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STATUS OF RESISTANT GERMPLASM IN EGGPLANT AND WILD *SOLANUM* SPECIES

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Resistant sources reported from *Solanum melongena* L. and wild *Solanum* species, for various pests and diseases have been listed and references cited. Several agricultural universities and research institutes have collected rich diversity of eggplant land races and other species of non- tuberiferous *Solanum*. The national germplasm collection and conservation responsibility is with the National Bureau of Plant Genetic Resources (NBPGR) and a total of 2419 accessions have been collected, conserved and evaluated for 44 agro- botanical characters at the Bureau. Scope for further identification and utilization of resistant sources has been discussed.

Key words : Aubergines, brinjal, eggplant, resistant germplasm, resistance mechanism, multiple resistance, *Solanum melongena* L., wild *Solanum*.

The eggplant, also known as brinjal and aubergine, is a native of India and has been cultivated in this country since ancient times. In India, the National Bureau of Plant Genetic Resources (NBPGR) is actively involved in building up germplasm through explorations and introductions, its characterization and subsequent identification of suitable donor types for utilization by user agencies in crop improvement programmes. Further International Plant Genetic Resources Institute, has also given top priority for collection, characterization, evaluation, documentation and conservation from south Asia. The main objectives in eggplant breeding are to incorporate traits for good quality, resistance to diseases such as little leaf, bacterial wilt, *Fusarium* wilt and *Phomopsis* blight and pests viz., shoot and fruit borer, jassids, aphids and spotted beetles and nematodes. In this article on attempt has been made to review the work done at various research centres and the progress made in resistance breeding in eggplant and to suggest further avenues of the breeding.

Pest and Disease Problems in Eggplant

In most of the tropical countries including India eggplant is attacked by a number of insect pests, diseases and nematodes during various stages of crop growth. The extent of losses caused by these pests depend on season, variety, soil and other factors (Dhamdhere *et al.*, 1995; Roy and Pande 1995).

Shoot and fruit borer (*Leucinodes orbonalis* Guen.) infestation is the major constraint to the production of eggplant not only in the Indian sub-continent but also in South Africa, Congo and Malaysia. In India the states in which very high yield losses have been recorded are Haryana, 63% (Dhankar *et al.*, 1977; Punjab, 61% (Singh and Guram, 1967); Tamil Nadu, 54% (Srinivasan and Gowder, 1959); Bengal, 50% (Som Chaudhury, 1973) and Maharashtra, 48% (Mote, 1981). Vitamin C in affected plants is reported to be reduced by 60% (Hami, 1955). The other insect pests, which cause considerable losses to the eggplant include the jassid, *Amrasca biguttula biguttula* Ishida, the aphid *Aphis gossypii* Glover and spotted beetle *Epilachna vigitioctopunctata* Fabr. (Borah, 1995).

Among the diseases, *Phomopsisi* blight, is a serious disease of eggplant and its infection as seedling blight, leaf spot and fruit rot is very common. This fungus perpetuates in soil and lives on affected host tissues, and is specific to eggplant. Once the seeds are sown or the seedlings are transplanted in the infested soil, the origanism becomes active. Bacterial wilt caused by *Pseudomonas solanacearum* has become a serious problem in India and most of the commercial varieties are susceptible to this disease. Little leaf of eggplant caused by Mycoplasma is another serious disease, resulting in crop damage ranging from 40 to 80% (Anjaneyulu, 1969).

To protect eggplant from depredation of common insect pests and from attack by several diseases and root-knot nematodes, several workers have suggested various control measures in the past. With the continuous use of chemicals for control, the targetted pests may become resistant to chemicals. Further the present control measures are not fully effective and are expensive and hazardous. Hence there is need for resistant cultivars to be developed.

Eggplant Germplasm Resistant to Pests and Diseases

Solanum melongena L. and its wild relatives are widely distributed in this sub-continent. About 22 species of non- tuberiferous *Solanum* are recorded in India (Bhaduri, 1951). A large number of workers have attempted screening of available germplasm including land races, local cultivars and wild *Solanum* species to detect the sources of resistance against various pests and diseases. Sources of resistance has been identified against major pests in the cultivated species viz., *Solanum melongena*. The major pests against which the resistance sources has been identified are bacterial wilt, *Phomopsis* blight, little leaf, brinjal shoot and fruit borer, leafhoppers, spotted beetles and root knot nematodes (Table 1).

Table 1. Sources of resistant germplasm in eggplant cultivars against various pests and diseases

Pest/Disease	Source of resistance	Reference
Bacterial wilt (*Pseudomonas solanacearum*)	WCGR 112-8 (resistant)	Gopinath & Madalageri (1986)
	Dingra's Multiple Purple, Sinampiro, Pusa Purple Cluster (resistant)	Rao *et al.*
	Pusa Purple Cluster (PPC), (resistant)	Mukherjee & Mukhopadhyay (1982)
	BB-11, BB-7 (resistant)	Sharma & Kumar (1995)
	BWR-34, PPC (resistant)	Bora *et al.*, (1993)
	BWR-54, PPC (immune)	Baleswar Singh (1991)
Phomopsis blight (*Phomopsis vexas*)	11a, 264 & 238 (highly resistant)	Kalada *et al.*, (1976)
Little leaf (Mycoplasma)	PPC (resistant)	Kale *et al.*, (1986)
	Nurki, Bowad Local No.4, Chikalgaon Local No.1, PPC (resistant)	Chakrabarty & Chaudhury (1974)
	Hissar Shyamal & H-10 (tolerant)	Kalloo (1994)
	Sel. 212-1, Sel 252-2-1 (resistant)	Chakrabarty & Chaudhury (1975)
	SM-78 × Sm-79, SM-78 × S-745 SM-77 × SM- 60, SM-75 × Sm-74	Ponnuswami & Irulappan (1993)
	SM-75 × SM-60 (F_2 generations of these crosses found resistant)	
Root-knot nematodes		
M.incognita race 1 & 2	Gulla (resistant)	Ravichandra *et al.*, (1990)
M.incognita	Local Round (resistant	Das *et al.*
	Vijaya & Black Beauty (resistant)	Yadav *et al.*
All root-knots	Sel.419, Sel.96-2, @olbaigan (resistant)	Verma & Chaudhury (1974)
	Black Beauty, T-2(UP), Vijaya, Banaras Giant (resistant)	Nandwana *et al.*, (1980)
Shoot & Fruit borer (*Leucinodes arbonalis* Gen.)	Banaras Giant, S-34, Arka Kusumakar, SM-215, S-258, SM-62, P-5-8, SM-2, S-2070	Pawar *et al.*, 1986

(*Contd. on next page*)

Pest/Disease	Source of resistance	Reference
	Malkapuri, Shirur Khandala-1, Khanpur, Rajangona, Songona Kagal (moderately resistant)	
	Tambalwadi Local, Gopuri, Pusa Purple Round, Jalagaon Local, Hingana,Dorla, Baramati, Punjab Bahar, Junagadh Bhattu (highly resistant to shoot infestationcvs), Nurki, PPC, Gulabi Dorla (highly resistant to fruit infestation)	
	Arka Kusumakar, Nischintapur, Brinjal Long Green, Attapati, Arka Shirish, Manipur, Makra and Chikon Long (relatively resistant)	Gangopadhyay *et al.*,(1996)
	Pusa Puple Long, H-128, H-129	Gill & Chadha (1979)
	Aushey (tolerant)	Dhankar *et al.*,(1977)
	Thorn Pendy, Black Pendy H-165, H-407 (tolerant)	Panda *e' al.*,(1971)
	Ex Beckwai, IHR-191 (tolerant)	Krishnaiah & Vijay (1975)
	SM-202, S-519, S-520, S-521, Solan-11, PPC-2 (tolerant	Lal *et al.*,(1976)
	S-4, H-4, Punjab chamkila, PPC (tolerant)	Gill & Chadha (1979)
	SM-17-4, PBR-129-5, Punjab Barsati (tolerant)	Singh & Chadha (1990)
	Nischindipur Local, Muktajhuri, Shymala Dhepa, Navkiran, Banaras Long Purple, BB-1, Murshidabad Local (tolerant)	Mukhopadhyay & Mandal (1994)
	Long Purple (tolerant)	Mehto & Lal (1981)
	Nimbkar green, Arka Kusumakar, SM-213 (tolerant)	Mote (1981)
	Ringen Giant, PPC, SM-62 (tolerant)	Nathan (1983)
	Kuchia	Ishaq & Chaudhuri (1984)
	Singnath	Kabir *et al.*, (1984)
	SM-17-4	Tewary & Moorthy (1985)
	IC-089864A and IC-144524	Sarath Babu *et al.*, (1997)
Leaf hoppers (*Amrasca biguttula biguttula* Ishida)	H4, Round Green, Dorly, Aushey, Mote (1978) Jumblimulayam (resistant)	

(Contd. on next page)

Pest/Disease	Source of resistance	Reference
	Junagadh Sel.1, Aushey, R-34, H-4, T-3 (resistant)	Bindra & Mahal (1981)
	S-188-2, S-258, S-34, PPC-Manjri Gola, Dorli, Mukti	Pawar *et al.*, (1986)
	Borgona-1, Local Khandesh, Khedshivpur (mod.resistant)	
	Pusa Kranti (tolerant)	Mote, (1982)
Aphids (*Aphis gossypii* Glover)	Sufal, Navkiran, ARM- 3, Krishna, Brinjal Long Green, Suttons Long (tolerant), KB-9, PPR, PPL, Banaras Giant, L-13, KB-5, Navkiran, BB-1,KB-10, Improved Muktakheshi (tolerant)	
	S-5	Subbaratnam & Butani (1981)
Spotted beetles (*Epilachna* spp.)	Arka Shirish, Hissar Sel.1-4 Shankar Vijay (res.cvs)	Raj & Kumarswami (1979)
	Shyamala Bhangar	Mukhopadhyay & Mandal (1994)

Multiple resistance:

Although several workers have reported multiple resistance in the wild species of *Solanum*, there has not been enough success in transferring resistance to *Solanum melongena* cultivars due to the incompatibility arising from the genetic make of different species. Mukhopadhyay and Mandal (1994) described cultivars Shyama Dhepa, Kalo Dhepa, Improved Muktakeshi, Banaras Long Purple and BB-1, as having multiple resistance against all the important insect pests. Literature search revealed some more cultivars of *S.melongena* having resistance to more than one pest (Table 2).

Table 2. Available cultivars with multiple resistanc

Cultivars	Resistance Available Against
Pusa Purple Cluster	Bacterial wilt, Little leaf and Shoot and fruit borer
Pusa Kranti	Leaf hopper and Bacterial wilt
Sm-17-4	Shoot and fruit borer and Little leaf
Pusa Purple Long, S-34, S-258, Aushey and H-4	Leaf hopper and Shoot and fruit borer
Shyama Dhepa, Kalo Dhepa, Improved Mukthakheshi, Banaras Long Purple and BB-1	Shoot and fruit borer, Leaf hopper and Aphids
Vijaya and Black Beauty	All species of *Meloidogyne*
Banaras Giant	Shoot and fruit borer and all species of *Meloidogyne*

Resistance sources from wild *Solanum* species

A large number of workers have found that wild *Solanum* species related to eggplant possess genes for resistance to diseases and insects (Table 3). The

Table 3. Source of resistant germplasm from wild eggplant relatives

Pest	Source of resistance	Reference
Bacterial wilt	*Solanum melongena var. insanum* (resistant & highly compatible with certain cvs)	Gopimany & George (1979)
Phomopsis blight	*S.xanthocarpum, S.indica S.gilo, S.khasianum, S.nigrum S.torvum* (resistant)	Kalada *et al.*, (1976)
Little leaf	*S.viarum* (immune), *S.indicum* & *S.sisymbrifolium* (resistant)	Chakrabarty & Choudhury (1974)
	S.integrifolium, S.gilo (resistant)	Chakrabarty & Choudhary (1975)
	S.viarum (immune)	Kale *et al.*, (1986)
Meloidogyne javanica	*S. torvum, S.macrocarpum, S.sisymbrifolium, S.warscewiczii* (resistant)	Vito *et al.*, (1992)
M.incognita	*S.khasianum, S.torvum, S.toxicarium* (immune)	Ali *et al.*, (1992)
	S.torvum, S.seaforthianum (resistant)	Shetty & Reddy (1985)
	S.torvum, S.macrocarpum, S.sisymbrifolium, S.warscewiczii (resistant)	Vito *et al.*, (1992)
M.arenaria	*S.sisymbrifolium, S.torvum* (resistant)	Vito *et al.*, (1992)
All root-knots	*S.torvum* (resistant)	Chadha (1988)
	S.sisymbrifolium, S.elaegnifolium (resistant)	Verma & Chaudhury (1974)
Shoot & Fruit borer	*S.incanum, S.xanthocarpum, S.Khasianum, S.sisymbrifolium* (immune)	Kale *et al.*, (1986)
	S.sisymbrifolium, S.khasianum S.xanthocarpum, S.nigrum (resistant)	Lal et al., (1976)
	S.incanum, S.khasianum, S.macranthum, S.mammosum (resistant)	Baksh & Iqbal (1979)
	S.macrocarpon (resistant)	Gangopadhyay et al., (1996)
	S.surattense, S.sisymbrifolium, S.indicum, S.viarum, S.aculeatissimum (resistant)	Sarath babu *et al.*, (1997)

wild species of *Solanum* have shown high degree of resistance besides immune reactions to several diseases and insects (Kale *et al.*, 1986). But these genes appear to have limited use in resistance breeding because of the difficulties in the interspecific hybridization. Sharma *et al.*, (1980) successfully crossed *S. khasianum* and *S. melongena* by embryo culture, but further studies were impossible due to failure in germination of the F_2 seed. Field resistance to fruit and shoot borer in the progenies derived from interspecific hybridization such as *S. incanum*× *S. melongena* (Baksh and Iqbal, 1979; Rao, 1981), *S. melongena* × *S. indica* (Rao and Kumar, 1980) and *S. melongena* × *S. integrifolium* (Rao and Baksh 1981) has been reported. It remains to be seen whether the resistance of wild relatives can be combined with acceptable fruit quality.

Kalada *et al.* (1976) studied the resistance to *Phomopsis vexans* in 399 entries, including wild *Solanum* species, eggplant cultivars and interspecific F_1 hybrids. *S. xanthocarpum, S. indicum, S. gilo, S. khasianum, S. nigrum* and *S. sisymbrifolium* were highly resistant and 2 lines of *S. melongena* were found resistant. The reactions of F_1 hybrids were variable. It was further observed that resistance to *Phomopsis* blight was recessive and governed by polygenes. Dominance gene effects were more pronounced than the additive in most of the crosses (Kalada *et al.*, 1977). Decker (1951) released two cultivars by hybridization namely Florida Market and Florida Beauty resistant to *Phomopsis* blight. The wild eggplant *S.melongena var. insanum* is reported to be resistant to bacterial wilt and is highly compatible with certain cultivars of eggplant (Gopimany and George, 1979).

Verma and Chaudhury (1974) reported that Sel. 96-2, Polbaigan and the wild species *S. sisymbrifolium* and *S. elaegnifolium* are highly tolerant to *Meloidogyne* spp. under field and lab conditions.

Resistance mechanism

Not much information is available on the genes involved in the resistance to eggplant pests. Identification of morphological or biochemical factors governing resistance will be helpful in the development of rapid screening techniques.

Resistance may be due to antixenosis or non-preference, and appears to have a biochemical basis in the case of insect pest complex, although non-preference for some cultivars has been attributed to histological factors such as compact vascular bundles in a thick layer, with lignified cells and less area of pith in the shoots (Panda *et al.*, 1971; Chellaiah and Srinivasan, 1983). Similarly, hardness of fruit skin and flesh due to a compact seed arrangement (Srinivasan and Basheet, 1961; Krishnaiah and Vijay, 1975; Mishra *et al.*, 1988), tight calyx to hinder initial larval entry into fruits (Panda *et al.*, 1971; Chellaiah and Srinivasan, 1983; Malik *et al.*, 1986) contribute to the non-preference for cultivars. Dilbagh Singh and Chadha (1991) attributed the resistance in SM- 17-4, PBr-129-5 and Punjab Barsati against *Leucinodes arbonalis* to a large number of small sized fruits per plant with shorter inter/intra cluster distance, late fruiting and longer fruiting period. Lal (1991) reported on the basis of fruit number, SM-202 was highly resistant, while Pusa Purple Cluster, SM-17-4, PBr-129-5 and SM202XPP1 (F_1) were fairly resistant. Medium and long fruited, KT-4, Large Round White and Long White Cluster were graded as tolerant. According to Pradhan (1966) long narrow fruited eggplant varieties were less infested than spherical fruited. Preference for egg laying was low in resistant varieties than susceptible ones, which may be one of the mechanisms of resistance. Larvae bore more successfully in round fruits than long fruits.

Resistance to jassid reported by earlier workers was due to more density and length of the hair on the leaves (Candena and Balatezàr, 1947). Gaikwad *et al.*, (1991) attributed resistance to jassid to leaf and midrib thickness and leaf area in eggplant.

Antibiosis as a basis for resistance in case of shoot and fruit borer was reported by Panda and Das (1975), who found that higher silica and crude fibre content in the shoots of resistant cultivars adversely affected the survival, growth, pupal period, sex ratio and fecundity. The higher content of sugars and amino acid acted as feeding stimulants in susceptible cultivars. Similarly, Ishaque and Chaudhuri (1984) observed low protein and sugar contents in resistant genotypes. Panda and Das (1975) suggested that resistance in Thorn Pendy and Black Penduy was due to the combined effect of antixenosis and antibiosis. As a result of high silica and crude fibre in the shoots, the larvae found difficulty in feeding. The insect also disliked feeding on them due to their low sugar and amino acid content. Due to the adverse affect on the pest life cycle, infestation of these genotypes started late and remained at a low level. Bajaj *et al.*, (1989) reported that the variety SM-17-4 which is relatively field resistant to shoot and fruit borer had higher glycoalkaloid content, peroxidase and polyphenol oxidase activity than the susceptible Punjab Chamkila. It is suggested that glycoalkaloids in association with phenolic compounds may be conferring resistance to eggplant towards the pest. Similar results were obtained by Darekar *et al.*, (1991). Gaikwad *et al.*, (1991) reported that total level of sugars, free amino acids and polyphenols in the leaves of eggplant were negatively correlated to jassid infestation.

Swaminathan and Srinivasan (1972) indicated that resistance to *Phomopsis* blight was recessive and genetically inherited. Dominance gene effects are more pronounced than additive in most of the crosses studied. Also they indicated that the resistance to bacterial wilt was controlled by single dominant gene. Chadha (1988) reported that *Solanum torvum* was resistant to root knot nematodes. It was used as arootstock for tongue grafting in a number of chosen cultivars of eggplant. The grafted hybrids behave as perennials and yield 3 to 4 times more.

Scope for Further Utilization of Resistance Sources

During the last three decades, work on eggplant collection from within the country and introduction from abroad, has been in progress at NBPGR, New Delhi. Extensive collections have been made under NBPGR/IPGRI collaborative project from all parts of India and parts of neighbouring countries like Bangladesh, Sri- Lanka and Nepal. As a result about 2531 germplasm accessions of *S.melongena* and about 337 accessions of related wild species have been assembled and these germplasm have been characterized in phased manner at NBPGR. Right now documented information on 1188 accessions characterized for 52 agro-botanic descriptions is available in the form of a catalogue at NBPGR.

Review of resistance indicates that information or sources and mechanism of resistance is available mainly for insect pests particularly shoot and fruit borer and leafhoppers. A number of morphological characters have been identified that have a direct or indirect bearing on pest resistance in eggplant. Table 4 lists these characters and their states associated with pest resistance. The number of accessions in the NBPGR germplasm collection having these features are also indicted in the table.

Table 4. Potential eggplant morphological character and the number of corresponding germplasm available at NBPGR for use in the resistance breeding

Character	Number of Accessions available
Stem spininess	14
Petiole spininess	5
Leaf spininess	80
Long fruited (more than 35 cm long)	14
Fruit calyx prickles (many)	2
Fruit pedicle prickles	3
Very many seeds/fruit (tightly arranged)	8
Number of fruits/cluster (more than 4)	14
Number of clusters/plant	18

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