

REVIEW

HOSTPLANT RESISTANCE IN RICE : PLANTHOPPERS

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Rice planthoppers, the brown planthopper (BPH), *Nilaparvata lugens* (Stal.) and the whitebacked planthopper (WBPH), *Sogatella rcifera* (Horvath) (Delphacidae : Hemiptera) are considered as the 'Green Revolution' induced pests. Importance of resistant rice cultivars in the rice pest management programme was realised in 1967 for the BPH and in 1973 for WBPH (Heinrichs, 1988). In all rice growing countries, national breeding programmes are being implemented to evolve resistant rice varieties to the planthoppers. There has been a substantial progress in this area and a number of varieties resistant to BPH and WBPH are now available for commercial cultivation in our country (Table 1). A large number of resistant sources have been identified for the planthoppers (Table 2). The concept of team research in developing resistant varieties has now been well appreciated by the participating scientists and in releasing modern rice varieties, there is greater awareness in infusing resistance. This paper reviews the state of art of the host plant resistance works on BPH and WBPH in India.

Brown planthopper (BPH), *Nilaparvata lugens* (Stal.)

Distinct differences in levels of resistance to the BPH under greenhouse conditions were first observed at IRRI in 1963 (Pathak *et al.*, 1969). Hence, a systematic evaluation of the world collection of *Oryza sativa* began in 1967 and by 1986, 400 accessions out of 50,000 accessions screened, have been identified as having resistance to *N. lugens* (Rapusas and Heinrichs, 1987). Most of the resistant accessions are from India and Sri Lanka. In addition, 132 wild *Oryza* spp. accessions have been identified as resistant (Heinrichs, 1988). Breeding programmes for BPH resistance have been established in most of the Asian countries and numerous varieties have been released since that of IR 76 in 1973 (Heinrichs, 1994). In India, many

BPH resistant varieties, viz., Jyothi, Co 42, Parijat, Bharti, Shakti, Sonasali, PY3, Suraksha, Sagar-Samba, Chandan, Vajram, Prathiba, Chaitanya, Krishnaveni, Nandi, MTU 4870, Bhadra, Asha, Pavizham, Karthika, Aruna, Makam, Remya, Kanakam and Udaya have been released. But biotype selection in BPH has impeded the development of resistant varieties in many areas.

BPH resistance could not be traced to any morphological or anatomical characteristics of rice plants and is usually attributed to either a lack of phagostimulants or to the presence of antifeedants (Saxena, 1986). Low concentrations of amino acids, especially the sucking stimulant, asparagine, was considered to impart resistance to BPH in Mudgo (Sogawa and Pathak, 1970). Later, Yoshihara *et al.* (1979, 1980) reported that soluble silicic acid and oxalic acid in resistant rice plants served as sucking inhibitors. But this claim was disputed by the fact that both these acids are water soluble and their occurrence in phloem sap has not yet been demonstrated. Silica, which is the elemental form of the silicic acid and occurs in the soil, is more likely to be transported through the xylem vessels. On the other hand, oxalic acid, a product of plant's cellular metabolism, is highly toxic even to the plant tissues and therefore, less likely to occur in the phloem. Using a BPH resistant Japanese breeding line, Shigematsu *et al.* (1982) identified β -sitosterol and other sterols in the phloem sap. β -sitosterol is a strong BPH sucking inhibitor and Kaneda (1982) reported that low asparagine content intensifies the inhibitory effect of β sitosterol. Volatile chemicals (essential oils, terpenoids, aldehydes, fatty acids, esters, waxes, etc.) extracted as steam distillates have been shown to affect the behaviour and biology of the BPH (Saxena and Okech, 1985) even though the exact identity of allelochemicals is yet to be made.

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Table 1. BPH resistant varieties released in India

Variety	Year of release	State	References
Suraksha (IET 7946)	1992	Andhra Pradesh	Prasada Rao <i>et al.</i> (1992)
PY3 (IR 13428 -45-2)	1985	Podicherry	Bhagavndos <i>et al.</i> (1985)
Sagar-Samba (RNR 52147)	1994	Andhra Pradesh	Kashikar <i>et al.</i> (1994)
Chandan (RNR 74802)	1989	Andhra Pradesh	Kashikar <i>et al.</i> (1990)
Vajram (MTU 5249)	1986	Andhra Pradesh	Suryanarayana <i>et al.</i> (1993)
Prathiba (MTU 5293)	1987	Andhra Pradesh	Suryanarayana <i>et al.</i> (1993)
Chaitanya (MTU 2067)	1988	Andhra Pradesh	Suryanarayana <i>et al.</i> (1993)
Krishnaveni (MTU 2077)	1989	Andhra Pradesh	Suryanarayana <i>et al.</i> (1993)
Nandi (MTU 5182)	1990	Andhra Pradesh	Suryanarayana <i>et al.</i> (1993)
MTU 4870	1991	Andhra Pradesh	Suryanarayana <i>et al.</i> (1993)
Bhadra (MO 4)	1978	Kerala	Bai <i>et al.</i> (1992)
Asha (MO 5)	1980	Kerala	Bai <i>et al.</i> (1992)
Pavizham (MO 6)	1982	Kerala	Bai <i>et al.</i> (1992)
Karthika (MO 7)	1985	Kerala	Bai <i>et al.</i> (1992)
Arma (MO 8)	1990	Kerala	Bai <i>et al.</i> (1992)
Makam (IET 9268)	1990	Kerala	Remabai <i>et al.</i> (1992)
Remya (IET 9266)	1990	Kerala	Remabai <i>et al.</i> (1992)
Kanakam (MO 11)	1990	Kerala	Remabai <i>et al.</i> (1992)
Udaya (CR 190-103)	1985	Orissa	Misra <i>et al.</i> (1985)

Cook *et al.* (1987) suggested that the surface of the rice plant plays a role in food plant selection by the BPH. Surface waxes have been shown to affect BPH behaviour. Reduced settling and probing of the plant surface after the exploration and movement off of the stem on to the leaves results from chemical cues in the wax. Chemical cues received by the BPH from the plant surface originate from the alkanes or carbonyl compounds of the epicuticular wax and vary among cultivars. Analysis indicates that the chemical differences between waxes are due to a higher ratio of long to short carbon chain components in resistant cultivars. The enhanced surface activity and BPH dispersal from IR 46 (Woodhead and Padjham, 1988) may account for the field resistance of this cultivar (Heinrichs, 1986). The resistance mechanism is believed to be associated with minor genes which could be exploited in breeding for polygenic resistance to the BPH. Briefly, rice breeders have identified at least ten major genes conferring resistance to various populations of BPH. Resistance conferred by five genes, **Bph1**, **Bph3**, **Bph6**, **Bph9** and **Bph10** is inherited with dominance, whereas resistance conferred by the others, **bph2**, **bph4**, **bph5**, **bph7** and **bph8** is inherited recessively. **Bph1** and **bph2** are tightly interlinked, as are **Bph3** and **bph4**; therefore, no rice cultivar can be developed with both **Bph1** and **bph2** or **Bph3** and **bph4**. The other three genes, **bph5**, **Bph6** and **bph7** apparently segregate

independently of these two pairs (Kabir and Khush, 1988). Rice cultivars carrying **Bph1** gene (e.g., IR 26) were released starting in 1973, but field populations of BPHs adapted to these cultivars within three years. Cultivars containing the **bph2** gene (e.g., IR 36 and IR 42) were released starting in 1976 and gave effective BPH control for another six years. These were replaced by rice cultivars with the **Bph3** gene (e.g., IR 56 and IR 60) in 1982, but isolated cases of adaptation of BPH to **Bph3** gene have been found recently (Gallagher *et al.*, 1994). Thus field population of BPH have become successively virulent to resistance conferred by each of the first three major genes incorporated into agronomically accepted cultivars. Such virulent population of BPH have come to be known as biotypes. There are four biotypes of BPH known. Biotype 1 was prevalent in southeast and east Asia before the large scale cultivation of BPH-resistant varieties. Biotype 2 originated in 1976 in the Philippines, and biotype 3 was selected in the laboratory by rearing insects on resistant variety ASD 7. **Bph1** conveys resistance to biotypes 1 and 3 and **bph2** to biotypes 1 and 2, and **Bph3** and **bph4** convey resistance to all the three biotypes. Results of international nurseries indicated that varieties with **Bph1** or **bph2** were not resistant in southern Asia, hence biotype 4 was found in B Asia. ARC 10550, susceptible to the three biotypes in the Philippines, has a recessive gene for resistance to biotype 4. This gene was designated

Table 2. Resistant sources of rice identified for planthoppers in India

Variety	Reference
<i>Nilaparvata lugens</i>	
1117-Pavazhem-M-06	Meerzainudeen <i>et al.</i> (1990)
153	Bharathi <i>et al.</i> (1987)
160-490	Meerzainudeen <i>et al.</i> (1990)
1851	Bharathi <i>et al.</i> (1987)
306-T-1005	Meerzainudeen <i>et al.</i> (1990)
322-T-2633	Meerzainudeen <i>et al.</i> (1990)
370-T-1186	Meerzainudeen <i>et al.</i> (1990)
454-IR-2131-5-3-4	Meerzainudeen <i>et al.</i> (1990)
460-NR-117	Meerzainudeen <i>et al.</i> (1990)
474-Chitraikar	Meerzainudeen <i>et al.</i> (1990)
495-IR-1-8-1	Meerzainudeen <i>et al.</i> (1990)
563-35/1	Meerzainudeen <i>et al.</i> (1990)
604-122/1	Meerzainudeen <i>et al.</i> (1990)
789-1979	Meerzainudeen <i>et al.</i> (1990)
931-4051	Meerzainudeen <i>et al.</i> (1990)
K1	Krishna <i>et al.</i> (1980)
K302	Rana <i>et al.</i> (1994)
K384	Rana <i>et al.</i> (1994)
K411	Rana <i>et al.</i> (1994)
K62	Rana <i>et al.</i> (1994)
K580	Rana <i>et al.</i> (1994)
K634	Rana <i>et al.</i> (1994)
K635	Rana <i>et al.</i> (1994)
K667	Rana <i>et al.</i> (1994)
K688	Rana <i>et al.</i> (1994)
K689	Rana <i>et al.</i> (1994)
K705	Rana <i>et al.</i> (1994)
K707	Rana <i>et al.</i> (1994)
K81	Rana <i>et al.</i> (1994)
AC 5352	Krishna <i>et al.</i> (1980)
AC 8895	Krishna <i>et al.</i> (1980)
AC 9611	Rana <i>et al.</i> (1994)
AD 85065	Kalode <i>et al.</i> (1983)
AD 86465	Kalode <i>et al.</i> (1983)
AD 87291	Kalode <i>et al.</i> (1983)
AD 87314	Nargis <i>et al.</i> (1992)
ADR 501	Bharathi <i>et al.</i> (1987)
ADR 52	Krishna <i>et al.</i> (1980)
ADT 4	Sundara Babu and Rajendran (1986)
ADT 5	Sundara Babu and Rajendran (1986)
ADT 8	Krishna <i>et al.</i> (1980)
ADT 13	Sundara Babu and Rajendran (1986)
ADT 19	Sundara Babu and Rajendran (1986)
ADT 37	Soundaraj <i>et al.</i> (1987)
AE 1443	Krishna <i>et al.</i> (1980)
Agyasal	Pophaly and Rana (1992)
Ama Koyali	Pophaly and Rana (1992)
Anjania	Murty <i>et al.</i> (1988)
ARC 10053	Kalode <i>et al.</i> (1983)
ARC 10313	Murugan and Velusamy (1992)
ARC 10413	Kalode <i>et al.</i> (1983)
ARC 10440	Kalode <i>et al.</i> (1983)
ARC 10482	Kalode <i>et al.</i> (1983)
ARC 10550	Velusamy and Chelliah (1984)
ARC 10595	Kalode <i>et al.</i> (1983)
ARC 10600	Kalode <i>et al.</i> (1983)

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Table 2. (Contd.).

Variety	Reference
ARC 10601	Kalode <i>et al.</i> (1983)
ARC 10606	Kalode <i>et al.</i> (1983)
ARC 10618	Kalode <i>et al.</i> (1983)
ARC 10619	Kalode <i>et al.</i> (1983)
ARC 10620	Kalode <i>et al.</i> (1983)
ARC 10654	Kalode <i>et al.</i> (1983)
ARC 10660	Pophaly and Rana (1992)
ARC 10666	Kalode <i>et al.</i> (1983)
ARC 10666	Kalode <i>et al.</i> (1983)
ARC 10744	Kalode <i>et al.</i> (1983)
ARC 10756	Kalode <i>et al.</i> (1983)
ARC 10777	Kalode <i>et al.</i> (1983)
ARC 10782	Kalode <i>et al.</i> (1983)
ARC 10792	Kalode <i>et al.</i> (1983)
ARC 10815	Kalode <i>et al.</i> (1983)
ARC 10835	Kalode <i>et al.</i> (1983)
ARC 10854	Kalode <i>et al.</i> (1983)
ARC 10856	Kalode <i>et al.</i> (1983)
ARC 10944	Seshu <i>et al.</i> (1974)
ARC 10945 A	Krishna <i>et al.</i> (1980)
ARC 10969	Seshu <i>et al.</i> (1974)
ARC 10972	Seshu <i>et al.</i> (1974)
ARC 11077	Kalode <i>et al.</i> (1983)
ARC 11122	Seshu <i>et al.</i> (1974)
ARC 11220	Kalode <i>et al.</i> (1983)
ARC 11224	Kalode <i>et al.</i> (1983)
ARC 11242	Seshu <i>et al.</i> (1974)
ARC 11252	Seshu <i>et al.</i> (1974)
ARC 11253	Seshu <i>et al.</i> (1974)
ARC 11262	Seshu <i>et al.</i> (1974)
ARC 11320	Kalode <i>et al.</i> (1983)
ARC 11321	Seshu <i>et al.</i> (1974)
ARC 11342	Velusamy and Chelliah (1984)
ARC 11374	Kalode <i>et al.</i> (1983)
ARC 11704	Krishna <i>et al.</i> (1980)
ARC 11959	Kalode <i>et al.</i> (1983)
ARC 12632	Kalode <i>et al.</i> (1983)
ARC 12720	Kalode <i>et al.</i> (1983)
ARC 12864	Venugopala Reddy and Kalode (1981)
ARC 13370	Kalode <i>et al.</i> (1983)
ARC 13507	Venugopala Reddy and Kalode (1981)
ARC 13827	Kalode <i>et al.</i> (1983)
ARC 13831	Kalode <i>et al.</i> (1983)
ARC 13854	Venugopala Reddy and Kalode (1981)
ARC 13966	Venugopala Reddy and Kalode (1981)
ARC 14034	Kalode <i>et al.</i> (1983)
ARC 14342 A	Krishna <i>et al.</i> (1980)
ARC 14368	Kalode <i>et al.</i> (1983)
ARC 14378	Kalode <i>et al.</i> (1983)
ARC 14394	Kalode <i>et al.</i> (1983)
ARC 14395 A	Kalode <i>et al.</i> (1983)
ARC 14408	Kalode <i>et al.</i> (1983)
ARC 14433	Kalode <i>et al.</i> (1983)
ARC 14452	Kalode <i>et al.</i> (1983)
ARC 14452 A	Kalode <i>et al.</i> (1983)
ARC 14466	Kalode <i>et al.</i> (1983)
ARC 14477 A	Kalode <i>et al.</i> (1983)

Table 2: (Contd).:

Variety	Reference
ARC 14489	Kalode <i>et al.</i> (1983)
ARC 14491	Kalode <i>et al.</i> (1983)
ARC 14495	Kalode <i>et al.</i> (1983)
ARC 14515 A	Kalode <i>et al.</i> (1983)
ARC 14518	Kalode <i>et al.</i> (1983)
ARC 14518 A	Kalode <i>et al.</i> (1983)
ARC 14521 A	Kalode <i>et al.</i> (1983)
ARC 14521	Kalode <i>et al.</i> (1983)
ARC 14525	Kalode <i>et al.</i> (1983)
ARC 14525 A	Kalode <i>et al.</i> (1983)
ARC 14526	Kalode <i>et al.</i> (1983)
ARC 14529 A	Kalode <i>et al.</i> (1983)
ARC 14531 A	Kalode <i>et al.</i> (1983)
ARC 14531 B	Kalode <i>et al.</i> (1983)
ARC 14539	Venugopala Reddy and Kalode (1981)
ARC 14541	Kalode <i>et al.</i> (1983)
ARC 14544	Kalode <i>et al.</i> (1983)
ARC 14547	Kalode <i>et al.</i> (1983)
ARC 14548	Kalode <i>et al.</i> (1983)
ARC 14549	Kalode <i>et al.</i> (1983)
ARC 14555	Kalode <i>et al.</i> (1983)
ARC 14664	Kalode <i>et al.</i> (1983)
ARC 14668	Kalode <i>et al.</i> (1983)
ARC 14681	Kalode <i>et al.</i> (1983)
ARC 14703	Venugopala Reddy and Kalode (1981)
ARC 14766	Krishna <i>et al.</i> (1980)
ARC 14888	Kalode <i>et al.</i> (1983)
ARC 15019	Kalode <i>et al.</i> (1983)
ARC 15021	Kalode <i>et al.</i> (1983)
ARC 15380	Kalode <i>et al.</i> (1983)
ARC 15382	Kalode <i>et al.</i> (1983)
ARC 15384	Kalode <i>et al.</i> (1983)
ARC 15394	Kalode <i>et al.</i> (1983)
ARC 15460	Kalode <i>et al.</i> (1983)
ARC 15657	Kalode <i>et al.</i> (1983)
ARC 15902	Kalode <i>et al.</i> (1983)
ARC 15987	Kalode <i>et al.</i> (1983)
ARC 18037	Kalode <i>et al.</i> (1983)
ARC 5500	Venugopala Reddy and Kalode (1981)
ARC 5754	Venugopala Reddy and Kalode (1981)
ARC 5757	Venugopala Reddy and Kalode (1981)
ARC 5764	Venugopala Reddy and Kalode (1981)
ARC 5780	Venugopala Reddy and Kalode (1981)
ARC 5780 (b)	Pophaly and Rana (1992)
ARC 5834	Kalode <i>et al.</i> (1983)
ARC 5838	Venugopala Reddy and Kalode (1981)
ARC 5914	Kalode <i>et al.</i> (1983)
ARC 5917	Venugopala Reddy and Kalode (1981)
ARC 5927	Kalode <i>et al.</i> (1983)
ARC 5951	Kalode <i>et al.</i> (1983)
ARC 5956	Kalode <i>et al.</i> (1983)
ARC 5973	Venugopala Reddy and Kalode (1981)
ARC 5976	Kalode <i>et al.</i> (1983)
ARC 5981	Venugopala Reddy and Kalode (1981)
ARC 5984	Kalode <i>et al.</i> (1983)
ARC 5988	Venugopala Reddy and Kalode (1981)
ARC 6007	Kalode <i>et al.</i> (1983)

Table 2. (Contd.).

Variety	Reference
ARC 6015	Kalode <i>et al.</i> (1983)
ARC 6047	Kalode <i>et al.</i> (1983)
ARC 6060	Kalode <i>et al.</i> (1983)
ARC 6067	Kalode <i>et al.</i> (1983)
ARC 6107	Kalode <i>et al.</i> (1983)
ARC 6172	Kalode <i>et al.</i> (1983)
ARC 6215	Kalode <i>et al.</i> (1983)
ARC 6550	Kalode <i>et al.</i> (1983)
ARC 6564	Krishna <i>et al.</i> (1980)
ARC 6587	Kalode <i>et al.</i> (1983)
ARC 6601	Kalode <i>et al.</i> (1983)
ARC 6610	Pophaly and Rana (1992)
ARC 6615	Kalode <i>et al.</i> (1983)
ARC 6623	Kalode <i>et al.</i> (1983)
ARC 6624	Kalode <i>et al.</i> (1983)
ARC 6632	Kalode <i>et al.</i> (1983)
ARC 6650	Thomas (1976)
ARC 7312	Kalode <i>et al.</i> (1983)
ARC 7313	Seshu <i>et al.</i> (1974)
Aruna	Bai <i>et al.</i> (1992)
Arupatham Chormai	Velusamy <i>et al.</i> (1989)
AS 18696	Meerzainudeen <i>et al.</i> (1990)
AS 18696	Meerzainudeen <i>et al.</i> (1990)
AS 89042	Meerzainudeen <i>et al.</i> (1990)
AS 99045	Meerzainudeen <i>et al.</i> (1990)
AS 89088	Nargis <i>et al.</i> (1992)
AS 89093	Nargis <i>et al.</i> (1992)
AS 89095	Nargis <i>et al.</i> (1992)
AS 89096	Nargis <i>et al.</i> (1992)
ASD 10	Sundara Babu and Rajendran (1986)
ASD 11	Velusamy and Chelliah (1984)
ASD 18	Rangasamy <i>et al.</i> (1991)
ASD 5	Sundara Babu and Rajendran (1986)
ASD 6	Sundara Babu and Rajendran (1986)
Asha	Bai <i>et al.</i> (1992)
Asha (MO5)	Derika <i>et al.</i> (1990)
B3h Thaladi 556-2282	Meerzainudeen <i>et al.</i> (1990)
B4h 11211-11-27-1	Meerzainudeen <i>et al.</i> (1990)
B4h TR-1270-Kuruvai	Meerzainudeen <i>et al.</i> (1990)
Babawee	Velusamy and Chelliah (1984)
Badhban	Murty <i>et al.</i> (1988)
Badshahbug	Murty <i>et al.</i> (1988)
Baktya	Pophaly and Rana (1992)
Balamawee	Velusamy and Chelliah (1984)
Bangoli 3	Murty <i>et al.</i> (1988)
Banspati	Murty <i>et al.</i> (1988)
Bansphita	Murty <i>et al.</i> (1988)
Barangi	Pophaly and Rana (1994)
Barhi	Murty <i>et al.</i> (1988)
Bariksafed	Murty <i>et al.</i> (1988)
Bas Bhura	Pophaly and Rana (1994)
Bansangi	Murty <i>et al.</i> (1988)
Bataru (Bataroo)	Murty <i>et al.</i> (1988)
Bayyakonden	Velusamy <i>et al.</i> (1989)
Benwar	Murty <i>et al.</i> (1988)
Bewara	Murty <i>et al.</i> (1988)
BG 12-1	Velusamy and Chelliah (1984)

Table 2. (Contd.)

Variety	Reference
BG 367-1	Velusamy <i>et al.</i> (1981)
BG 367-4	Velusamy and Chelliah (1984)
BG 367-5	Velusamy and Chelliah (1984)
BG 367-9	Velusamy <i>et al.</i> (1981)
BG 379-1	Velusamy <i>et al.</i> (1981)
BG 379-5	Velusamy <i>et al.</i> (1981)
Bahdra	Kalode (1985)
Bhakawa	Murty <i>et al.</i> (1988)
Bharathi/IR 2071-625-2-1	James and Varkey (1977)
Bhata-Gada-Khuta	Pophaly and Rana (1994)
Bhatha Dhowi	Pophaly and Rana (1994)
Bhianspath	Pophaly and Rana (1994)
BKNBR 1030-11-2	Velusamy and Chelliah (1984)
BKNBR 1088-83	Velusamy and Chelliah (1984)
BKNBR 1139-24-3	Velusamy and Chelliah (1984)
BPT 2217	Rajendran (1992)
BPT 4363	Rajendran (1992)
BPT 4365	Rajendran (1992)
BPT 4371	Rajendran (1992)
BR 153-213-10-1-3	Meerzainudeen <i>et al.</i> (1990)
BR 51	Pophaly and Rana (1992)
Budiyabanko	Murty <i>et al.</i> (1988)
Chaitanya	Suryanarayana <i>et al.</i> (1993)
Chandan	Kashikar <i>et al.</i> (1990)
Chapdo	Murty <i>et al.</i> (1988)
Chempan	Krishna <i>et al.</i> (1980)
Chemparampandi	Krishna <i>et al.</i> (1980)
Chennellu	Krishna <i>et al.</i> (1980)
Chennirayenam	Krishna <i>et al.</i> (1980)
Cheriy Chittari	Krishna <i>et al.</i> (1980)
Chhatri	Pophaly and Rana (1992)
Chhotikanhai	Pophaly and Rana (1994)
Chinna Samba	Velusamy <i>et al.</i> (1989)
Chittari	Krishna <i>et al.</i> (1980)
Choron Bawla	Murugan and Velusamy (1992)
Chota Digha	Murugan and Velusamy (1992)
Co 1	Sundara Babu and Rajendran (1986)
Co 14	Sundara Babu and Rajendran (1986)
Co 17	Sundara Babu and Rajendran (1986)
Co 19	Sundara Babu and Rajendran (1986)
Co 21	Sundara Babu and Rajendran (1986)
Co 22	Sundara Babu and Rajendran (1986)
Co 26	Sundara Babu and Rajendran (1986)
Co 42	Kalode (1985)
Company Chittari	Krishna <i>et al.</i> (1980)
CR264-404-5	Rajendran (1992)
CR266-407-4	Rema Bai and Gopinathan Nair (1992)
Dahi Barhi	Pophaly and Rana (1994)
Dhaura Basan	Pophaly and Rana (1992)
Dhori Sulti	Pophaly and Rana (1994)
Dhour	Pophaly and Rana (1994)
Dhumki	Pophaly and Rana (1994)
Djawa Sredek	Krishna <i>et al.</i> (1980)
Djeleta	Seshu <i>et al.</i> (1974)
Dodkj	Pophaly and Rana (1994)
Dokalam	Pophaly and Rana (1994)
Eana Patta	Krishna <i>et al.</i> (1980)

Table 2. (Contd.),

Variety	Reference
Eswarana Mangalam	Krishna <i>et al.</i> (1980)
Farsa Phool	Pophaly and Rana (1994)
G453	Rana <i>et al.</i> (1994)
G703	Rana <i>et al.</i> (1994)
Gada Khota	Pophaly and Rana (1994)
Ganga Prasad	Pophaly and Rana (1994)
Ganga Puruha	Pophaly and Rana (1994)
Gapita	Krishna <i>et al.</i> (1980)
Ghaiya	Murugan and Velusamy (1992)
GS 531	Krishna <i>et al.</i> (1980)
Hasa	Pophaly and Rana (1994)
Hashikalini	Murugan and Velusamy (1992)
Hathi Pangada	Pophaly and Rana (1994)
Hinga	Pophaly and Rana (1994)
IC 25113	Krishna <i>et al.</i> (1980)
IC 25172	Krishna <i>et al.</i> (1980)
IET 5741	Velusamy and Chelliah (1984)
IET 6315	Velusamy and Chelliah (1984)
IET 6859	Velusamy and Chelliah (1984)
IET 6860	Velusamy and Chelliah (1984)
IET 7004	Velusamy and Chelliah (1984)
IET 7575	Gubbaiah and Vidya Chandra (1985)
IET 7720	Bharathi <i>et al.</i> (1988)
IET 8059	Bharathi <i>et al.</i> (1988)
IET 8371	Rao and Padhi (1986)
IET 9751	Meerzainudeen <i>et al.</i> (1990)
IET 9757	Meerzainudeen <i>et al.</i> (1990)
IET 9812	Meerzainudeen <i>et al.</i> (1990)
IET 9879	Meerzainudeen <i>et al.</i> (1990)
IET 10329	Samiayyan <i>et al.</i> (1990)
IET 10725	Samiayyan <i>et al.</i> (1990)
IET 10875	Samiayyan <i>et al.</i> (1990)
IET 11357	Nargis <i>et al.</i> (1992)
IET 11454	Samiayyan <i>et al.</i> (1990)
IET 11464	Samiayyan <i>et al.</i> (1990)
IET10486	Rana <i>et al.</i> (1994)
IET10666	Rana <i>et al.</i> (1994)
IET10797	Rana <i>et al.</i> (1994)
IET10849	Rana <i>et al.</i> (1994)
IET11105	Rana <i>et al.</i> (1994)
IET11481	Rana <i>et al.</i> (1994)
IET11582	Rana <i>et al.</i> (1994)
IET12173	Rana <i>et al.</i> (1994)
IET12195	Rana <i>et al.</i> (1994)
IET12199	Rana <i>et al.</i> (1994)
IET12204	Rana <i>et al.</i> (1994)
IET12206	Rana <i>et al.</i> (1994)
IET12767	Rana <i>et al.</i> (1994)
IET12770	Rana <i>et al.</i> (1994)
IET12776	Rana <i>et al.</i> (1994)
IET12785	Rana <i>et al.</i> (1994)
IET12793	Rana <i>et al.</i> (1994)
IET12800	Rana <i>et al.</i> (1994)
IET12802	Rana <i>et al.</i> (1994)
IET12803	Rana <i>et al.</i> (1994)
IET12805	Rana <i>et al.</i> (1994)
IET13541	Ghosh and Ganguli (1994)

Table 2. (Contd).

Variety	Reference
IET2030	Rana <i>et al.</i> (1994)
IET9259	Rana <i>et al.</i> (1994)
IR 13427-60-1	Velusamy and Chelliah (1984)
IR 13429-196-1-20	Das <i>et al.</i> (1984)
IR 1487-194-5	Seshu <i>et al.</i> (1974)
IR 1541-76-3-65	Seshu <i>et al.</i> (1974)
IR 1545-339-2	Seshu <i>et al.</i> (1974)
IR 17494-32-1-1-3-2	Velusamy <i>et al.</i> (1981)
IR 17494-32-3-4	Velusamy and Chelliah (1984)
IR 17496-32-3-4	Velusamy and Chelliah (1984)
IR 17525-56-2-2-2	Das <i>et al.</i> (1984)
IR 25884	Meerzainudeen <i>et al.</i> (1990)
IR 28127-45-2	Bharathi <i>et al.</i> (1988)
IR 29723-186-2-2-3	Bharathi <i>et al.</i> (1988)
IR 29723-88-2-3-3	Bharathi <i>et al.</i> (1988)
IR 31803-32-2	Bharathi <i>et al.</i> (1988)
IR 32822-2-2-3-2	Bharathi <i>et al.</i> (1988)
IR 24	Rema Bai and Gopinathan Nair (1992)
IR 40	Rema Bai and Gopinathan Nair (1992)
IR 52	Velusamy <i>et al.</i> (1986)
IR 62	Velusamy <i>et al.</i> (1986)
IR 64	Velusamy <i>et al.</i> (1986)
IR1552	Rema Bai and Gopinathan Nair (1992)
IR22082-41-2	Rema Bai and Gopinathan Nair (1992)
IR25984-92-1-3	Rema Bai and Gopinathan Nair (1992)
IR33059-26-2-2	Rana <i>et al.</i> (1994)
IR35353-94-2-2-3	Rana <i>et al.</i> (1994)
IR39423-124-3-3-1	Rana <i>et al.</i> (1994)
IR54742-11-10-13-21-1	Velusamy (1991)
IR54742-11-15-3-7-2	Velusamy (1991)
IR54742-11-2-8-2-1	Velusamy (1991)
IR54742-11-8-7-3-2	Velusamy (1991)
IR54742-11-8-7-3-3	Velusamy (1991)
IR54742-13-29-12-9-1	Velusamy (1991)
IR54742-13-29-12-9-2	Velusamy (1991)
IR54742-18-17-20-15-1	Velusamy (1991)
IR54742-18-17-20-15-3	Velusamy (1991)
IR54742-18-3-8-10-3	Velusamy (1991)
IR54742-1-18-12-11-2	Velusamy (1991)
IR54742-1-20-10-11-1	Velusamy (1991)
IR54742-1-20-10-11-2	Velusamy (1991)
IR54742-1-20-10-11-3	Velusamy (1991)
IR54742-22-19-3-15-3	Velusamy (1991)
IR54742-22-19-3-7-2	Velusamy (1991)
IR54742-22-19-3-7-3	Velusamy (1991)
IR54742-23-11-19-6-3	Velusamy (1991)
IR54742-23-19-16-10-2	Velusamy (1991)
IR54742-23-19-16-10-3	Velusamy (1991)
IR54742-23-19-16-12-1	Velusamy (1991)
IR54742-23-19-16-12-2	Velusamy (1991)
IR54742-25-1-23-7-1	Velusamy (1991)
IR54742-25-1-23-7-3	Velusamy (1991)
IR54742-31-16-25-22-3	Velusamy (1991)
IR54742-31-21-20-10-2	Velusamy (1991)
IR54742-31-9-26-15-3	Velusamy (1991)
IR54742-33-9-14-26-2	Velusamy (1991)
IR54742-33-9-14-26-3	Velusamy (1991)

Table 2. (Contd),

Variety	Reference
IR54742-33-9-14-26-4	Velusamy (1991)
IR54742-4-7-9-7-1	Velusamy (1991)
IR54742-5-36-4-17-2	Velusamy (1991)
IR54742-5-36-4-17-3	Velusamy (1991)
IR54742-6-1-14-15-1	Velusamy (1991)
IR54742-6-1-14-15-2	Velusamy (1991)
IR54742-6-1-14-15-3	Velusamy (1991)
IR54742-6-20-3-9-1	Velusamy (1991)
IR54745-2-10-17-8-1	Velusamy (1991)
IR54745-2-10-17-8-3	Velusamy (1991)
IR54745-2-21-12-17-2	Velusamy (1991)
IR54745-2-23-19-8-1	Velusamy (1991)
IR54745-2-2-25-26-3	Velusamy (1991)
IR54745-2-34-3-10-3	Velusamy (1991)
IR54745-2-45-3-24-3	Velusamy (1991)
IR54751-2-41-10-5-1	Velusamy (1991)
IR54751-2-41-10-5-2	Velusamy (1991)
IR54751-2-41-10-5-3	Velusamy (1991)
IR54751-4-22-10-17-2	Velusamy (1991)
IR54751-4-25-4-17-1	Velusamy (1991)
IR54751-4-6-7-21-2	Velusamy (1991)
IR54751-4-6-7-21-3	Velusamy (1991)
IR54752-50-19-19-1	Velusamy (1991)
IR54752-50-19-19-3	Velusamy (1991)
IR5741-73-2-3	Rema Bai and Gopinathan Nair (1992)
IR9830-26-3-3	Rema Bai and Gopinathan Nair (1992)
Jagnath Prasad	Pophaly and Rana (1994)
Jagratri	Rana <i>et al.</i> (1994)
Jalki	Pophaly and Rana (1994)
Jaybay Rang	Pophaly and Rana (1994)
JBS 1168	Krishna <i>et al.</i> (1980)
Jitendra	Mallik <i>et al.</i> (1995)
Jyothi	Kalode (1985)
Kabari	Sahu <i>et al.</i> (1989)
Kakadi	Pophaly and Rana (1994)
Kakadiha	Pophaly and Rana (1994)
Kalam	Pophaly and Rana (1994)
Kalamdani	Pophaly and Rana (1994)
Kalamdani	Pophaly and Rana (1994)
Kali Kamod	Pophaly and Rana (1994)
Kanai Khondharo	Pophaly and Rana (1994)
Kanak	Pophaly and Rana (1994)
Kanakam	Bai <i>et al.</i> (1992)
Kandradiya	Pophaly and Rana (1994)
Kanhaiya	Pophaly and Rana (1994)
Kankadiya	Pophaly and Rana (1994)
Kanthgulas	Pophaly and Rana (1994)
Kappe	Pophaly and Rana (1994)
Kapursar	Pophaly and Rana (1994)
Karapari	Pophaly and Rana (1994)
Karhani	Pophaly and Rana (1994)
Karthika	Bai <i>et al.</i> (1992)
Karuvai	Velusamy <i>et al.</i> (1987)
KAU 10667	Velusamy and Chelliah (1989)
KAU 126 (IET 9266)	Devika <i>et al.</i> (1990)
KAU 129 (IET 9288)	Devika <i>et al.</i> (1990)
KAU 153-1 (IET 9380)	Bai <i>et al.</i> (1990)

Table 2. (Contd).

Variety	Reference
KAU 1626-2	Velusamy and Chelliah (1984)
KAU 168	Devika <i>et al.</i> (1990)
KAU 170	Devika <i>et al.</i> (1990)
KAU 200	Devika <i>et al.</i> (1990)
KAU 204	Devika <i>et al.</i> (1990)
KAU 93	Devika <i>et al.</i> (1990)
KAU153-1	Rema Bai and Gopinathan Nair (1992)
KAU169	Rema Bai and Gopinathan Nair (1992)
KAU173-2	Rema Bai and Gopinathan Nair (1992)
KAU2084	Rema Bai and Gopinathan Nair (1992)
KAU93	Rema Bai and Gopinathan Nair (1992)
KD 14-1-39	Rajendran and Adiroubane (1990)
Khandagiri	Mohanty <i>et al.</i> (1994)
Khatia Pati	Pophaly and Rana (1994)
Kichili Samba	Velusamy <i>et al.</i> (1989)
Kochi Samba	Velusamy <i>et al.</i> (1989)
Kodagan	Velusamy <i>et al.</i> (1987)
Kothandam	Velusamy <i>et al.</i> (1987)
Kashnaveni	Suryanarayana <i>et al.</i> (1993)
Kula Peruvela	Krishna <i>et al.</i> (1980)
Kuru Hondarawala	Rema Bai and Gopinathan Nair (1992)
Lal Basant	Murty <i>et al.</i> (1988)
Lal Basumati	Krishna <i>et al.</i> (1980)
Lal Dhapa	Krishna <i>et al.</i> (1980)
Lekham Samba	Rema Bai and Gopinathan Nair (1992)
LauNgu	Krishna <i>et al.</i> (1980)
LX H/2-281	Krishna <i>et al.</i> (1980)
M102	Rema Bai and Gopinathan Nair (1992)
M66-13-45-1	Rema Bai and Gopinathan Nair (1992)
Madan	Velusamy <i>et al.</i> (1989)
Majila	Pophaly and Rana (1992)
Makam	Bai <i>et al.</i> (1992)
Mangalapuram	Velusamy <i>et al.</i> (1987)
Manika	Mohanty <i>et al.</i> (1994)
Manoharsali	Krishna <i>et al.</i> (1980)
Maranel	Velusamy <i>et al.</i> (1987)
Mawee	Krishna <i>et al.</i> (1980)
MDU3	Jebaraj <i>et al.</i> (1990)
Meher	Mohanty <i>et al.</i> (1994)
MHL1	Krishna <i>et al.</i> (1980)
MO4	Rema Bai and Gopinathan Nair (1992)
MO5	Rema Bai and Gopinathan Nair (1992)
MR 1523	Samal and Misra (1990)
MTU4870	Rema Bai and Gopinathan Nair (1992)
MTU5194	Rema Bai and Gopinathan Nair (1992)
MTU5295	Rema Bai and Gopinathan Nair (1992)
Mudukiriyal	Krishna <i>et al.</i> (1980)
Muthu Samba	Velusamy <i>et al.</i> (1989)
Naganctie	Krishna <i>et al.</i> (1980)
Nagarjuna	Prasad <i>et al.</i> (1990)
Nandi	Suryanarayana <i>et al.</i> (1993)
Nang Lay	Krishna <i>et al.</i> (1980)
OB 678	Velusamy <i>et al.</i> (1981)
P598-163-6-102	Bharathi <i>et al.</i> (1987)
P743-16-105-2	Bharathi <i>et al.</i> (1987)
P778-2-16-103	Bharathi <i>et al.</i> (1987)
Podiwi A8	Krishna <i>et al.</i> (1980)

Table 2. (Contd).,

Variety	Reference
Pandari Ajan	Pophaly and Rana (1992)
Pandi	Krishna <i>et al.</i> (1980)
Parakulam	Krishna <i>et al.</i> (1980)
Pavizham	Kalode (1985)
Ph 97	Seshu <i>et al.</i> (1974)
Pelita 1/1	Seshu <i>et al.</i> (1974)
PM 1409	Rajendran <i>et al.</i> (1987)
PM 5845	Rajendran <i>et al.</i> (1987)
Pokkali	Krishna <i>et al.</i> (1980)
Ppb 270	Seshu <i>et al.</i> (1974)
PR51673-172-1-3	Rana <i>et al.</i> (1994)
Prathiba	Suryanarayana <i>et al.</i> (1993)
Ptb 4	Sundarababu and Rajendran (1986)
Ptb 8	Velusamy and Chelliah (1984)
Ptb 13	Misra <i>et al.</i> (1986)
Ptb 15	Velusamy and Chelliah (1984)
Ptb 19	Thomas (1976)
Ptb 20	Sundarababu and Rajendran (1986)
Ptb 21	Krishna <i>et al.</i> (1980)
Ptb 247	Krishna <i>et al.</i> (1980)
Ptb 27	Sundarababu and Rajendran (1986)
Ptb 28	Krishna <i>et al.</i> (1980)
Ptb 33	Thomas (1976)
Ptb 33A	Krishna <i>et al.</i> (1980)
Ptb 41	Sundara Babu and Rajendran (1986)
PY2	Narayanasamy and Raman (1981)
PY3	Bhagavandoss <i>et al.</i> (1985)
R296-110	Rana <i>et al.</i> (1994)
R296-133	Rana <i>et al.</i> (1994)
R435-1209	Rana <i>et al.</i> (1994)
R435-65	Rana <i>et al.</i> (1994)
R649-1715	Rana <i>et al.</i> (1994)
R650-1820	Rana <i>et al.</i> (1994)
R6-2521	Shrivastava (1976)
R6-2522	Shrivastava (1976)
R845-89-43	Rana <i>et al.</i> (1994)
R847-89-1	Rana <i>et al.</i> (1994)
Rashmi	Pophaly and Rana (1992)
Rathu Heenati	Velusamy and Chelliah (1984)
RD	Velusamy and Chelliah (1984)
Remya	Bai <i>et al.</i> (1992)
RP1015-100-25-4	Rema Bai and Gopinathan Nair (1992)
RP1015-15-7-7-2	Rema Bai and Gopinathan Nair (1992)
RP1015-45-114-1	Rema Bai and Gopinathan Nair (1992)
RP1579-1398-99	Bharathi <i>et al.</i> (1988)
RP1579-1585-28-205	Bai <i>et al.</i> (1989)
RP1579-1633	Rajendran and Adiroubane (1990)
RP1579-28-54	Bai <i>et al.</i> (1989)
RP1579-52-47	Bai <i>et al.</i> (1989)
RP1579-56-1907	Rema Bai and Gopinathan Nair (1992)
RP1579-73-1864	Rema Bai and Gopinathan Nair (1992)
RP1606-1260-62	Bharathi <i>et al.</i> (1988)
RP1746-1723-8	Meerzainudeen <i>et al.</i> (1990)
RP1746-1757-62	Bharathi <i>et al.</i> (1988)
RP1746-1799-1802	Bharathi <i>et al.</i> (1988)
RP1756-39	Rema Bai and Gopinathan Nair (1992)
RP1960-1569-24-224	Bai <i>et al.</i> (1989)

Table 2. (Contd),

Variety	Reference
RP1976-18-6-4-2	Bai <i>et al.</i> (1989)
RP2068-12-1-8-1	Rao and Padhi (1986)
RP2068-17-2-2	Rema Bai and Gopinathan Nair (1992)
RP2068-18-3-1	Bai <i>et al.</i> (1989)
RP2068-18-3-5	Rao and Padhi (1986)
RP2068-18-4-5	Bai <i>et al.</i> (1989)
RP2068-32-2-2	Rema Bai and Gopinathan Nair (1992)
RP2069-3-4-1-2	Rao and Padhi (1986)
RP2071-18-1-1	Rao and Padhi (1986)
RP2076-46-4-2	Rao and Padhi (1986)
RP2081-122-45-48	Bharathi <i>et al.</i> (1987)
RP2231-51-36-4	Rajendran (1992)
RP2232-395-125-10	Bharathi <i>et al.</i> (1987)
RP2332-148-35-4	Meerzainudeen <i>et al.</i> (1990)
RP2332-16-3	Meerzainudeen <i>et al.</i> (1990)
RP2332-18-15	Rajendran (1992)
RP2332-19-9-6	Meerzainudeen <i>et al.</i> (1990)
RP2333-228-225	Rajendran (1992)
RP2337-202-93-10	Meerzainudeen <i>et al.</i> (1990)
RP2337-275-16-5	Meerzainudeen <i>et al.</i> (1990)
RP2337-313-14-11	Meerzainudeen <i>et al.</i> (1990)
RP2337-416-38-7	Meerzainudeen <i>et al.</i> (1990)
RP2337-43-4-1	Meerzainudeen <i>et al.</i> (1990)
RP2337-46-5-4	Meerzainudeen <i>et al.</i> (1990)
RP2362-161-16-1	Meerzainudeen <i>et al.</i> (1990)
RP2362-161-6-4	Rajendran (1992)
RP2362-16-15-4	Bharathi <i>et al.</i> (1987)
RP2362-227-22	Meerzainudeen <i>et al.</i> (1990)
RP2362-55-10-10	Bharathi <i>et al.</i> (1987)
RP2363-56-16-10	Bharathi <i>et al.</i> (1987)
RP2397-409-103-40	Rajendran (1992)
RP2397-425-105-48	Rajendran (1992)
RP2541-167-290	Meerzainudeen <i>et al.</i> (1990)
RP2541-168-291	Meerzainudeen <i>et al.</i> (1990)
RP2542-1657-194	Rajendran (1992)
RP2543-1444-46	Rajendran (1992)
RP2543-1464-152	Rajendran (1992)
RP2543-147-283	Meerzainudeen <i>et al.</i> (1990)
RP2543-149-285	Meerzainudeen <i>et al.</i> (1990)
RP2543-152-286	Rajendran (1992)
RP2547-1621-37-217	Bai <i>et al.</i> (1989)
RP2695-5-3-81	Rema Bai and Gopinathan Nair (1992)
RP2695-5-7-32	Rema Bai and Gopinathan Nair (1992)
RP31-17-2	Seshu <i>et al.</i> (1974)
RP5-48	Seshu <i>et al.</i> (1974)
RP6-516-33-1-1	Seshu <i>et al.</i> (1974)
RP9-3	Seshu <i>et al.</i> (1974)
RP9-4	Seshu <i>et al.</i> (1974)
RP9-6	Seshu <i>et al.</i> (1974)
RPW6-18	Seshu <i>et al.</i> (1974)
S2204	Krishna <i>et al.</i> (1980)
S61	Krishna <i>et al.</i> (1980)
Sagar-Samba	Kashikar <i>et al.</i> (1994)
Sajeddhanwar	Sahu <i>et al.</i> (1989)
Salivahana	Rana <i>et al.</i> (1994)
Sefa	Murugan and Velusamy (1992)
Semora Mangga	Seshu <i>et al.</i> (1974)

Table 2. (Contd).,

Variety	Reference
Siam 7	Krishna <i>et al.</i> (1980)
Sigadis	Seshu <i>et al.</i> (1974)
Sinna Sivappu	Velusamy and Chelliah (1984)
Soinphul	Pophaly and Rana (1992)
Sornavazhai	Chandramohan and Chelliah (1984)
Suduru Samba	Velusamy and Chelliah (1984)
Suraksha	Prasada Rao <i>et al.</i> (1992)
Swarnalata	Velusamy and Saxena (1989)
Synthia	Seshu <i>et al.</i> (1974)
T3	Krishna <i>et al.</i> (1980)
T7	Velusamy and Chelliah (1984)
T10	Krishna <i>et al.</i> (1980)
T12	Krishna <i>et al.</i> (1980)
T16	Krishna <i>et al.</i> (1980)
T27	Krishna <i>et al.</i> (1980)
T1415	Krishna <i>et al.</i> (1980)
T1421	Krishna <i>et al.</i> (1980)
T1426	Krishna <i>et al.</i> (1980)
T1432	Krishna <i>et al.</i> (1980)
T1465	Krishna <i>et al.</i> (1980)
T1471	Krishna <i>et al.</i> (1980)
T2755	Krishna <i>et al.</i> (1980)
Thodavalan	Velusamy <i>et al.</i> (1987)
TKM6	Seshu <i>et al.</i> (1974)
TNAU BPHR8275	Rema Bai and Gopinathan Nair (1992)
TNAU LFR831311	Rajendran and Adirajan (1990)
TNAU831521	Bharathi <i>et al.</i> (1988)
TNAU-BPHR831116 (ASD11/IR8)	Paramasivam <i>et al.</i> (1993)
TNAU-BPHR831293 (T7/IR20)	Paramasivam <i>et al.</i> (1993)
TNAU-BPHR831294 (T7/IR36)	Paramasivam <i>et al.</i> (1993)
TNAU-BPHR831297 (T7/IR36)	Paramasivam <i>et al.</i> (1993)
TNAU-BPHR831305 (T7/IR8)	Paramasivam <i>et al.</i> (1993)
TNAU-BPHR831307 (ASD11/IR8)	Paramasivam <i>et al.</i> (1993)
TNAU-BPHR83742 (T7/IR36)	Paramasivam <i>et al.</i> (1993)
Triveni/IR1539	James and Varkey (1977)
Triveni/Mudgo	James and Varkey (1977)
Triveni/R2061/461	James and Varkey (1977)
Udaya	Misra <i>et al.</i> (1985)
Umsun	Krishna <i>et al.</i> (1980)
Vajram	Suryanarayana <i>et al.</i> (1993)
Valan Channel	Velusamy <i>et al.</i> (1987)
Valan Samba	Velusamy <i>et al.</i> (1989)
Valarakkan	Velusamy <i>et al.</i> (1989)
Vali	Velusamy <i>et al.</i> (1987)
Valsara Champara	Krishna <i>et al.</i> (1980)
Vazhaipoo Samba	Velusamy and Chelliah (1984)
Vella Chenipan	Krishna <i>et al.</i> (1980)
Vellathil Cheera	Krishna <i>et al.</i> (1980)
Vellutha Cheera	Krishna <i>et al.</i> (1980)
Velumbala	Velusamy <i>et al.</i> (1987)
Vijaya	Bharathi <i>et al.</i> (1987)
W1263	Chandramohan and Chelliah (1984)
<i>Oryza latifolia</i>	Velusamy (1987)
<i>O. alta</i>	Velusamy (1987)
<i>O. australiensis</i>	Velusamy (1987)
<i>O. longistaminata</i>	Velusamy (1987)
<i>O. officinalis</i>	Velusamy (1987)
<i>O. punctata</i>	Velusamy (1987)

Table 2. (Contd).

Variety	Reference
<i>Sogatella furcifera</i>	
A1	Vaidya and Kalode (1979)
ABC6248	Lal and Pathak (1993)
AC5352	Krishna <i>et al.</i> (1980)
AD28883	Velusamy and Sudara Babu (1986)
AD85001	Velusamy and Sudara Babu (1986)
AD85004	Velusamy and Sudara Babu (1986)
ADR52	Kalode <i>et al.</i> (1977)
ADT38	Sivasubramanian <i>et al.</i> (1987)
Anaikomban	Pathak <i>et al.</i> (1986)
AR26-5-3-5	Tripathi and Pandya (1987)
ARC5752	Jeyarani and Velusamy (1992)
ARC5778	Gunathilagaraj (1983)
ARC5916	Gunathilagaraj (1983)
ARC5955	Vaidya and Kalode (1979)
ARC5959	Gunathilagaraj (1983)
ARC5973	Gunathilagaraj (1983)
ARC5976	Vaidya and Kalode (1979)
ARC5978	Gunathilagaraj (1983)
ARC5983	Gunathilagaraj (1983)
ARC5988	Gunathilagaraj (1983)
ARC6031	Gunathilagaraj (1983)
ARC6044	Gunathilagaraj (1983)
ARC6062	Gunathilagaraj (1983)
ARC6096	Gunathilagaraj (1983)
ARC6108	Gunathilagaraj (1983)
ARC6158	Gunathilagaraj (1983)
ARC6172	Gunathilagaraj (1983)
ARC6248	Shukla <i>et al.</i> (1987)
ARC6564	Krishna <i>et al.</i> (1980)
ARC6579	Gunathilagaraj (1983)
ARC6601	Gunathilagaraj (1983)
ARC6610	Gunathilagaraj (1983)
ARC6623	Gunathilagaraj (1983)
ARC6624	Krishna <i>et al.</i> (1980)
ARC6632	Gunathilagaraj (1983)
ARC6650	Krishna <i>et al.</i> (1980)
ARC7080	Gunathilagaraj (1983)
ARC7312	Gunathilagaraj (1983)
ARC10079	Vaidya and Kalode (1979)
ARC10464	Singh <i>et al.</i> (1984)
ARC10550	Gunathilagaraj and Chelliah (1984)
ARC10572-A	Gunathilagaraj (1983)
ARC10623	Gunathilagaraj (1983)
ARC10810	Gunathilagaraj (1983)
ARC10849	Gunathilagaraj (1983)
ARC10912	Gunathilagaraj (1983)
ARC11085	Gunathilagaraj (1983)
ARC11208	Vaidya and Kalode (1979)
ARC11215	Gunathilagaraj (1983)
ARC11220	Gunathilagaraj (1983)
ARC11281	Gunathilagaraj (1983)
ARC11321	Singh <i>et al.</i> (1984)
ARC11324	Lal <i>et al.</i> (1983)
ARC11351	Vaidya and Kalode (1979)
ARC11367	Gunathilagaraj <i>et al.</i> (1983)
ARC13788	Gunathilagaraj <i>et al.</i> (1990)

Table 2. (Contd)..

Variety	Reference
ARC14394	Krishna and Seshu (1980)
ARC14529A	Krishna <i>et al.</i> (1980)
ARC14529B	Krishna <i>et al.</i> (1980)
ARC14539B	Kalode <i>et al.</i> (1977)
ARC14636	Krishna and Seshu (1980)
ARC14766	Krishna <i>et al.</i> (1980)
ARC14766A	Kalode <i>et al.</i> (1977)
ARC14950B	Gunathilagaraj (1983)
ARC15694	Gunathilagaraj (1983)
ASD7	Gunathilagaraj (1983)
B3906D-14-ST-16-48-3	Singh <i>et al.</i> (1993)
Babawee	Lal <i>et al.</i> (1983)
Baggi Minji22	Singh <i>et al.</i> (1993)
Balamawee	Lal <i>et al.</i> (1983)
Batri	Sahu <i>et al.</i> (1989)
BG379-2	Velusamy <i>et al.</i> (1989)
BG380-2	Velusamy <i>et al.</i> (1989)
Birupa	Mohanty <i>et al.</i> (1994)
BR316-15-4-41	Velusamy <i>et al.</i> (1989)
BR4-34-13-5	Singh <i>et al.</i> (1993)
BR850-9-1-1	Singh <i>et al.</i> (1993)
Chaita Anaser	Jeyarami and Velusamy (1984)
Chemban	Kalode <i>et al.</i> (1977)
Chempaa	Kalode <i>et al.</i> (1977)
Chembarampandi	Kalode <i>et al.</i> (1977)
Chennellu	Kalode <i>et al.</i> (1977)
Cheriyachittari	Kalode <i>et al.</i> (1977)
Chethuvali	Velusamy <i>et al.</i> (1987)
CO29	Kushwaha and Singh (1986)
CO31	Velusamy and Sundara Babu (1986)
CO39	Velusamy and Sundara Babu (1986)
CR294-54-8	Lal and Pathak (1993)
CR333-6-1	Lal and Pathak (1993)
CR333-6-2	Lal and Pathak (1993)
Dihula	Sahu <i>et al.</i> (1989)
Eswara Mangalam	Vaidya and Kalode (1979)
G453	Rana <i>et al.</i> (1994)
G703	Rana <i>et al.</i> (1994)
GH305	Singh <i>et al.</i> (1993)
G453	Rana <i>et al.</i> (1994)
G703	Rana <i>et al.</i> (1994)
GH305	Singh <i>et al.</i> (1993)
GS531	Vaidya and Kalode (1979)
HAU4-63-3	Kushwaha <i>et al.</i> (1982)
HBC5	Rani <i>et al.</i> (1992)
HKR30	Lal and Pathak (1993)
HKR112	Lal and Pathak (1993)
HKR119	Lal and Pathak (1993)
HKR120	Pal <i>et al.</i> (1986)
Horonamawee	Velusamy <i>et al.</i> (1986)
IET4695	Vaidya and Kalode (1979)
IET5688	Lal and Pathak (1993)
IET5741	Gunathilagaraj and Chelliah (1984)
IET6123	Gunathilagaraj and Chelliah (1984)
IET6288	Vaidya and Kalode (1979)
IET6311	Gunathilagaraj and Chelliah (1984)
IET6315	Gunathilagaraj and Chelliah (1984)

Table 2. (Contd),.

Variety	Reference
IET8817	Kushwaha and Singh (1986)
IET10251	Nalini and Gunathilagaraj (1992)
Indrasan	Pathak <i>et al.</i> (1984)
IR12665-7-1-3-6	Singh <i>et al.</i> (1993)
IR1339	Vaidya and Kalode (1979)
IR13427-15	Gunathilagaraj (1983)
IR13427-40-2-3-3-3	Gunathilagaraj (1983)
IR13427-45-3-1-2-2-2	Ramaraju and Babu (1987)
IR13427-60-1	Gunathilagaraj (1983)
IR13429-109-2-2-1	Gunathilagaraj (1983)
IR13429-196-1	Velusamy <i>et al.</i> (1986)
IR13458-7-2-1-1-3-3	Vaidya and Kalode (1979)
IR13475-7-3-2	Velusamy <i>et al.</i> (1986)
IR13543-16	Gunathilagaraj (1983)
IR136-39-39	Gunathilagaraj (1983)
IR15429-268-1-2-1	Velusamy <i>et al.</i> (1986)
IR15527-21-2-3	Velusamy <i>et al.</i> (1986)
IR15529-256-1	Velusamy <i>et al.</i> (1986)
IR15779-74-1-8-2	Ramaraju and Babu (1987)
IR15795-151-2-3-2-2	Velusamy <i>et al.</i> (1986)
IR15797-74-1-3-2	Vaidya and Kalode (1979)
IR17307-11-2-3-2	Vaidya and Kalode (1979)
IR17496-2-25-1	Lal <i>et al.</i> (1983)
IR174-96-2-25-1	Vaidya and Kalode (1979)
IR1850-93-2	Velusamy <i>et al.</i> (1989)
IR19661-131-1-2	Gunathilagaraj (1983)
IR2035-117-3	Singh <i>et al.</i> (1993)
IR2415-90-4-3	Vaidya and Kalode (1979)
IR25587-133-3-2-2-2	Velusamy <i>et al.</i> (1989)
IR27316-6-2-2	Ramaraju and Babu (1987)
IR28154-101-3-2	Velusamy <i>et al.</i> (1986)
IR28224-3-2-3-2	Velusamy <i>et al.</i> (1989)
IR28228-12-3-1-1-2	Velusamy <i>et al.</i> (1989)
IR29658-43-3-2-1	Velusamy <i>et al.</i> (1989)
IR29692-65-2-3-3	Velusamy <i>et al.</i> (1989)
IR29692-99-3-2-1	Velusamy <i>et al.</i> (1989)
IR29723-88-2-3-3	Velusamy <i>et al.</i> (1989)
IR31429-14-2-3	Singh <i>et al.</i> (1993)
IR31785-58-1-2-3-3	Singh <i>et al.</i> (1993)
IR31803-32-2	Ramaraju and Babu (1987)
IR32307-107-3-22	Shukla <i>et al.</i> (1987)
IR32429-122-3-1-2	Velusamy <i>et al.</i> (1989)
IR32453-20-3-2-2	Velusamy <i>et al.</i> (1989)
IR33043-46-1-3	Velusamy <i>et al.</i> (1989)
IR35353-94-2-1-3	Velusamy <i>et al.</i> (1989)
IR35361-59-3-3-2	Velusamy <i>et al.</i> (1989)
IR43342-10-1-3-3	Singh <i>et al.</i> (1993)
IR36	Varma <i>et al.</i> (1979)
IR52	Velusamy <i>et al.</i> (1989)
IR54	Velusamy <i>et al.</i> (1989)
IR56	Velusamy <i>et al.</i> (1989)
IR58032-1	Gunathilagaraj <i>et al.</i> (1990)
IR58036-5	Gunathilagaraj <i>et al.</i> (1990)
IR58036-5	Nalini and Gunathilagaraj (1992)
IR58044-5	Gunathilagaraj <i>et al.</i> (1990)
IR58046-5	Gunathilagaraj <i>et al.</i> (1990)
IR62	Velusamy <i>et al.</i> (1986)

Table 2. (Contd).

Variety	Reference
IR64	Velusamy <i>et al.</i> (1986)
IR781-144-1-1R8/2	Vaidya and Kalode (1979)
IR9093-211-6	Gunathilagaraj (1983)
IR9852-22-3	Velusamy <i>et al.</i> (1986)
IRI339	Lal <i>et al.</i> (1983)
Jitendra	Mallik <i>et al.</i> (1995)
Kairali	Rosamma <i>et al.</i> (1994)
Karanphool	Sahu <i>et al.</i> (1989)
Karuvalli	Velusamy <i>et al.</i> (1987)
KAU1717	Lal <i>et al.</i> (1983)
KAU25100	Lal <i>et al.</i> (1983)
Khalasu	Sahu <i>et al.</i> (1989)
Khandagiri	Mohanty <i>et al.</i> (1994)
Kodagan	Velusamy <i>et al.</i> (1987)
Kodiyam	Krishna <i>et al.</i> (1980)
Kothandam	Velusamy <i>et al.</i> (1987)
Lal Basmati	Kalode <i>et al.</i> (1977)
LXH/2-281	Kalode <i>et al.</i> (1977)
Mahia Bankoi	Misra and Misra (1992)
Mangalapuram	Velusamy <i>et al.</i> (1987)
Maranel	Velusamy <i>et al.</i> (1987)
Meher	Mohanty <i>et al.</i> (1994)
MO1	Pathak <i>et al.</i> (1986)
MO4	Gunathilagaraj (1983)
MR1523	Krishna <i>et al.</i> (1980)
Mudukriyal	Krishna <i>et al.</i> (1980)
Muskhan 41	Jeyarani and Velusamy (1994)
N'diang Marie	Jeyarani and Velusamy (1994)
Pandi	Kalode <i>et al.</i> (1977)
Pant Dhan10	Pandey <i>et al.</i> (1994)
PM1004	Rajendran <i>et al.</i> (1987)
PM1409	Rajendran <i>et al.</i> (1987)
PM5845	Rajendran <i>et al.</i> (1987)
Podiwi-A8	Krishna <i>et al.</i> (1980)
PR106	Dhaliwal <i>et al.</i> (1979)
PR445	Dhaliwal <i>et al.</i> (1979)
PR560	Dhaliwal <i>et al.</i> (1979)
PR561	Dhaliwal <i>et al.</i> (1979)
PR563	Dhaliwal <i>et al.</i> (1979)
Prasad	Verma <i>et al.</i> (1979)
Ptb5	Velusamy and Sundara Babu (1986)
Ptb12	Prasad <i>et al.</i> (1990)
Ptb19	Kalode <i>et al.</i> (1977)
Ptb21	Kalode <i>et al.</i> (1977)
Ptb33	Kalode <i>et al.</i> (1977)
Ptb33A	Krishna <i>et al.</i> (1980)
Pundia	Misra and Misra (1992)
Pusa587-2-1	Tripathi and Pandya (1987)
Raihu Heenati	Lal <i>et al.</i> (1983)
Rening Genawee	Jeyarani and Velusamy (1992)
RNDR88-1-1	Tripathi and Pandya (1987)
RP1125-2-1-1	Lal and Pathak (1993)
RP1579-1615-30-21-36	Lal and Pathak (1993)
RP1579-28	Lal and Pathak (1993)
RP1579-48	Lal and Pathak (1993)
	Lal and Pathak (1993)
	Lal and Pathak (1993)

Table 2. (Contd.),

Variety	Reference
RP1800-14-8-16-3	Velusamy and Sundara Babu (1986)
RP1800-21-20-25-2	Lal and Pathak (1993)
RP1801-101-90-89	Lal and Pathak (1993)
RP1801-45-50-72	Lal and Pathak (1993)
RP1831-36-1-4	Tripathi and Pandya (1987)
RP1832-23-3-4	Tripathi and Pandya (1987)
RP2068-12-1-8-1	Kushwaha and Singh (1986)
RP2068-15-1-4-2	Pathak <i>et al.</i> (1986)
RP2068-16-9-5	Kushwaha and Singh (1986)
RP2068-17-2-1	Pathak <i>et al.</i> (1986)
RP2068-17-2-2	Pathak <i>et al.</i> (1986)
RP2068-17-3-7	Lal and Pathak (1993)
RP2068-18-2-6	Kushwaha and Singh (1986)
RP2068-18-3-1	Lal and Pathak (1993)
RP2068-18-3-5	Kushwaha and Singh (1986)
RP2068-18-4-5	Kushwaha and Singh (1986)
RP2068-18-4-7	Kushwaha and Singh (1986)
RP2069-39-3-1-4	Kushwaha and Singh (1986)
RP2069-3-4-1-2	Kushwaha and Singh (1986)
RP2069-3-4-4-6	Kushwaha and Singh (1986)
RP2069-3-5-2-2	Kushwaha and Singh (1986)
RP2081-176-122-14	Lal and Pathak (1993)
RP2081-210-48-57	Lal and Pathak (1993)
RP2149	Mitra and Bentur (1981)
RP2151-40-1	Tripathi and Pandya (1987)
RP2151-64-3-1-1	Lal and Pathak (1993)
RP2203-2-16-18	Lal and Pathak (1993)
RP2203-3-75-119	Lal and Pathak (1993)
RP633-519-1-3-4-1	Verna <i>et al.</i> (1979)
RP79-8-3-2-1	Kushwaha <i>et al.</i> (1982)
R-68-1	Shrivastava (1976)
Samanta	Mohanty <i>et al.</i> (1994)
Senawee	Jeyarani and Velusamy (1994)
Siam Garden	Jeyarani and Velusamy (1994)
Sufaida172	Velusamy <i>et al.</i> (1986)
Sulai	Kalode <i>et al.</i> (1977)
Sunduru Samba (Sudura Samba)	Lal <i>et al.</i> (1983)
Surnavazhai	Chandramohan and Chelliah (1984)
T1406	Kalode <i>et al.</i> (1977)
T1425	Kalode <i>et al.</i> (1977)
T1426	Kalode <i>et al.</i> (1977)
T1471	Kalode <i>et al.</i> (1977)
T1477	Kalode <i>et al.</i> (1977)
T16	Vaidya and Kalode (1979)
T2005	Kushwaha and Singh (1986)
T7	Gunathilagaraj and Chelliah (1984)
Thodavalan	Velusamy <i>et al.</i> (1987)
TNAU BPHR83742	Paramasivan <i>et al.</i> (1993)
TNAU80942	Velusamy and Sundara Babu (1986)
UPR174-14	Pathak <i>et al.</i> (1985)
UPR239-151-1-1	Pathak <i>et al.</i> (1985)
UPR254-139-2	Pathak <i>et al.</i> (1985)
UPR254-85-1	Pathak <i>et al.</i> (1985)
UPR79-104	Pathak <i>et al.</i> (1985)
UPR79-11	Pathak <i>et al.</i> (1985)
UPR79-123	Pathak <i>et al.</i> (1985)
UPR79-169	Pathak <i>et al.</i> (1985)

Table 2. (Contd.).

Variety	Reference
UPR965-10-1-1	Lal and Pathak (1993)
Valan Chennel	Velusamy <i>et al.</i> (1987)
Vali	Velusamy <i>et al.</i> (1987)
Valsara Champara	Kalode <i>et al.</i> (1977)
Vazhaipoo Sambal	Kushwaha and Singh (1986)
Vellailangayan	Krishna <i>et al.</i> (1980)
Vellathil Cheera	Kalode <i>et al.</i> (1977)
Velumbala	Velusamy <i>et al.</i> (1987)
Velutha Cheera	Kalode <i>et al.</i> (1977)
W1263	Chandramohan and Chelliah (1984)
WC1240	Jeyarami and Velusamy (1992)
WC1544-2	Gunathilagaraj (1983)
<i>Oryza latifolia</i>	Velusamy <i>et al.</i> (1994)
<i>Oryza officinalis</i>	Velusamy <i>et al.</i> (1994)
<i>Oryza punctata</i>	Velusamy <i>et al.</i> (1994)

bph5 and is independent of other four genes. Subsequent analysis revealed that the dominant gene of Swarnalata was designated **Bph6**. The recessive gene of T12 was designated **bph7**. The single recessive genes which are allelic to each other but are nonallelic to **bph2** and **bph4** were found in Col.5 Thailand and Col.11 Thailand and Chio Saba. The recessive gene of these cultivars is nonallelic to **bph5** and **bph7** because **bph5** and **bph7** do not confer resistance to biotypes 1, 2 and 3 but the new gene does. Therefore, this recessive gene is different from all the other recessive genes and was designated **bph8**. Three varieties - Kalaramana, Balamawee and Pokkali - were found to have single dominant genes which are allelic to each other but are different from **Bph1** and **Bph3**. This gene was designated as **Bph9**.

Several genes for resistance to the BPH have been transferred from wild *Oryza* species to

Table 3. Genes for resistance to *N. lugens* in rice and their reaction to different biotypes (Panda and Khush, 1995)

Gene	Chromosome location	Reaction to indicated biotype			
		1	2	3	4
Bph 1	4	R	S	R	S
bph 2	4	R	R	S	S
Bph 3	10	R	R	R	R
bph 4	10	R	R	R	R
bph 5	-	S	S	S	R
Bph 6	-	S	S	S	R
bph 7	-	S	S	S	R
bph 8	-	R	R	R	-
Bph 9	-	R	R	R	-
Bph 10 (t)	-	R	R	R	-

cultivated rice through wide hybridization (Jena and Khush, 1990). Genetic analysis to determine allelic relationships of these genes with known genes are underway. An introgression line from the cross of cultivated rice and *O. australiensis* has a dominant gene for BPH resistance which has been tentatively designated as **Bph10 (t)**. It confers resistance to three biotypes. Thus on the basis of genetic analysis of about 90 varieties, 10 genes have been identified. The reaction of the known genes against four biotypes is shown in Table 3 (Panda and Khush, 1995).

The genes for resistance to BPH in rice varieties can be inferred without genetic analysis by determining their reaction to different biotypes. If a variety is resistant to biotypes 1 and 3, it is likely to have **Bph1**; if it is resistant to biotypes 1 and 2, it has **bph2**; and if it is resistant to all the three biotypes, it may have any of these - **Bph3**, **bph4**, **bph8** and **Bph9**. Thus, varieties can be classified into varietal groups on the basis of their reaction to different biotypes before embarking on genetic analysis (Panda and Khush, 1995).

The concept of biotypes in BPH has been questioned on the grounds of stability of these biotypes and the usefulness of the term (Claridge and Den Hollander, 1980, 1983; Claridge *et al.*, 1984; Gallagher, 1988; Padgham *et al.*, 1989; Gallagher *et al.*, 1994).

Although minor morphometric differences among 'biotypes' have been identified (Saxena and Barrion, 1985), there is much overlap in

morphological characters, and after one generation of exposure to a susceptible variety, differences among 'biotypes' became smaller yet (Claridge *et al.*, 1984). Thus, morphological differences among biotypes may be a function of the selection regime imposed by laboratory rearing. Claridge and Den Hollander (1982) found ample variation for virulence with 'biotype' and after 10 generations of selection on different rice varieties, differences between 'biotypes' were greatly reduced. These results indicate that sufficient genetic variation exists for rapid adaptation and concomitant change in virulence to different rice varieties. In addition, biochemical evidence for BPH showed that the so-called 'biotypes' differed very little genetically and were no more different than the variants which exist in field populations (Den Hollander, 1989; Demayo *et al.*, 1990). Thus, BPH biotypes cannot be considered discrete genetic entities. Whereas certain 'biotypes' exhibit adaptation to particular host varieties compared to others, short periods of selection on novel varieties can alter their survival and performance. Results of Claridge and Den Hollander (1982), Gallagher (1988) and others, illustrate that there is not a one-to-one correspondence between a single gene in a BPH biotype and any single gene for resistance in the rice host.

Breeders and growers may be able to maximise the useful lifetimes of resistance genes by varying the direction and intensity of selection for adapted BPH genotypes by manipulating the crop's genetic structure in space and time. Several approaches have been proposed over the years such as rotating different cultivars, planting multiple resistant lines within the same field and combining different resistance genes within the same cultivar (Pathak and Khush, 1979; Khush, 1984; Heinrichs, 1986; Saxena and Khan, 1989). Each of these tactics may be useful, but the relative utility of each will be dependent on the genetic structure and mode of action of the virulence genes (i.e., the genes conferring adaptation to plant resistance genes) within the pest population.

Hybrids of rice varieties between *O. sativa* and other wild species *viz.*, *O. latifolia*, *O. officinalis*, *O. eichengeri* and *O. ridileyi* were specifically produced to widen the gene pool of rice and

transfer useful alien genes to rice. Hybrids were produced between *O. sativa* and *O. ridileyi* by adopting embryo rescue technique to transfer yellow stem borer resistance to cultivated rice (IRRI, 1991). In the same manner, genes conferring resistance to BPH have been transferred to cultivated rice from its two wild relatives *viz.*, *O. officinalis* (Jena and Khush, 1986) and *O. australiensis* (IRRI, 1991, 1993). The back crossing of hybrids derived between *O. sativa/O. latifolia* facilitated the transfer of BPH and whitebacked planthopper resistance genes from *O. latifolia* to *O. sativa*. All of the BPH resistant progenies were like the recurrent *O. sativa* parent in plant type, and did not carry any undesirable traits of *O. latifolia*. As many as 188 of the 2295 BC₃F₃ progenies tested were found to be resistant to WBPH (IRRI, 1993). Jena and Khush (1990) transferred resistance to BPH and WBPH to *O. sativa* breeding lines by crossing *O. officinalis*, a wild species with 2n=24 chromosomes and CC genomic constitution. A total of 400 F₁AC hybrids were obtained through the embryo rescue technique (Jena and Khush, 1986, 1989). These sterile AC hybrids between cultivated *O. sativa* and distant *O. officinalis* were backcrossed to *O. sativa*. Most of the BC₁ progenies were allotriploid (AAC) and a few were hypotriploid. AAC progenies were again backcrossed to *O. sativa*. BC₂ progenies consisting of disomics or aneuploids were identified in these progenies and were examined for the presence of *O. officinalis* chromosomes. Eleven different traits from *O. officinalis* were identified in these progenies including resistance to BPH and WBPH. Restricted recombinations were observed because of low pairing between A and C genomes. Because of this restricted recombination, the genotype of the recurrent parent was reconstituted after only two backcrosses.

The other example is the production of interspecific hybrids between *O. sativa* and *O. australiensis* (2n=24) with EE genome (Multani *et al.*, 1994). *O. australiensis* remains an important source for BPH resistance. Interspecific hybrids between three breeding lines of *O. sativa* and four accessions of *O. australiensis* were obtained after pollinating 20,234 spikelets of AE hybrids with (*O.*

sativa pollen. To overcome this problem an autotetraploid of an elite breeding line (IR 31917-45-3-2) was induced and crossed with *O. australiensis*, to get F₁ hybrid plants (AAE) following embryo rescue. These triploids were backcrossed to *O. sativa*. The chromosome number of 16 BC₁ plants varied from 28 to 31, and all were male sterile. BC₂ plants had 24-28 chromosomes. Eight monosomic alien addition lines (MAALs) having a 2n chromosome complement of *O. sativa* and one chromosome of *O. australiensis* were selected from the BC₂F₂ progenies. BC₂ progenies consisting of disomic and aneuploid plants were examined for the presence of *O. australiensis* traits including BPH resistance. Resistance breeding programme for BPH may be expected to be a long term advantage only in combination with other control strategies, particularly biological control. In the absence of insecticide use, natural enemies of BPH generally maintain good levels of control. Effective pest management in tropical countries will depend on an integration of resistance breeding and biological control (Claridge, 1990).

Whitebacked planthopper (WBPH), *Sogatella furcifera* (Horvath)

The damage due to *S. furcifera* on rice crop has long been recorded but detailed studies on varietal resistance to WBPH have not been made until 1975 when research on host-plant resistance has been stepped up both at the IRRI and many Asian countries. The screening technique was perfected in 1967 (IRRI, 1967). Using the bulk seedling test, 48554 *O. sativa* accessions were screened and 401 (0.8 %) were selected resistant. They originated from 21 countries. Several species of wild rices were also identified as resistant to WBPH (Heinrichs *et al.*, 1985). Of the several IR varieties released, four varieties (IR 48, IR 52, IR 60 and IR 62) were found moderately resistant to WBPH (Heinrichs, 1986).

WBPH thrives on high-yielding, susceptible rice cultivars but fails to feed, grow, survive and reproduce adequately on resistant cultivars. No mechanical barriers to WBPH feeding have been identified in resistant plants. In resistant varieties, the mechanisms that operate against the pest are

antibiosis or a combination of both (Vaidya and Kalode, 1981; Gunathilagaraj and Chelliah, 1985; Saxena and Khan, 1989). Tolerance mechanism is associated with resistance in hybrid rices to WBPH (Nalini and Gunathilagaraj, 1995).

At least five genes have been identified that confer resistance to the WBPH. Four of them are dominant and designated as **Wbph 1**, **Wbph 2**, **Wbph 3** and **Wbph 5**. One is recessive and designated as **wbph 4** (Saxena and Khan, 1989). These five genes have been incorporated into improved germplasm at IRRI. WBPH resistant lines are being evaluated in coordinated trials. However, no resistant variety has yet been released (Khush and Chaudhary, 1981). Variety Pant Dhan 10 (IR 9763-11-2-2-3) is field resistant to WBPH in Uttar Pradesh and evaluated as IET 8616 in the All India Coordinated trials (Pandey *et al.*, 1994). ADT 38 (IR 21820-154-3-2-2-3) released in May 1987 for Tamil Nadu is also reported to be resistant to the WBPH (Sivasubramanian *et al.*, 1987) and HKR 120 (Ptb 33/4* IR 3403-267-1) is a promising new rice resistant to WBPH in Haryana (Pal *et al.*, 1986).

In addition to major genes, minor genes also contribute to resistance against *S. furcifera* in some rice varieties and probably retard the selection of biotypes. Resistance has also been observed in wild rice species *viz.*, *Oryza eichingeri*, *O. latifolia*, *O. minuta*, *O. nivara*, *O. officinalis*, *O. paraguayensis*, *O. punctata*, *O. ridileyi* and *O. rufipogon* (Heinrichs *et al.*, 1985). Because no modern variety is highly resistant to WBPH, attempts are being made to incorporate resistance genes into improved breeding lines. By wide crossing of cultivated rice and wild rice *O. officinalis* and through subsequent back crossing, breeding lines have been obtained which are highly resistant to WBPH.

It is interesting that none of the genes conferring resistance to any laboratory population of BPH also confer resistance to WBPH (Romana *et al.*, 1986). This suggests that different, largely independent factors govern resistance to each planthopper species. This obviously presents a problem to plant breeders desiring to develop cultivars resistant to both BPH and WBPH.

simultaneously. Nevertheless, the four released cultivars moderately resistant to WBPH (IR 48, IR 52, IR 60 and IR 62) also are resistant to atleast two of the three Philippine BPH laboratory populations (Heinrichs, 1986). Little is known at present about the potential abilities of WBPH to adapt to any of these resistant cultivars and the same cautious and research recommendations for the BPH are also applicable to the WBPH (Denno and Perfect, 1994).

Despite the availability of thousands of resistant sources for hoppers in India, host plant resistance studies have not made any significant impact on rice crop production in our country. It has only resulted in publication of a large number of 'research notes' without logical follow-up and conclusion. The reasons identified for the limited impact of host plant resistance in general (Teetes, 1985) are:

- ✧ failure of entomologists and plant breeders to complete their task after identifying the insect resistant germplasm
- ✧ failure of farmers to accept and use insect resistant cultivars
- ✧ the insecticide crutch
- ✧ tendency to separate crop production and crop protection, and
- ✧ failure to produce adequate information about the pest and the resistant cultivars.

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EFFECT OF ETHREL AND CYCOCEL ON YIELD COMPONENTS OF CASSAVA

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ABSTRACT

The effect of ethrel and cycocel each at three concentrations on the yield component of cassava varieties reveals that the total number of roots per plant was significantly influenced by CCC 5000 ppm and the same was more pronounced at the peak bulking phase. Among the varieties, Co.1 recorded a greater number of roots. The number of tuberous roots was more under the treatment ethrel 250 ppm and the variety Co.1 had the highest root number. The yield of tubers was significantly influenced by CCC, 10,000 ppm and the variety Co.1 recorded the highest yield.

KEY WORDS : Total number of roots, peak bulking, tuberous roots, yield components

A study of yield components in cassava could go a long way in increasing its productivity. Among the components, number of tubers, weight of tubers and girth of tubers are considered important. According to Jennings (1970), the number and size of tuber, the size and efficiency of the leaf canopy, the ratio of top/root and the duration of the period of dormancy are the yield components. Magoon *et al.* (1970) correlated the total yield with number of tubers per plant, tuber length, tuber circumference rind thickness and height of the plant. The storage root formation and development has been described in quantitative terms by many. Here an attempt was made to study the effect of growth substance on the yield components namely the number of total roots, tuberous roots and tuber yield.

MATERIALS AND METHODS

Studies were undertaken at the Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 1983-86 with two varieties of cassava namely Co.1 and MVD.1 along with a promising culture

ME.116. Growth substance ethrel and CCC were applied each at three concentrations beginning from one month after planting at fortnightly intervals.

Main Plot Treatment

- T1 Ethrel 250 ppm
- T2 Ethrel 500 ppm
- T3 Ethrel 1000 ppm
- T4 CCC 2000 ppm
- T5 CCC 5000 ppm
- T6 CCC 10,000 ppm
- T7 Water spray
- T8 Control

Sub Plot

- V1. Co.1
- V2. ME 116
- V3. MVD.1