evaluated and found to support the production of aflatoxin (34–110 μg g^{-1} seed) (Mehan 1989).

We report the evaluation of 35 germplasm accessions of wild *Arachis* belonging to 24 species in six sections for in vitro seed colonization by artificial inoculation with a recently identified highly aggressive and toxigenic strain of *A. flavus* (isolate *Af* 11-4) and for aflatoxin production (Table 1). Sixty seeds (weighing 4–10 g depending on seed size) from each accession were surface sterilized with 0.1% aqueous solution of mercuric chloride for 2 min and washed in two changes of distilled sterilized water. Seeds were uniformly wounded by pricking with a sterile needle, to allow invasion by *A. flavus* spores. Seeds were placed in a sterilized petri dish (9 cm diameter) and spray inoculated with *A. flavus* spore suspension (1×10^6 spores mL^{-1}) using an atomizer. The petri dishes were shaken vigorously to roll the seeds allowing uniform distribution of inoculum on the seeds. The experiment was conducted in two replications with 30 seeds per replication. The petri dishes were placed at high humidity (>95% RH) in semi-rigid plastic boxes, lined with wet cotton wool and blotting paper, with closely fitting lids, and incubated at 25°C in the dark for 10 days.

Individual seeds were scored for surface colonization by *A. flavus* and for colonization severity using the following rating scale: 1 = <5% seed surface colonized with scanty mycelial growth and no sporulation; 2 = 5–25% seed surface colonized with good mycelial growth and scanty sporulation; 3 = 26–50% seed surface colonized with good mycelial growth and good sporulation; and 4 = >50% seed surface colonized with heavy sporulation. The seeds were then sprayed with ethanol and washed before using for aflatoxin estimation. An indirect competitive enzyme-linked immunosorbent assay (ELISA) method was used (Devi et al. 1999).

Large variation occurred both for seed colonization severity (1 to 4) and aflatoxin production [high (>5000 μg kg^{-1} seed) to negligible (<100 μg kg^{-1} seed)] among accessions belonging to different sections and species (Table 1). Accessions ICG 13212 (*A. pusilla,*), ICG 11560 (*A. chiquitana*), and ICG 8131 and ICG 14875 (*A. triseminata*) recorded low colonization severity and relatively low aflatoxin content compared with those of control susceptible cultivars J 11 and JL 24. Resistance of the above accessions needs to be evaluated for seed infection by *A. flavus*.

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Identification of Elite Short-duration, Rosette Resistant Lines in World Germplasm Collections

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Groundnut rosette is a major constraint to groundnut production in sub-Saharan Africa and its offshore islands (Subrahmanyam et al. 1991, 1997, Naidu et al. 1999a). It is caused by a complex of three agents: groundnut rosette assistor virus (GRAV), groundnut rosette virus (GRV), and satellite RNA of GRV. The disease is transmitted by aphids (*Aphis craccivora*) in persistent manner (Naidu et al. 1999a). Groundnut rosette is estimated to cause annual

yield losses globally worth US$ 156 million (ICRISAT 1992).

In the past, several medium- and long-duration rosette resistant groundnut varieties, such as RG 1, RMP 12, and RMP 91, have been developed and released for general cultivation. However, their adoption rate by farmers was low in most of sub-Saharan Africa, characterized by short and erratic rainfall. The need for short-duration, rosette resistant varieties has been well recognized in the breeding programs, and attempts have been made in the past to breed such varieties by crossing rosette resistant sources with short-duration agronomically superior spanish varieties. However, success in combining short-duration and rosette resistance in good agronomic background by breeding has not been met with desirable success, probably due to complex nature of inheritance of these traits (Reddy and Subrahmanyam 1997). Hence, a rigorous search was made to identify short-duration rosette resistant germplasm with good agronomic features by screening the world germplasm using the infector row technique (Bock and Nigam 1988, Subrahmanyam et al. 1998). This article describes the botanical features and performance of two short-duration, rosette resistant elite germplasm, ICG 12988 and ICG 12991.

Origin and development

ICGs 12988 and 12991 are germplasm lines collected in farmer's fields in Madhya Pradesh, India in October 1988 under the collector numbers US 22 and US 25, respectively. They were introduced into ICRISAT at the Chitedze Agricultural Research Station near Lilongwe, Malawi in 1994 for evaluation against rosette and early leaf spot (caused by *Cercospora arachidicola*). The original sources had some susceptible plants, which might have been due to mixtures or outcrossing. So we purified them by culling out the diseased plants for two seasons.

Morphological and agronomic characters

ICGs 12988 and 12991 belong to the spanish botanical group with erect growth habit, sequential branching, and medium-sized, dark green, elliptic leaves. On average, ICG 12988 has 4.2 primary and 2.5 secondary branches and ICG 12991 has 4.5 primary and 2.6 secondary branches. They mature in 95–105 days after sowing (DAS) at Chitedze [1149 m asl (above sea level)] and in 90–100 DAS at Chitala (550 m asl), Malawi compared with JL 24 which matures in 110–120 DAS at Chitedze and 90–100 DAS at Chitala.

ICGs 12988 and 12991 have two-seeded small pods with thin shells and slight to medium reticulation. Pods of both lines have slight to medium constriction with no or little beak. Seeds are tan with a 100-seed mass of 31.5 g for ICG 12988 and 30.8 g for ICG 12991 and have no fresh seed dormancy. Both varieties have high shelling percentage: 76.5 for ICG 12988 and 76.0 for ICG 12991. Average oil content is 43.6% in ICG 12988 and 43.3% in ICG 12991. Average protein content is 26.7% in ICG 12988 and 27.1% in ICG 12991.

Disease reaction

The reaction of ICGs 12988 and 12991 to rosette in the disease nursery at Chitedze for four seasons is given in Table 1. The mean disease incidence in these trials was 6.0% for ICG 12988 and 4.5% for ICG 12991 (Fig. 1). The susceptible control varieties, Malimba and JL 24, showed

Table 1. Reaction of groundnut genotypes ICGs 12988 and 12991 and control cultivars Malimba and JL 24 under high rosette disease situation at Chitedze Agricultural Research Station, Malawi during 1994–98.

Genotype	Rosette incidence (%)					Disease index (1996)
	1994/95	1995/96	1996/97	1997/98	Mean	
ICG 12988	8	5	10	1	6.0	1.5
ICG 12991	9	0	6	3	4.5	1.4
Malimba (control)	100	93	92	–	95.0	2.8
JL 24 (control)	100	96	87	97	95.0	2.8
Trial mean	–	13.6	19.4	29.0		1.65
SE	–	±4.2	±5.3	±4.6		±0.09
CV (%)	–	26.7	25.3	5.1		6.0

Figure 1. Field reaction of groundnut genotype ICG 12991 against rosette at Chitedze, Malawi.

95% disease incidence. Rosette disease index (Olorunju et al. 1991) was lower for ICG 12988 (1.5) and ICG 12991 (1.4) compared to the susceptible varieties (2.8).

Reaction to the vector

Both ICG 12988 and ICG 12991 are resistant to the vector *A. craccivora* (Naidu et al. 1999b). Laboratory studies on aphid survival, reproduction, and feeding behavior showed low rate of nymphal development, reduced fecundity, and smaller-sized aphids on ICG 12991 compared to susceptible genotypes JL 24 and CG 7 (Minja et al. 1999). Resistance to aphids increases with age of the plants (Naidu et al. 1999b). Field resistance of ICG 12988 and ICG 12991 to rosette is attributed to resistance to vector aphids.

Yield performance

Both ICGs 12988 and 12991 were identified as short-duration, high-yielding lines with resistance to rosette during the 1994/95 crop season and subsequently in 1995/96, 1996/97, and 1997/98 at Chitedze, Malawi (Subrahmanyam et al. 1998).

The magnitude of differences in pod yield between rosette resistant germplasm (ICGs 12988 and 12991) and susceptible cultivars (Malimba and JL 24) was very high under high disease pressure (Table 2). In yield trials under high disease pressure at Chitedze, Malawi, during the 1996/97 and 1997/98 crop seasons, ICG 12988 and ICG 12991 gave a yield advantage of over 1020%. Under low disease pressure in the same years, ICG 12988 gave a yield advantage of 6.8% and ICG 12991 over 14.7%. Under high

Table 2. Performance of groundnut genotypes ICGs 12988 and 12991 and control cultivars Malimba and JL 24 under high and low rosette disease situations at Chitedze Agricultural Research Station, Malawi, 1996/97 and 1997/98 crop seasons.

	Pod yield (t ha^{-1})						Shelling (%)						100-seed mass (g)					
	HDP[1]			LDP[2]			HDP			LDP			HDP			LDP		
Genotype	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean
ICG 12988	0.97	1.51	1.27	3.65	2.01	2.83	74	80	77	76	76	76	31	27	29	38	30	34
ICG 12991	0.92	1.55	1.24	3.96	2.12	3.04	74	77	76	78	75	77	30	26	28	37	30	34
Control																		
Malimba	–	0.02	–	–	2.88	–	–	61	–	–	74	–	–	31	–	–	34	–
JL 24	0.10	0.11	0.11	3.22	2.07	2.65	57	61	59	75	71	73	35	25	30	43	33	38
Trial mean	0.3	0.70		2.55	1.38		61	64		64	69		31	33		35	39	
SE	±0.06	±0.11		±0.26	±0.13		±4.0	±6.9		±2.0	±3.3		±1.9	±4.8		±2.4	±4.7	
CV (%)	21.0	20.6		12.6	24.1		8.0	14.0		5.3	6.8		7.5	14.4		8.4	11.9	

1. HDP = High disease pressure.
2. LDP = Low disease pressure.

Table 3. Performance of groundnut genotypes ICGs 12988 and 12991 and control cultivar JL 24 in on-farm trials at three locations in Karonga Agricultural Development Division, Malawi during the off-season, 1997.

	Pod yield (t ha^{-1})				Shelling (%)			
Genotype	Iponga	Katininda 1	Katininda 2	Mean	Iponga	Katininda 1	Katininda 2	Mean
ICG 12988	3.2	4.2	5.7	4.37	78	75	74	75.7
ICG 12991	4.1	3.6	3.7	3.80	76	69	76	73.7
JL 24 (control)	2.7	4.0	5.4	4.03	70	66	72	69.3
Trial mean	2.7	3.6	4.8		66	63	66	
SE	±0.29	±0.37	±0.70		±1.0	±2.4	±2.3	
CV (%)	22	23	30		7.0	8.0	7.0	

disease pressure, even the shelling percentage of the susceptible cultivars was low compared to that of ICGs 12988 and 12991.

In on-farm trials conducted during the 1997 off-season at three locations in Karonga, Malawi, the mean pod yields of ICGs 12988 and 12991 were similar to that of JL 24 under no disease situation. However, both ICGs 12988 and 12991 had better shelling percentage (Table 3).

In farmer-participatory yield trials conducted at 45 locations in different agroecological zones of Malawi during the 1998/99 growing season, ICG 12988 and ICG 12991 gave an average yield advantage of over 6% and 7%, respectively. Rosette incidence during the season was negligible (<1%) at all locations.

Both ICG 12988 and ICG 12991 are high yielding and have an excellent potential for cultivation in production systems characterized by short rainy seasons and recurrent rosette epidemics in sub-Saharan Africa.

Seed availability

The Genetic Resources and Enhancement Program, ICRISAT, PO Box 1096, Lilongwe, Malawi, maintains the breeder seed of ICG 12988 and ICG 12991. Limited quantities of seed are made available on request.

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Management of Collar Rot of Groundnut by *Pseudomonas fluorescens*

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Collar rot caused by *Aspergillus niger* is a widespread disease in groundnut. *Aspergillus niger* causes rotting of seed, pre-emergence soft rot of the hypocotyls, and post-emergence collar rot of seedlings. Collar rot spreads through the spores adhering to the seeds and pods from one season to the other. Several workers have tried to manage this disease by seed dressing with different fungicides (Sidhu and Chohan 1971, Whitehead and Thirumalachar 1974). Application of fungicides to soil and plants can cause soil and air pollution, hazards for humans, animals, and beneficial rhizosphere microorganisms. Therefore, an alternative method of biological control of plant pathogens has been focused recently. The present study was conducted to find out the effective biocontrol agent against collar rot as an alternative to fungicide.

Experimental trials were conducted at the Agricultural Research Station, Aliyarnagar, Tamil Nadu, India for two years in 1997 and 1998 cropping seasons. Groundnut cultivars Co 2 [rainy season (kharif)] and VRI 4 [postrainy season (rabi)], susceptible to collar rot were sown in 3 × 5 m^2 plots in a randomized block design with three replications and eight treatments. The commercial product of the antagonists, viz., *Trichoderma viride* and *T. harzianum*, both at 4 g kg^{-1} of seed and *Pseudomonas fluorescens* at 10 g kg^{-1} were used for seed treatment (ST). The treated seeds were shade dried and sown. Carbendazim seed treatment (2 g kg^{-1}) was also included as one of the treatments. Neem cake was applied to the respective plots at 160 kg ha^{-1} before sowing. Control plots were maintained without any soil application (SA).

Pre-emergence rotting was estimated by counting the number of germinated seeds at 10 days after sowing (DAS). Disease incidence was recorded 25 and 45 DAS by counting the infected plants.

Among the treatments, *P. fluorescens* (ST) + neem cake (SA) was found to be the best in reducing collar rot (6.63%) followed by *T. viride* (ST) + neem cake (SA) (7.89%), and *P. flourescens* (ST) (8.27%) as compared to 18.77% in control (Table 1). Treatments receiving *T. viride* (ST) + neem cake (SA) gave higher pod yield (1849.49 kg ha^{-1}) followed

Table 1. Effect of antagonists on collar rot incidence in groundnut during 1997–99, Aliyarnagar, Tamil Nadu, India[1].

Treatment[2]	Collar rot incidence[3] (%)				
	K 1997	R 1997/98	K 1998	R 1998/99	Mean
Trichoderma viride (ST)	11.88 (20.13)	9.12 (17.56)	11.83 (20.09)	13.26 (21.39)	11.53 (19.82)
T. harzianum (ST)	15.73 (23.34)	13.44 (21.47)	14.42 (22.30)	15.41 (23.11)	14.75 (22.63)
Pseudomonas fluorescens (ST)	8.99 (17.36)	6.45 (14.77)	8.24 (16.64)	9.39 (17.85)	8.27 (16.74)
T. viride (ST) + neem cake (SA)	8.49 (16.95)	6.36 (14.65)	7.32 (15.68)	9.39 (17.85)	7.89 (16.32)
T. harzianum (ST) + neem cake (SA)	12.51 (20.70)	10.30 (18.72)	10.22 (18.63)	11.19 (19.55)	11.06 (19.46)
P. fluorescens (ST) + neem cake (SA)	6.66 (15.00)	5.73 (13.81)	6.46 (14.77)	7.66 (16.11)	6.63 (14.89)
Carbendazim (ST)	3.30 (10.47)	2.27 (8.72)	3.46 (10.78)	3.20 (10.30)	3.06 (10.14)
Control	20.60 (26.99)	17.79 (24.95)	19.07 (25.91)	17.61 (24.80)	18.77 (25.70)
CD ($P = 0.05$)	0.45	0.58	0.54	0.31	

1. Collar rot susceptible groundnut cultivars were tested; Co 2 in kharif (K) (rainy season) and VRI 4 in rabi (R) (postrainy season).
2. ST = Seed treatment; and SA = Soil application.
3. Figures in parentheses are transformed values.