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Karnataka J. Agric. Sci.,27 (4): (445-448) 2014

Potential genotypes for resistance to foliar diseases and productivity in groundnut (*Arachis hypogaea* L.)

B. N. MOTAGI[1], G. K. NAIDU, C. C. ANGADI AND M. V. C. GOWDA

Department of Genetics and Plant Breeding
University of Agricultural Sciences, Dharwad - 580 005, Karnataka, India
[1] International Crop Research Institute for the Semi Arid Tropics (ICRISAT)
PMB 3491, Sabo Bakin Zuwo Road, Tarauni, Kano, Nigeria
E-mail: bnmotagi@gmail.com

(Received: November, 2012 ; Accepted: November, 2014)

Abstract: Induced mutagenesis and extensive hybridization with interspecific derivatives were sought to break undesirable associations between foliar disease resistance and maturity. Several foliar disease resistant mutants and second cycle interspecific-derivatives were isolated in Spanish bunch background. In the present study, a set of ten genotypes were assessed for foliar disease, productivity and physiological parameters over two rainy seasons under foliar disease protected and unprotected conditions. Mutant (28-2) and second cycle interspecific derivative (GPBD 4/ D 39d) were resistant to foliar diseases with high yield potential even under foliar disease epidemic. 28-2 was also resistant to *Spodoptera*, thrips and *Aspergillus* infection besides having bold kernels. GPBD 4 was iron absorption efficient and had high O/L ratio (1.68). These cultures had stable and superior performance over check, JL 24 across years. They also possessed desirable agronomic features, early maturity, high partitioning and better quality, thus showing their potential for cultivation in the farmers field.

Key words: Groundnut, Late leaf spot, Productivity, Rust

Introduction

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop of the world grown on an area of 24.6 m ha with a production of 41.3 m.t. and productivity of 1676 kg/ha during 2012 (Anon, 2014). Groundnut seeds mainly crushed for cooking oil and used for confectionary purpose. Protein rich meal is used as livestock feed and haulms are important source of fodder, especially in developing countries. Though India is a leading producer, the productivity is very low (756 kg/ha) compared to USA (3393 kg/ha) and China (3143 kg/ha). The low productivity is mainly due to several biotic and abiotic stresses afflicting the crop. Among the biotic stresses, late leaf spot (*Phaeoisariopsis personata* Berk & Curt. V.Arx) and rust (*Puccinia arachidis* Speg.) are the two most destructive fungal foliar diseases of groundnut worldwide. In India, late leaf spot and rust normally occur together and cause yield loss up to 70 per cent. These diseases have an adverse influence on the recovery of pods, quality of seeds and haulms especially during rainy season. Late leaf spot pathogen also produces dornithin, a potent mycotoxin that affects the fodder quality. The non-genetic solution (fungicide spray) to disease management is uneconomical in rainfed agro-ecology due to lower yield levels and resource limitations of the farmers. Resistant cultivars facilitate an economic and environmentally sound management of the diseases and thus promote sustainable productive agriculture.

Among the four botanical types of groundnut, Spanish bunch cultivars are most popular in India as they possess desirable pod and kernel features and mature early facilitating double cropping under rainfed conditions. However, these cultivars are highly susceptible to foliar diseases and suffer heavy yield loss under disease epidemic. Several genotypes resistant to late leaf spot and rust have been identified, but most of them are Valencia landraces and Virginia interspecific derivatives with many undesirable features like late maturity, thick shell, low productivity and poor adaptation, making them unsuitable for direct cultivation (Gowda *et al.,* 1995). A cursory analysis of improved groundnut cultivars revealed that, out of 135 varieties released so far in the country, only Girnar 1, ICG (FDRS) 4, ICG (FDRS) 10 and ICGV 86590 are resistant to foliar diseases. Only two disease resistant parents (NCAc 17090 and PI 259747) appear in the parentage of resistant cultivars released in India (Nigam, 2000). However, these resistant cultivars suffer from inferior agronomic traits such as low shelling out-turn, long duration, poor pod and seed features. Because of this, they are not popular among the farmers in spite of their higher yield under disease epidemics. Further, there exists negative association between foliar disease resistance and maturity/yield in groundnut (Gowda *et al.,* 1996). Identification of newer sources of resistance in Spanish types is of great significance in resistance breeding. Induced mutagenesis and inter-specific hybridization were sought as an alternative approach to generate material combining desirable agronomic features with disease resistance and high productivity. In the present study, an attempt has been made to assess the potentiality of genotypes for resistance to foliar diseases and productivity in the material generated by employing such approaches.

Material and methods

Spanish bunch mutant (28-2) and interspecific-derivatives (D 39d and B 37c) were evaluated along with ruling but susceptible Spanish bunch cultivars (JL 24, TMV 2, Dh 8, R 8808 and TAG 24), a rust resistant Valencia cultivar (ICGV 86590) and a Virginia bunch interspecific germplasm line (ICGV 87165) for their reaction to foliar diseases, productivity and physiological parameters over two rainy seasons (2007 and

Table 1. Pedigree and salient features of groundnut genotypes

Cultivar	Pedigree	Botanica lgroup	Year of Release	Salient features
Mutant (28-2)	EMS mutant of Valencia 1 (VL1)	SB	2003	Resistant to late leaf spot, desirable pod and kernel features combined with early maturity
GPBD 4 (D 39d)	KRG1 x ICGV86855 F_2-B_1-B_1-B_1-B_1	SB	2003	Resistant to late leaf spot and rust, desirable pod and kernel features
B 37c	JL 24 x ICGV 87165 F_2-B_1-B_1-B_1-B_1	SB	-	Resistant to late leaf spot and rust, desirable pod and kernel features
ICGV 86590	X14-4-B-19-B x PI 259747	VL	1991	Resistant to rust, prominent pod reticulation, released for cultivation
ICGV 87165	PI 261942 x CS 9	VB	1994	Germplasm line highly resistant to late leaf spot and rust
Dh 8	Selection from RS 144	SB	-	Moderately resistant to late leaf spot
R 8808	ICGS 11 x Chico	SB	1997	Moderately resistant to rust, released for cultivation
JL 24	Selection from EC 94943	SB	1978	Widely cultivated but susceptible to late leaf spot and rust
TMV 2	Mass selection from "Gudiatham Bunch"	SB	1940	Widely cultivated but susceptible to late leaf spot and rust
TAG 24	TGS 2 x TGE 1	SB	1992	Early maturing, widely adapted but susceptible to late leaf spot and rust

SB: Spanish bunch, VL: Valencia, VB: Virginia bunch

2008). The pedigree and salient features of these genotypes is presented in Table 1.

Split plot design was used for evaluation of the material. The main plots consisted of spray treatments *viz.*, foliar disease control by Chlorothalonil spray (P- protected) v/s no disease control, water spray (UP-unprotected) and the subplots comprised ten genotypes. Each genotype was raised in five-rows of 5 m length with a spacing of 30 x 10 cm in three replications. At 30 days after sowing (DAS), 1.15 kg ha^{1} Chlorothalonil (Kavach) in 800 liters water was applied using a knapsack sprayer. Subsequent sprayings were done at 15 days interval till harvest of the crop. Control plots were sprayed with 800 liters ha^{-1} water at the same intervals. The recommended package of practices for groundnut crop was used while raising the crop.

High disease pressure of rust and late leaf spot was created using the infector row technique in unprotected plots. Infector row of highly susceptible cultivar (TMV 2) was sown after each test entries. Inoculation was done with pure late leaf spot/rust pathogen suspension @ 20,000 spores mL^{-1} when crop was at 30 days old using automizer. Scattering leaf debries collected from previous season's diseased crop along the infector rows provided additional late leaf spot/rust inoculum. To maintain optimum temperature (23-25^{o} C) and long periods of leaf wetness with intermittent dry periods, plants were sprinkled with water everyday in the evening hours for at least 8-10 days after inoculation.

Modified 9-point scale was used for field screening of genotypes (Subba Rao *et al.,* 1990). Cumulative AUDPC (area under disease progress curve) and Healthy leaf area duration (HLAD) an overall indicator of disease resistance were also calculated.

Oil content was determined by nuclear magnetic resonance (NMR) technique. Fatty acid content was estimated following Mecer *et al.* (1990). From the fatty acid data, oleic (O) and linoleic (L) ratio was computed. In each genotype, pod yield (q ha^{-1}) was multiplied by shelling out-turn (%) to derive kernel yield (q ha^{-1}) and which in turn multiplied with oil content (%) to derive oil yield (q ha^{-1}). Fodder yield was expressed in t ha^{-1}. Physiological parameters namely pod growth rate (PGR) and partitioning coefficient (PC) were computed as suggested by Pixley *et al.* (1990).

Results and discussion

Genotype D 39d followed by B 37c and ICGV 87165 were superior for both late leaf spot (LLS) and rust resistance by recording significantly lower values for field disease score and AUDPC (Table 2). Mutant 28-2 was resistant to late leaf spot while, ICGV 86590 exhibited resistance to rust. Genotypes Dh 8 (LLS) and R 8808 (Rust) recorded moderate values for disease components and field disease score (FDS), indicating moderate/ partial resistance to foliar diseases. On the contrary, TAG 24, TMV 2 and JL 24 had higher values for FDS and AUDPC revealing their susceptibility to foliar diseases.

Table 2. Performance of groundnut genotypes for foliar disease resistance under unprotected condition (Pooled over two seasons)

Genotype	Field disease score (Modified 1-9 scale)		AUDPC	HLAD
	Late Leaf Spot	Rust		
Mutant (28-2)	5	7	1713^{c}	178.7^{d}
GPBD 4 (D 39d)	4	3	1199^{a}	210.4^{c}
B 37c	4	3	1442^{b}	243.5^{b}
ICCV 86590	8	3	2710^{g}	157.3^{de}
ICCV 87165	4	3	1413^{b}	262.3^{a}
Dh 8	7	8	2965^{i}	124.0^{f}
R 8808	8	7	2327^{d}	167.4^{de}
JL 24	9	8	2412^{e}	148.2^{e}
TMV 2	9	8	2565^{f}	157.6^{de}
TAG 24	9	8	2904^{h}	095.5^{g}
S.Em.±	-	-	15.8	4.1
C.D. (5%)	-	-	48.9	12.9

Figure(s) with same superscript(s) do not differ significantly at 5% level of probability, AUDPC- Area Under Disease Progress Curve, HLAD - Healthy leaf area duration

Pooled ANOVA for yield/ yield loss indicated that effect of seasons was non-significant except for fodder yield. while, there was a significant genotypic and interaction effects for all the yield/ yield loss indicating the differential response of genotypes to seasons (Table 3). All the genotypes recorded higher (pod, seed, oil and fodder) yield levels in fungicide sprayed (P) condition compared to unprotected (UP) diseased condition. Performance of genotypes over the seasons for productivity indicated that, resistant genotypes D 39d and mutant 28-2 were superior for pod, seed and oil yields, while, ICGV 87165 followed by D 39d and 28-2 for fodder yield as they recorded highest values and least reduction due to disease for these productivity parameters (Table 3). Higher yield in D 39d and 28-2 was due to their higher shelling out-turn (68-75%) and oil content (40-45%) besides high partitioning coefficient under diseased condition (Table 4). Further, D 39d also had high pod growth rate (24.2). On the contrary, susceptible cultivars JL 24 and TMV 2 had lower yield levels and highest reduction due to foliar diseases.

Late leaf spot and/or rust resistant genotypes *viz*., ICGV 87165 and ICGV 86590 had low partitioning coefficient (42-59%) and late maturity (115-125 days). On the contrary, mutant 28-2 and D 39d had desirable combination of late leaf spot and/or rust resistance with early maturity (100-110 days) and high partitioning coefficient (63%) similar to that of ruling but susceptible cultivars in the Spanish background. Mutant 28-2 was also resistant to tobacco cut worm (*Spodoptera litura*) and Thrips (Rajendraprasad *et al.*, 2000). It had high hundred seed mass (49.2 g) besides having tolerance to *Aspergillus* infection (Harish Babu *et al.,* 2004) and hence can be a potential genotype for confectionary (HPS) purpose. D 39d was found to be iron absorption efficient (Motagi *et al.,* 2000) and hence can be cultivated even in calcareous soils. Its oil was characterized by high O/L ratio (1.68) revealing better nutritional and keeping quality. D 39d had small sized seeds similar to popularly cultivated variety TMV 2, which confers economy in seed rate. Mutant 28-2 and D 39d have been registered with National Bureau of Plant

Table 3. Pooled ANOVA and performance of groundnut genotypes for productivity (Pooled over two seasons)

Genotype	Pod yield (q ha^{-1})			Kernel yield (q ha^{-1})			Oil yield (q ha^{-1})			Fodder yield (t ha^{-1})		
	UP	P	% R	UP	P	% R	UP	P	% R	UP	P	% R
Mutant (28-2)	35.6^{b}	42.9^{ab}	17.0	24.3^{c}	30.0^{ab}	19.0	09.9^{c}	13.5^{b}	28.1	10.8^{d}	12.7^{cd}	15.6
GPBD 4 (D 39d)	38.7^{a}	44.0^{ab}	12.0	29.2^{a}	34.7^{a}	15.9	13.4^{a}	16.1^{a}	17.6	12.1^{c}	14.2^{cd}	15.8
B 37c	38.5^{a}	43.3^{ab}	09.1	27.3^{b}	31.6^{ab}	12.3	11.2^{b}	13.9^{b}	17.7	16.7^{b}	19.8^{b}	15.8
ICGV 86590	29.7^{cd}	40.5^{bc}	26.6	16.8^{g}	24.3^{c}	30.8	06.5^{e}	10.4^{c}	37.1	09.7^{e}	15.7^{c}	38.0
ICGV 87165	38.0^{a}	47.0^{a}	19.4	22.5^{d}	29.2^{ab}	22.9	09.5^{c}	13.2^{b}	28.5	23.9^{a}	27.3^{a}	11.8
Dh 8	29.0^{cd}	35.5^{c}	18.0	18.7^{f}	24.5^{c}	23.3	07.3^{d}	09.9^{c}	25.6	07.0^{h}	09.7^{de}	28.0
R 8808	30.5^{c}	43.7^{ab}	30.4	20.5^{e}	30.5^{ab}	33.1	07.8^{d}	12.5^{bc}	38.0	09.1^{f}	10.9^{de}	16.3
JL 24	23.3^{ef}	38.2^{dc}	39.0	15.8^{g}	27.1^{ab}	40.5	06.3^{ef}	11.2^{bc}	41.9	08.0^{g}	15.7^{c}	48.6
TMV 2	22.4^{ef}	38.7^{dc}	42.0	14.8^{gh}	28.6^{ab}	48.0	05.8^{ef}	11.7^{c}	50.4	06.8^{h}	15.8^{c}	56.2
TAG 24	24.5^{e}	36.4^{c}	32.6	15.7^{gh}	25.0^{c}	37.4	05.6^{f}	10.2^{c}	46.1	05.6^{I}	09.0^{de}	38.5
S.Em.±	0.5	1.0	1.1	0.3	1.4	1.3	0.2	0.6	1.6	0.2	0.7	1.2
C.D. (5%)	1.5	3.2	3.6	1.1	4.4	3.9	0.5	1.7	4.9	0.5	2.3	3.6
Pooled ANOVA												
Season	10377.6^{NS}		31.6^{NS}	83307.2^{NS}		6.3^{NS}	583.0^{NS}		49.0^{NS}	39.1**		273.5**
Genotype	24438.4**		760.9**	15664.6**		798.5**	394.0**		777.7**	184.8**		1516.9**
Interaction	613.1**		92.8**	364.0**		135.7**	216.7**		203.6**	1.9**		96.6**
Error	161.5		9.4	94.2		11.3	17.9		17.3	0.2		9.5

Figure(s) with same superscript(s) do not differ significantly at 5% level of probability, UP - Unprotected condition, P - Protected condition, % R - % reduction over protected condition, NS- Non significant, * and ** indicate significance at 5 and 1 % leval of probability, respectively

Table 4. Physiological, seed and oil quality parameters in selected groundnut genotypes under unprotected condition (Pooled over two seasons)

Genotype	Physiological parameters		Seed quality		Oil quality		Days to
	Pod Growth Rate	Partitioning Coefficient	Shelling Out- turn (%)	100 Seed Mass (g)	Oil Content (%)	O/L Ratio	Maturity
Mutant (28-2)	20.0^{d}	63.6^{a}	68.1^{c}	49.2^{b}	40.1^{bc}	0.95^{g}	100-105
GPBD 4 (D 39d)	24.2^{a}	63.1^{a}	75.3^{a}	36.5^{de}	45.3^{a}	1.68^{a}	105-110
B 37c	23.3^{b}	54.5^{c}	70.9^{b}	54.6^{a}	41.0^{bc}	1.30^{d}	110-115
ICGV 86590	21.3^{c}	59.8^{ab}	56.5^{f}	35.6^{de}	38.6^{cd}	0.96^{g}	115-120
ICGV 87165	19.0^{f}	42.5^{d}	59.3^{e}	47.4^{b}	42.0^{b}	1.51^{b}	120-125
Dh 8	18.4^{g}	61.9^{ab}	64.6^{cd}	28.5^{f}	38.8^{c}	1.38^{c}	95-100
R 8808	21.3^{c}	63.7^{a}	67.1^{c}	42.7^{c}	37.7^{cd}	0.91^{h}	95-100
JL 24	19.9^{de}	62.8^{ab}	67.1^{c}	40.4^{c}	41.1^{bc}	0.97^{g}	95-100
TMV 2	19.5^{e}	62.5^{ab}	65.9^{cd}	33.6^{de}	39.3^{bc}	1.06^{e}	95-100
TAG 24	19.6^{de}	63.8^{a}	64.3^{cd}	35.2^{de}	35.1^{e}	1.02^{f}	90-95
S.Em.±	0.1	1.1	0.8	0.8	0.6	0.01	-
C.D. (5%)	0.3	3.3	2.4	2.8	1.7	0.03	-

Figure(s) with same superscript(s) do not differ significantly at 5% level of probability

Genetic Resources (NBPGR), New Delhi, as valuable germplasm with INGR numbers 98003 and 01031, respectively (Gowda *et al.,* 1998 and 2002).

It is clear from the present study that, mutant (28-2) and cross-derivative (GPBD 4) derived from mutation and recurrent interspecific hybridization, respectively had resistance to biotic and/or abiotic stresses besides possessing desirable agronomic features, high productivity and quality in Spanish background, thus are the potential genotypes for cultivation in farmers field.

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