Progress in Breeding Groundnut Varieties Resistant to Peanut Bud Necrosis Virus and its Vector

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Abstract

Peanut bud necrosis disease (PBND), caused by peanut bud necrosis virus (PBNV), and transmitted by Thrips palmi *is an important disease of groundnut in South and Southeast Asia. Several cultivated groundnut germplasm lines showed consistently low disease incidence under field conditions (field resistance). Eight accessions of wild* Arachis *species did not show disease under field conditions. Field resistance could be due to vector and/or to virus resistance. The current breeding strategy includes improving the level of resistance to thrips and PBNV, and combining them into superior agronomic backgrounds. Several high-yielding varieties with high levels of resistance to PBND have been developed. These varieties possess moderate resistance to the vector. Two of these, ICGV 86031 and JCGV 86388, show resistance to PBNV when mechanically sap-inoculated with low virus concentration (10^{-2}). Considering the level of resistance to the vector and PBNV, it appears that further improvement in the level of resistance through conventional breeding may be difficult to achieve.*

Introduction

Peanut bud necrosis disease (PBND) is an economically important virus disease of groundnut (*Arachis hypogaea* L.) in South and southeast Asia. It is caused by peanut bud necrosis virus (PBNV) and transmitted by *Thrips palmi* Karny. The disease can cause yield losses of over 50% and its incidence ranges from 5 to 80% in all the major groundnut-growing areas of India (Ghanekar et al. 1979, Amin and Mohammad 1980, Amin and Reddy 1983, Reddy et al. 1991, and Patil 1993).

In the field, genotypes can differ considerably in the incidence of PBND due to the collective effects of resistance to the virus and resistance to the vector. Reduced incidences are indicated as field resistance.

Genotypic differences in field resistance are reported among the 8000 groundnut germplasm accessions screened for this resistance at ICRISAT Asia Center (IAC), Patancheru, India. Compared with subsp *hypogaea,* the genotypes belonging to subsp *fastigiata* are, in general, more susceptible. In most cases, field resistance is associated with nonpreference of the vector. In a few genotypes, slower multiplication of the virus in the plant is also responsible for a lower disease incidence in the field.

We report here, the progress made in identification of sources of field resistance, and the development of breeding populations with an improved level of resistance.

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Field Resistance

Resistance in cultivated groundnut

Several germplasm lines with consistently low disease incidence under field conditions have been identified at IAC. These are: ICG numbers 848, 851, 852, 862, 869, 885, 2271, 2306, 2307, 2323, 2741, 3042, 3806, 3873, 5030, 5024, 5043, 5044, 6135, 6317, 6323, 7676, and 7892, and belong to subsp *hypogaea.* These lines showed less than 20% disease incidence compared with over 80% in the susceptible control JL 24 (1CRISAT unpublished data).

Resistance in wild *Arachis* species

Five accessions of A. *duranensis* (30064, 30065, 36002, 36002-2, and 36005) and one accession each of A. *volida* (30011), A *correntina* (9530), and A. *monticola* (30063) showed no disease symptoms under field conditions. Of these, A. *duranensis,* A *correntina,* and A. *monticola* are cross-compatible with cultivated groundnut.

Resistance to Vector and Virus

Field resistance is a result of resistance to the vector, the virus, or a combination of both.

One-hundred-and-forty varieties and interspecific derivatives of groundnut with field resistance were screened in the field for resistance to the vector, on the basis of thrips injury on a 1-9 scale, where 1 = highly resistant, 2-3 = resistant, 4-5 = moderately resistant, 6-7 = susceptible, and 8-9 = highly susceptible. The vector-resistant genotypes were then screened for PBNV resistance by mechanical inoculation (using a 10^{-1} and 10^{-2} dilution of infected plant extract) under controlled greenhouse conditions. The thrips injury score and PBND incidence of the selected genotypes are presented in Table 1. The thrips injury score of ICGV numbers 86029, 86031, 86388, 89281, 90046, 91177, 91180, 91220, 91223, 91239, 91241, 91245, 91246, 91249, and an interspecific derivative 346-2 ranged from 2.5 to 5.0, compared with 7.5 of the susceptible control ICGV 87123. They also showed field resistance with a disease incidence ranging from 4.8 to 20.0%, compared with 54.4% in JL 24. Forty-two genotypes were screened for resistance to PBNV. All the genotypes were susceptible to PBNV at higher virus concentration (10^{-1} dilution). However, at the lower virus concentration (10^{-2} dilution), three genotypes, ICGV 86388, ICGV 91239, and ICGV 91245 showed resistance to the virus while the others were highly susceptible. The disease incidence in ICGV 86388, ICGV 91239, and ICGV 91245 ranged from 23 to 42%, compared with 40% in ICGV 86031 (resistant control) and 80% in JL 24 (susceptible control). Of these, ICGV 86388 was further tested in three additional inoculation tests (Table 2). The disease incidence in ICGV 86388 averaged 31% compared with 45% in ICGV 86031 and 87% in JL 24. The mean yield of ICGV 86388 over three seasons and eight locations was 2.04 t ha"^{1}, compared with 1.68 t ha^{1} of JL 24, the susceptible control (Table 3). The mean PBND incidence in these fields was 17.8% in ICGV 86388 and 60.7% in JL 24. ICGV 86388, a selection from the cross (Dh 3-20 x USA 20) x NC Ac 2232, is a sequentially branched variety with dark green elliptic leaves, mostly 2-seeded small pods, with a shelling turnover of 70%, and a 100-seed mass of 37 g. Its tan-colored seeds contain 53% oil. It has higher resistance to PBNV than the earlier reported resistant variety ICGV 86031 (Dwivedi et al. 1993).

Table 1. Thrips injury score and peanut bud necrosis disease (PBND) incidence (%) in 15 groundnut genotypes at Rajendranagar and ICRISAT Asia Center.

Genotype	Thrips injury score[1]	PBND incidence (%)		
			Mechanical inoculation[3]	
		Field[2]	10^{-1}	10^{-2}
ICGV 86029	4.0	20.0	100.0	69.0
ICGV 86388	5.0	15.0	90.0	37.0
ICGV 91177	4.0	4.8	80.0	85.0
ICGV 91180	4.0	10.8	83.0	83.0
ICGV 91220	3.5	15.8	100.0	70.0
ICGV 91223	3.5	14.8	95.0	52.0
ICGV 91239	2.5	10.0	81.0	23.0
ICGV 91241	4.0	7.5	62.0	65.0
ICGV 91245	4.0	7.7	100.0	42.0
ICGV 91246	4.0	8.0	54.0	48.0
ICGV 91249	4.0	8.9	94.0	56.0
346-2	2.5	12.5	[4]	-
Controls				
JL 24	-	54.4	93.0	79.5
ICGV 86031	4.5	11.1	100.0	40.2
ICGV 87123	7.5	20.5	-	-

1. Mean of nonreplicated data reported from two locations (Rajendranagar and Patancheru) during the 1992/93 postrainy season.
2. Nonreplicated data from the 1992 rainy season.
3. Plants were mechanically inoculated with 10^{-1} and 10^{-2} dilution of infected plant extract during the 1993 rainy season under controlled greenhouse conditions.
4. - = data not available.

Table 2. Cumulative peanut bud necrosis disease (PBND) incidence (%) of ICGV 86388 and controls by mechanical inoculation under controlled greenhouse conditions, ICRISAT Asia Center, 1993-95.

Genotype	Cumulative PBND incidence (%) at 10^{-2} dilution of infected plant extract			Mean
	1993/94	1994	1994/95	
ICGV 86388	17.7 (24.4)[1]	52.7 (46.6)	21.0 (27.4)	30.5
Controls				
ICGV 86031	26.2 (17.4)	71.7 (58.0)	37.0 (37.6)	45.0
JL 24	78.2(62.8)	93.7 (76.9)	90.0 (72.1)	87.3
SE	(±4.27)	(±2.64)	(±1.86)	[2]
CV (%)	(23.0)	(11.0)	(9.0)	

1. Figures in parentheses are angular transformed values.
2. - = data not available.

Table 3. Pod yield and peanut bud necrosis disease (PBND) incidence (%) of ICGV 86388 and JL 24.

Genotype	Pod yield (t ha-[1])				Mean PBND incidence[4] (%)
	1988[1]	1989[2]	1993[3]	Mean	
ICGV 86388	2.10	2.38	1.35	2.04	17.8
JL 24 (control)	1.65	2.24	0.95	1.68	60.7

1. Mean of six locations.
2. Mean of three locations.
3. Mean of two locations.
4. PBND incidence averaged over three rainy seasons under field conditions.

Breeding Strategy

The breeding strategy to improve the level of field resistance includes improving the resistance to thrips and to PBNV, and combining them in superior agronomic backgrounds. The segregating populations (F_2 and subsequent generations) derived from crosses made with these objectives are sown late in the season at wider spacing. The wider spacing and late sowing encourage thrips infestation. These populations are advanced by the bulk pedigree method under mild selection pressure for yield. Each population is divided into different bulks, based on plant type and pod and seed characteristics at the time of harvest. The advanced generation bulks (F_5) are initially screened for field resistance in a nonreplicated, one-row plot disease nursery at Narkoda, Andhra Pradesh. The Narkoda location achieves high disease incidence in most years. The resistant (ICGV 86031) and susceptible (JL 24) controls are sown after every 10 rows of test materials. The PBND incidence is recorded from 30 days after sowing (DAS) at a 15-day interval until 1 week before harvest. The promising uniform bulks are then assigned ICGV numbers and are further screened in replicated trials at Narkoda and at Mainpuri in Uttar Pradesh. The field-resistant varieties, selected on the basis of two seasons of screening, are evaluated for their yield potential under high- and low-input conditions at IAC. They are also screened for resistance to the vector under field conditions, and for resistance to PBNV by mechanical inoculation (using 10^{-1} and 10^{-2} dilutions of infected plant extract) under greenhouse conditions. The varieties with combined resistance to the vector and PBNV are again used in the crossing program at IAC and are also supplied to national programs for further agronomic evaluation.

Progress in Resistance Breeding

Several high-yielding cultivars released in India such as ICGVs 87123 (ICGS 11), 87128 (ICGS 44), 87187 (ICGS 37), and 87141 (ICGS 76), which were developed primarily for high yield potential, were found to have field resistance. Following the above approach, several new high-yielding varieties have been developed with higher levels of field resistance (Table 4). The average PBND incidence in these varieties ranged from 13.6 to 23.7% compared with 16.7% in ICGV 86031 and 58.4% in JL 24. ICGVs 91228 and 90013 produced high mean pod yield (3 t ha^{-1}). While ICGV 91228 is better adapted to the rainy season, ICGV 90013 is adapted to both rainy and postrainy seasons. The mean pod yield of ICGV 86031 and JL 24 in these trials was 2.671 ha^{-1} and that of JL 24 was 1.98 t ha^{-1}. JL 24, an early-maturing cultivar, is widely adapted to rainfed conditions in India. It has also been released in Myanmar and the Philippines under different names. Whereas

Table 4. Performance of selected peanut bud necrosis disease (PBND) field-resistant groundnut varieties, ICRISAT Asia Center, rainy and postrainy seasons, 1993 and 1994.

	Pod yield (t ha^{-1})						
	Rainy 1994	Postrainy 1993/94		Rainy 1993			
Variety	EBDRGVT[1] (SB/VB)	ABDRGVT (SB)	ABDRGVT (VB)	ABDRGVT (SB)	ABDRGVT (VB)	Mean	PBND (%)[2]
ICGV 91228	2.14	-3	4.01	-	2.85	3.00	21.0
ICGV 90266	2.08	-	3.56	-	2.45	2.70	20.8
ICGV 91229	2.08	-	3.95	-	2.78	2.94	20.3
ICGV 91190	2.06	4.29	-	2.44	-	2.93	16.4
886 x 2741	2.01	-	4.18	-	2.73	2.97	15.6
ICGV 90009	1.77	3.59	-	2.60	-	2.65	21.2
ICGV 90013	1.77	4.45	-	2.81	-	3.01	20.3
ICGV 91192	1.73	4.36	-	2.35	-	2.81	15.1
ICGV 91071	1.62	-	3.89	-	2.65	2.72	23.7
ICGV 90056	1.62	-	4.18	-	2.39	2.73	22.6
ICGV 91249	1.60	.	3.64	-	2.34	2.53	17.2
ICGV 86598	1.54	3.24	-	2.46	-	2.41	16.4
ICGV 91053	1.52	3.96	-	2.66	-	2.71	19.7
ICGV 91177	1.42	4.16	-	2.07	-	2.55	13.6
ICGV 88248	1.35	3.13	-	1.81	-	2.10	14.9
Controls							
ICGV 86031	1.39	4.37	4.28	1.23	2.09	2.67	16.7
JL 24	1.08	2.52	2.70	1.42	2.17	1.98	58.4
SE	±0.118	±0.247	±0.226	±0.200	±0.175		
CV (%)	12	11	10	19	13		

1. EBDRGVT = Elite Peanut Bud Necroses Disease Resistant Groundnut Varietal Trial, ABDRGVT = Advanced Peanut Bud Necroses Disease Resistant Groundnut Varietal Trial, VB = Virginia Bunch, SB = Spanish Bunch.
2. Mean of six locations.
3. - = data not available.

the newly developed varieties show better field resistance and have a greater yield potential than JL 24, they have 5-8% lower shelling percentage and are late-maturing. However, some of them, e.g., ICGV 90013, 90056, and 88248, contain more oil (50%) than JL 24 (45%).

Of the several interspecific derivatives evaluated for field resistance and yield, only 886 x 2741 showed stable resistance (mean PBND incidence 15.6%;) and high pod yield (2.97 t ha^{-1}). It is derived from a cross between A *hypogaea* x A. *cardenasii.*

The field-resistant varieties reported here are not immune to the disease but have reduced disease incidence under field conditions. The resistance in these varieties is mainly due to their moderate resistance to the vector. Most lack resistance to the virus. ICGV 86031 and ICGV 86388 also have, in addition to vector resistance, PBNV resistance at lower virus concentration. Considering the level of resistance to the vector and to PBNV in newly developed varieties, it seems that further improvement in the level of resistance through conventional breeding may be difficult to achieve.

References

Amin, P.W., and Mohammad, A.B. 1980. Groundnut pests research at ICRISAT. Pages 158-166 *in* Proceedings of an International Workshop on Groundnuts, 13-17 Oct 1980, ICRISAT Center, India. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Amin, P.W., and Reddy, D.V.R. 1983. Assessment of yield loss from bud necrosis disease of groundnut in Andhra Pradesh, India in the rabi 1981-82 season. Pages 333-336 *in* Proceedings of the National Seminar on Crop Losses due to Insect Pests, 7-9 Jan 1983, Andhra Pradesh Agricultural University, Rajendranagar, Hyderabad, Andhra Pradesh, India (Krishnamurthy Rao, B.H., and Murthy, K.S.R.K., eds.). Vol. 2. Hyderabad, India: The Entomological Society of India. [Special issue: Indian Journal of Entomology, 1983.]

Dwivedi, S.L., Reddy, D.V.R., Nigam, S.N., Ranga Rao, G.V., Wightman, J .A., Amin, P.W., Nagabhushanam, G.V.S., Reddy, A.S., Scholberg, E., and Ramraj, V.M. 1993. Registration of ICGV 86031 peanut germplasm. Crop Science 33:220.

Ghanekar, A.M., Reddy, D.V.R,, Iizuka, N., Amin, P.W., and Gibbons, R.W. 1979. Bud necrosis of groundnut *(Arachis hypogaea* L.) in India caused by tomato spotted wilt virus. Annals of Applied Biology 93:173-179.

Patil, S.A. 1993. Bud necrosis disease in Karnataka. Pages 28-31 *in* Proceedings of a Workshop on Collaborative Research in India on Breeding Groundnuts for Resistance to Bud Necrosis Disease, 28 Sep 1992, ICRISAT Asia Center, India. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. (Limited distribution.)

Reddy, D.V.R, Wightman, J A , Beshear, R.J., Highland, B., Black, ML, Sreenivasulu, P., Dwivedi, S.L., Demski, J.W., McDonald, D., Smith Jr, J.W., and Smith, D.H. 1991. Bud necrosis: a disease of groundnut caused by tomato spotted wilt virus. Information Bulletin no. 31, Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.