*	43.3*a*
TN88-63	7.8*cd*	50.5*bc*	44.5*a*	42.8*a*
KVX 61-2	6.0*d*	57.8*c*	22.5*cd*	39.0*a*
KVX 61-1	3.8*d*	54.3*c*	16.5*d*	40.8*a*
Suvita-2	0	–	17.0*d*	38.3*a*
IT81D-994	0	–	18.0*d*	39.8*a*
IT82D-849	0	–	0	–
B301	0	–	0	–
Mean	12.5	49.5	28.6	39.3
Standard error	3.8	6.0	6.4	8.0

*a–d*Mean values followed by the same letter in a column do not differ significantly according to the Waller-Duncan test at $k = 100$. Cultivars with 0 values were excluded from the analysis as they were considered resistant.

Cinzana. With the race from Maradi, significant ($P < 0.05$) differences were observed among susceptible cultivars for numbers of emerged *S. gesnerioides* stems per pot only.

Laboratory Experiments

As in pot experiments, both B301 and IT82D-849 showed resistance to either *S. gesnerioides* race in the laboratory experiment, while Suvita-2 and IT81D-994 were resistant to the race from Cinzana only (Table 3).

DISCUSSION

One of the most effective ways to control *S. gesnerioides* could be to grow resistant cowpea cultivars. This seems a feasible approach for small-scale African farmers since additionnal inputs are not required. During the last decade, some cowpea cultivars exhibiting resistance or low susceptibility to *S. gesnerioides* attack were identified. The first identification of resistance to *S. gesnerioides* came from field trials in Burkina Faso, where cultivars 58-57 and Suvita-2 (formerly known as Gorom Local) supported no or very low emergence of *S. gesnerioides* (Aggarwal et al. 1984). However, these two cultivars showed moderate levels of susceptibility to *S. gesnerioides* in Niger and Mali, and even high level of susceptibility in Nigeria (Aggarwal et al. 1986). This indicated the possibility that different races of *S. gesnerioides* exist, each with its own distinct ability of attacking cowpea cultivars.

Other sources of resistance were later identified, among which cultivars B301 and IT82D-849 showed the most promising results, as they exhibited stable resistance throughout Burkina Faso, Niger and Nigeria (Aggarwal 1991). In the present study, both cultivars supported no emergence of *S. gesnerioides* from Cinzana, Mali and Maradi, Niger in pot and laboratory experiments. However, we found some cowpea plants parasitized by the *S. gesnerioides* race from Cinzana in B301 field plots. Although B301 was considered to be a stable source of resistance to *S. gesnerioides* in semi-arid West Africa, some susceptibility to a race from Benin has already been reported (Lane et al. 1994). In the present study, however, since B301 was resistant in both pot and laboratory experiments, it is likely that cowpea plants attacked in B301 plots were not B301 plants. As a matter of fact, seeds from mature parasitized plants appeared somewhat different from characteristic B301 seeds. Whatever it may be, these results would have to be confirmed before making premature conclusions.

Parker and Polniaszek (1990) demonstrated that while cowpea cultivars 58-57 and Suvita-2 were resistant to *S. gesnerioides* races from Burkina Faso, they were susceptible to races from Niger and Nigeria. The present study confirms these results, as important differences were observed in regard to the varietal specificity of the two *S. gesnerioides* races tested. The existence of such an interpopulation divergence is consistent with what we could expect from an autogamous species such as *S. gesnerioides* (Musselman et al. 1981).

The occurrence of distinct varietal specificity among *S. gesnerioides* races highlights the risk of specific races overcoming the resistance of some cowpea cultivars, thus indicating the need to perform cowpea selection for resistance to various *S. gesnerioides* races. Nevertheless, it is possible that there still is some risk of rapid adaptation of the parasitic weed to a new host. As pointed out by Olivier et al. (1996), in such a species where the seed production is so important, rare genetic events are likely to occur more frequently than in other species. The existence of a few alleles present at very low frequencies could be sufficient to allow quick adaptation to a new cultivar, driven by strong selection pressure resulting from repeated monoculture practices. However, as suggested by Lane et al. (1994), the breakdown of resistance is unlikely to become a major problem in the

Table 3. Reaction of 12 cowpea cultivars to parasitism from two races of *S. gesnerioides* in laboratory

Cultivar	Race from Cinzana	Race from Maradi
TVU 7607	Susceptible[z]	Susceptible
Dan Illa	Susceptible	Susceptible
KVX 183-1	Susceptible	Susceptible
KVX 61-74	Susceptible	Susceptible
KVX 65-114	Susceptible	Susceptible
TN88-63	Susceptible	Susceptible
KVX 61-2	Susceptible	Susceptible
KVX 61-1	Susceptible	Susceptible
Suvita-2	Resistant	Susceptible
IT81D-994	Resistant	Susceptible
IT82D-849	Resistant	Resistant
B301	Resistant	Resistant

[z]Cowpea plants supporting *S. gesnerioides* plants more than 1 cm long were classified as susceptible and others as resistant.

development of new resistant cowpea cultivars due to relatively low rates of *S. gesnerioides* reproduction and dissemination as compared with pathogenic fungi where new virulent races can spread rapidly.

The present study confirmed the potential of several cowpea cultivars to control *S. gesnerioides* infestation. Although they were susceptible to the *S. gesnerioides* race from Maradi, cultivars Suvita-2 and IT81D-994 were resistant to the race from Cinzana. Another cultivar, IT82D-849, was resistant to both races. These cultivars, as well as B301, could be used as resistant parents in genetic improvement programmes. Studies on inheritance of *S. gesnerioides* resistance in Suvita-2 in Burkina Faso (Aggarwal et al. 1984) and Mali (Touré et al. 1997), as well as in B301 in Nigeria (Singh and Emechebe 1990), Mali and Niger (Touré et al. 1997) have indicated the existence of single dominant genes controlling resistance. B301 has already been used as resistant source in some cowpea breeding programs (Singh and Emechebe 1991). Unfortunately, the low quality of B301 seeds seems to be transmitted to the progenies, and farmers in West Africa still lack well-adapted, high-yielding and good-quality cowpea cultivars with resistance to *S. gesnerioides*.

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