"MECHANISM OF RESISTANCE INVOLVED IN BROWN PLANTHOPPER (BPH) *Nilaparvata lugens* (Stal.) RESISTANT DONORS OF IGKV, RICE GERMPLASM"

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By

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CERTIFICATE- I

This is to certify that the thesis entitled "**MECHANISM OF RESISTANCE INVOLVED IN BROWN PLANTHOPPER (BPH)** ***Nilaparvata lugens*** **(Stal.) RESISTANT DONORS OF IGKV, RICE GERMPLASM"** submitted in partial fulfilment of the requirements for the degree of **DOCTOR OF PHILOSOPHY IN ENTOMOLOGY** of the Indira Gandhi Agricultural University, Raipur (M.P.) is a record of the bonafide research work carried out by **SHRI DHANENDRA KUMAR RANA** under my guidance and supervision. The subject of the thesis has been approved by Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigation has been duly acknowledged by him.

Dr. D.J. POPHALY
Chairman of the advisory committee

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CERTIFICATE - II

This is to certify that the thesis entitled **"MECHANISM OF RESISTANCE INVOLVED IN BROWN PLANTHOPPER (BPH) *Nilaparvata lugens* (Stal.) RESISTANT DONORS OF IGKV, RICE GERMPLASM"** submitted by **SHRI DHANENDRA KUMAR RANA** to the Indira Gandhi Agricultural University, Raipur (M.P.) in partial fulfilment of the requirements for the degree of **DOCTOR OF PHILOSOPHY IN ENTOMOLOGY** in the DEPARTMENT OF ENTOMOLOGY has been approved by the Student's Advisory Committee and External Examiner after an oral examination of the same.

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INTRODUCTION

CHAPTER - I

INTRODUCTION

The brown planthopper (BPH) *Nilaparvata lugens* (Stal) has in recent years caused extensive damage to the rice crop in Asia. Although an important pest in Japan for many years, it was formerly only a minor pest in most tropical countries of Asia. In the past few years, however, the BPH population have greatly increased and caused severe yield losses in several countries. Large scale damage by the insect has been reported in India, Indonesia, Philippines and SriLanka, and infestation of varying degree is now commonly observed in many countries.

Rice *(Oryza sativa* L.) is the staple food of more than 60 per cent of the world's population in which most of the people belong to South-East Asian countries. Its production was 527 million tonnes from 148 million hectare global area and average yield was 3600 kg/ha in 1993. Approximately 92% of all rice is produced from 90% of global area in Asia (IRRI, 1995).

Among the rice growing countries, India has the largest area of 41.64 million hectares but second in production with 72.6 million tonnes of paddy during 1994-95. In Madhya Pradesh, rice is grown in 5.35 million hectares with the production of 6.46 million tonnes during 1994-95, which is

12.8% of total area and 8.9% of total production in the country. The productivity of rice in India and Madhya Pradesh is 1744 kg/ha and 1273 kg/ha, respectively (Agril. Statistics, 1995). The productivity of rice in Chhattisgarh region of M.P. is only about 1000 kg/ha which is very low due to various constraints among them damage caused by insect-pest is one of the major constraints in reducing grain yield.

In Southern states of India, where the rice crop is grown round the year, the pests viz., Stem borer, leaf and planthoppers, gall midge and Whorl maggot are mainly responsible for low grain yield. But in Madhya Pradesh and particularly in Chhattisgarh region the pest problem is altogether different to that of Southern states. In order *of.* severity, the rice gallmidge, leaf and planthoppers, stemborer, caseworm, leaf folder and rice hispa are major insect pests.

With the spread of high yielding rice varieties and of intensive cultivation, the brown planthopper, *Nilaparvata lugens* (Stal), (Homoptera : Delphacidae) , has become a very serious pest of rice throughout tropical Asia since 1970 (Dyck and Thomas, 1979). It has been known to be widely distributed in Southern Asia, since Stal first recorded this insect in Java in 1854 (Mochida *et al.*, 1977). It feeds on the basal portion of the rice plant by sucking the plant sap

through stylet and consequently plugging xylem and phloem tubes of the leaf sheaths. Light infestations reduces plant: height, the number of productive tillers, crop vigour and induces the production of unfilled grains (Bae and Pathak, 1970). Heavy infestations cause complete drying or "Hopperburn" of the crop (Kisimoto, 1960). In addition to the direct feeding damage, this pest is also a vector *of* the grassy stunt virus which makes its status as a pest even more serious (Rivera et *al*., 1966).

Brown planthopper (BPH) has become a very serious pest of rice in India. Although the pest was first reported In Kerala during 1958 and 1962, the first severe outbreak occurred in Kerala in 1973-74, damaging about 50,000 ha of rice (Bai et *al*. 1992). In Chhattisgarh region of Madhya Pradesh severe outbreak of BPH was occurred in 1976, resulting 34.4 per cent yield loss (Gangrade et *al*., 1978). Subsequently, it has been reported from many other states of India viz., Andhra Pradesh, Bihar, Haryana, Orissa, Punjab, Tamil Nadu and Uttar Pradesh. Grain loss were also measured which ranged from 10 per cent in moderately affected fields to 70 per cent in severely affected fields (Kulshreshtha *et al*., 1974).

Hinckley (1963) estimated loss of US$ 50,000 when BPH destroyed about 22% of the rice crop in 2800 ha in Fiji. Dyck and Thomas (1979) estimated the monetary losses due to

BPH damage and grassy stunt virus to the extent of US$ 311.62 million in eleven Asian countries and in India alone US$ 20 million, including US$ 12 million in Kerala state.

Attempt to control this pest with chemical methods has given rise to many problems viz., resurgence, insecticidal resistance to BPH, destruction of natural enemies. The use of chemicals to control this pest is beyond the capacity of marginal farmers. Moreover towards the maturity stage of crop growth, application of insecticides causes presence of their residues in rice bran and straw above the tolerance level (Rajukkannu et *al*., 1988). An outbreak of brown planthopper in Thailand during April 1988 due to the application of monocrotophos for the control of other pests (Sindhusake et *al*., 1988).

The uncritical use of pesticides in the wake of the green revolution in many Asian countries has upset the ecological balance. The most dramatic evidences of this was recorded in Indonesia where the rice brown planthopper, a minor pest before the green revolution, infested rice crops in Java and North Sumatra in 1976-77. In a bid to control the outbreak, the aircraft balanketed more than one million hectare rice fields with pesticides, but to no avail (Anonymous, 1990).

Therefore, looking to the figures of economic losses, pesticides hazard and environmental pollution; development

and use of resistant variety is not only cheapest but it is safest method to control this pest.

Fortunately, the world's second largest (21,000 accessions) rice germplasm collection of Chhattisgarh region of M.P. established by Dr. R.H. Richharia during 1971 to 1981 (Sharma et *al.*, 1987) is available at I.G.K.V., Raipur (India) which needs to be tested systematically. The importance of this germplasm needs no emphasis. This has been stressed many times both at National and International levels particularly in context of fast spread of high yielding varieties resulting in large scale erosion of useful genes (Richharia, 1979 and Chang, 1985).

An interesting point is that the most of natural germplasm with the developing countries like India, Europ, Japan, Indonesia. Inspite of this fact, gene hunters of developed countries have made best use of these basic material for socio-economic growth and development.

In most cases host plant resistance is biochemical in nature and phytochemicals involved are mostly belong to five groups like aectogenins, alkaloids, flavonoids, glycosides, isoprenoids etc. (Pathak and Dale, 1983). These chemicals act as feeding deterrents, growth inhibitors, toxicants and alike. Besides such secondary plant substances, certain principal nutrient contribute towards susceptibility of host

plant. While information is available on performance of certain chemicals acting as probing/sucking stimulants/deterrents against the brown planthopper, *Nilaparvata lugens* (Sogawa, 1982). The following phenolic substances are present in rice plants, P-Coumaric acid, P-hydroxybenzoic acid, ferulic acid, vamillic acid, chlorogenic acid, and several flavonoids (Kuwatsuka and Oshima, 1961).

Chemical ecology of host plant is a complex phenomenon. Variety of chemicals are released by the host plant as a defense mechanism under selective environmental situation. Even this is a step-wise chemical reason, depending on various ecological situation. In general phenols are widespread in plant kingdom and said to offer resistance to insect and disease attack. Therefore, estimation of total phenol was a main target in biochemical studies in host-plant information studies. Phenols react with Phosphomolybic acid in folin Ciocaltau reagent in alkaline medium and produce blue coloured complex. Phenols chemical structure based on the aromatic alcohol phenol are predominantly hydrophilic.

Brown planthopper *Nilaparvata lugens* is a serious insect pest of rice in Chhattisgarh region of Madhya Pradesh. It is occurring every year in irrigated rice and created unprecedented pest control problems in past few

years. Its severe outbreak was observed in 1975. Chemical protection measures are loosing its ground day by day for many reasons, viz. resurgence, development of insecticidal resistance to insect and towards the maturity stage of crop growth, application of insecticides like monocrotophos, quinalphos etc., leave their residues in rice bran and straw above the tolerance level and also cause destruction of natural enemies. By and large, use of chemicals is beyond the economic capacity of marginal farmers. Moreover, *N.lugens* virulent prolific populations a constant threat to the stability of resistant/tolerant varieties. Thus to stay ahead of the problem, it is necessary to be well equipped with new BPH resistant genetic material with inbuilt known mechanism of resistance.

In view of above facts and situation, the following studies were carried out in controlled condition of glasshouse :

1. Isolation of brown planthopper (BPH) *Nilaparvata lugens* (Stal) resistant donors from rice germplasm.

2. Probing behaviour of BPH insect in selected resistant donors.

3. Egg laying responses in selected resistant donors.

4. Biochemical basis of BPH resistance in some selected donors.

REVIEW OF LITERATURE

CHAPTER - II

REVIEW OF LITERATURE

The brown planthopper, *Nilaparvata lugens* (Stal) belongs to the family Delphacidae and order Hemiptera. Throughout the world, fourteen determined and two undermined species are reported as the members of genus *Nilaparvata* (Mochida, 1977) of which *N. lugens* is recognized as a serious pest of rice (Nasu, 1964).

The occurrence and evolution of prolific biotypes of BPH is a constant threat to the stability of the present pest resistant rice *(O. sativa)* varieties presently under cultivation (Pathak and Saxena, 1980). A biotype of the BPH is generally referred to as population which has a specific ability or inability to survive on and infest rice varieties with specific genes for resistance to this insect. The population which can not infest any varieties with resistance genes is called biotype 1, while those population infesting resistant varieties carrying Bph 1 and bph 2 genes are described as biotypes 2 and 3, respectively (IRRI, 1976). Five different BPH biotypes are known (TARI, 1981) till now.

The possibility of developing BPH biotypes on resistant rice varieties was anticipated as early as 1969, soon after the first discovery of BPH resistant variety Mudgo (IRRI,

1970). One of the major disadvantage associated with the use of resistant varieties is the development of new biotypes which are capable to overcome the resistance (Glass, 1975).

Resistant varieties were released for commercial cultivation but the situation became alarming when resistance of these varieties was no longer function because of the selection of virulent biotypes of the pest, in Indonesia (Harahap, 1979), Philippines and Vietnam (Khush, 1979) and Solomon Islands (Stapley, 1974). Studies have indicated that biotype selection can occur within a relatively short period of time (Pathak & Heinrichs, 1982b).

For instance, three years after its release, IR-26 become susceptible in Philippines in 1975, are the same sequence of biotype development occurred in India (Krishna *et al*., 1976); Indonesia (Mochida *et al*., 1977; Oka, 1978) and Solomon Islands (Stapley *et al*., 1979).

Resistant cultivars with bph 2 gene have been identified at the IRRI such as 'IR36' and 'IR42' were released and are widely cultivated in the Philippines and Indonesia (Khush, 1984) . The resistance of IR 42 was reported to have "Broken down" in Indonesia due to the development of new biotype (Oka and Bahagiawati, 1984) and IR56 with the Bph 3 gene was released.

Seven differential donors tested at Raipur with local population of BPH showed variations in reactions as compared to IRRI BPH population. Similarly twenty one IR varieties exhibited differences when the results were examined against 3 BPH biotypes at IRRI. Thus, conclude that, the Raipur BPH population is different from that at IRRI. Corollary to this, fifteen Pattambi BPH donors also behaved dissimilarly towards Raipur BPH population, thereby indicating Pattambi BPH population to less virulent than that of Raipur (Pophaly and Rana, 1994).

The brief review has been presented on following sub heading:

1. Isolation of resistant donors
2. Screening of rice germplasm
3. Mechanism of resistance
4. Feeding test
5. Mark probing test
6. Ovipositional response
7. Biochemical studies

2.1 Isolation of resistant donors :

Brown planthopper biotype 1, 2 and 3 are being maintained as isolated inbred population at IRRI. Biotype 1 was kept on susceptible Taichung native 1 (TN1) since 1965. Biotype 2 and 3 were developed from natural population by forced breeding on the resistant variety Mudgo with Bph 1

and ASD 7 with bph 2 genes, respectively (IRRI, 1976). BPH is being carried on 40 to 50 days old plants inside of 0.5 x 0.5 x 1 m cage described by Pathak and Khush (1979).

Lee *et al.* (1983) Japonica varieties Milyang 64, Milyang 65 and Milyang 66 were developed as new elite lines at Yeongnam crops experiment station in 1981. Milyang 64 was produced from a cross between Milyang 15 and chock 48-1 and Milyang 65 and 66 were developed from crosses between Milyang 15 and chock 48-5. Milyang 64 and 66 were resistant to biotypes 1 and 2 at seedling stage and Milyang 65 were resistant to biotype 1.

The BPH population of Hyderabad and Pantnagar is maintained separately on 30 to 50 days old potted plants of TN1 variety in glasshouse to prevent any possible mixing. Optimum temperature of 27+3^{o}C and relative humidity 65 to 85 per cent were provided for better multiplication and survival of the insects (Bhattacharyya *et al.*, 1983).

Ito et *al.* (1994) Biotypes of brown planthopper populations collected in and around the Muda area in Peninsular Malaysia in 1989 and 1990 were examined by comparing the amount of honeydew excreted by the female adults on 5 standard rice varieties : Mudgo (which has the Bph 1 gene for resistance to the brown planthopper) , ASD 7 (bph 2), Rathu Heenati (Bph 3), Babawee (bph 4) and TN1 (no resistance genes) . Most populations from the Muda area

showed similar biotypical properties regardless of the collection sites or crop seasons. Among the 4 resistant varieties used, high mortality was recorded on Rathu Heenati and Babawee. A relatively larger amount of honeydew was discharged on ASD 7; this was followed by Mudgo. Little honeydew excretion was recorded on Rathu Heenati and Babawee. A similar trend was also observed in most populations collected from other sites on the west and east coasts of Peninsular Malaysia. Two explanations are considered for this phenomenon, i.e., these biotypes had developed in Malaysia or immigrated from Sumatra, Indonesia.

Nilaparvata lugens was mass reared by Pophaly and Rana (1995) throughout the year in glasshouse at 30°C + 5°C on potted TN1 variety to get the steady supply of insects for various studies.

2.1.1 Screening of rice germplasm :

India is very rich in plant genetic diversity. Germplasm carries gene pool and utilizatioin of this genetic diversity to a fullest length is still incomplete. Many scientists evaluated rice germplasm material pooled from various sources and tested against brown planthopper (BPH) insect.

A total of 515 AC varieties from genetic stock screened against BPH at Cuttack, India. 21 were found resistant and 8

moderately resistant. Out of few hundred varieties, 10 AC and Ptb 10, Ptb 21 and MNP 76 were found to be resistant (CRRI, 1977; 1978 Annual Report).

At Coimbatore, 988 entries were evaluated against BPH and 22 were identified as promising (Balasubramanian et *al*., 1978). A total of 6170 rice varieties representing to many germplasm bank or genetic stock were screened against BPH. Out of these 112 and 167 varieties found to be resistant and moderately resistant, respectively (Misra et *al*., 1978; 1983 and Misra, 1982).

Over 35,000 germplasm accessions and breeding material have been evaluated against BPH at Hyderabad since 1973. As a result about 600 resistant donors have been identified (Kalode et *al*., 1979; 1983). The first high yielding variety IR 8 released by IRRI, resulted in emergence of *N. lugens* as a pest, major genes Bph 1 & bph 2 were identified by Pathak and Khush (1979) from traditional varieties of India and Shri Lanka.

Altogether 187 germplasm of rice were screened against two ecologically isolated populations of BPH from Pantnagar and Hyderabad. Two rice accessions namely, Manohar sali and T 1415 proved to be resistant to BPH Pantnagar population and moderately susceptible and susceptible to Hyderabad population respectively. However, eight cultivars have exhibited resistance reaction against Hyderabad BPH

population. Among these only three were moderately resistant, while the remaining five totally succumbed to Pantnagar population. These observations indicated that Pantnagar and Hyderabad populations differ considerably (Bhattacharyya et *al*., 1983).

Mishra et *al*. (1983) a total of 2297 ARC, 317 AC, 750 JBS and 1000 NCS cultivars were screened against the rice brown planthopper under artificial infestation. The resistant cultivars included 34 ARC, 3 AC, one JBS and 6 NCS while 70 ARC cultivars and 31 NCS varieties were found to be moderately resistant.

A total of 50,423 rice accessions tested against BPH at IRRI during 1967 to 1984. Out of these, 555 accessions were found to be resistant (Heinrichs, 1984). Thirty accessions have been reported as highly resistant, out of 465 accessions evaluated at Coimbatore (Velusamy and Chelliah, 1984).

Lei et *al*. (1984) of 313 rice varieties screened, 37 cultivars were resistant at the seedling stage and 53 showed resistance in the field. Among the resistant varieties were cultivars from India, Srilanka, Indonesia, Thailand, IRRI, Taiwan, China, Japan, Barma, Malaya and Pakistan. Mudgo, BG 367-8 and BG 367-9 have suitable chracteristics and are being used in the breeding programme.

Four varieties of IR series (IR 56, IR 58, IR 60 and IR 62) were found to be resistant to BPH biotype 1, 2 and 3 (Heinrichs et *al*., 1985). Five varieties namely ASD 11, IET 5741, IET 6315, T7 and V.P. Samba were identified as BPH resistant at Coimbatore (Velusamy, 1985).

The rice varieties IR 5 to IR 64 were evaluated for resistant to *Nephotettix virescens, Sogatella furcifera* and *Nilaparvata lugens*. Only IR 62 and IR 64 were highly resistant while IR 5, IR 36, IR 42, IR 46 and IR 60 were moderately resistant to all 3 pests (Velusamy et *al*., 1986). Of 24 Korean cultivars Gaya, Chilsung and Samgang were found resistant to *Nilaparvata lugens* and Cheong cheong was moderately resistant to *Sogatella furcifera.* In test of 20 other Korean cultivars, Ballgunchal, Milyang 30, Nampung and Hangangchal were resistant to *N. lugens* (Lee, 1987). Screening result of eight rice varieties for resistant to BPH insect in Philippines, Bangladesh, Salomon Islands and Sri Lanka indicated only two varieties viz. Utri Rajapan and Triveni were resistant in all locations (Medrano et *al*., 1987).

Screening of 185 rice accessions done (Germplasm collection of M.P., India) at Philippines for resistant to 2nd and 3rd instar nymphs of BPH biotype 1 showed eighteen were resistant and sixteen moderately resistant to BPH population accessions viz., Aolesar cross 116, Dudga, Haruma

dubraj, Aagyasal and Aagyasar are also known resistant to bacterial blight disease (Sahu, 1987). The resistance of hybrid rice to the delphacids *Nilaparvata lugens* and *Sogatella furcifera* was tested. Of 38 cross combinations, 9 were resistant to both pests, *6* to *N. lugens* and *6* to *S. furcifera* (Zhang et *al.*, 1987).

Kaneda (1988) reviewed the work on BPH genes for resistance and cultivars classified according to the genes present.

Gene	Cultivars
Bph 1	Mudgo, MTU 15, IR 747 B2.6, Tibiriwewa, SLO 12, Sudrvi 305, Andaragahawewa etc.
bph 2	ASD 7, ASD 9, Ptb 18, Ptb 34, 11-105, IR 1154-243, M.I. 329, Hathiel, Murungakayan 302, 115, PTB 21 (+ Bph 3) etc.
Bph 3	Rathu Heenati, Ptb 19, Ganglala, Mudu, Kiriyal, Hondrawala 378, PTB 33 (+bph 2) etc.
bph 4	Babawee, Kahata Samba, Kulukuruwee, etc.
bph 5	ARC 10550, Leb Mue Nahng, ARC 15782 etc.
Bph 6	Swarnalata
bph 7	T 12
bph 8	Thai Col 5, Thai Col 11, Chin Saba
Bph 9	Kaharamana, Pokkali, Balamawee (70-518).

A total of 200 traditional rice cultivars were screened for resistance to BPH in M.P., India, in 1987. Anjania, Badidhan, Badshah Bhog, Bangoli 3, Budiya bonko, Bansbhira,

Barhi, Barik Safed, Basangi, Lal Basant, Bataru, Benwar, Bewara, Banspatri, Bhakawa and Chapdo were resistant (Murthy et *al*., 1988).

Rice varieties with genes for resistance to BPH were evaluated in Tamilnadu, India. Rathu Heenati, Babawee, ARC 10550, Swarnalata and Ptb 33 were resistant in screening trials while IR 747-B2-6 and ASD 7 were susceptible (Velusamy and Saxena, 1989). One hundred ninety-five breeding lines derived from *Oryza officinalis* were evaluated against BPH, 54 were exhibited high level of resistant to BPH with score 1 (Velusamy, 1991).

Nearly 1700 entries from national and international trials and 1830 segregating breeding lines were evaluted to BPH. Only eight entries showed high level of resistant in replicated test. Newly identified moderately resistant included 3 from Tamil Nadu and 4 from Assam rice germplasm. RB 2325 (Ratna/Majila) and RP 2335 (Ratna/ARC 10666) were two new crosses identified with their promising performance to BPH (DRR, 1990).

BPH resistant donors such as Ptb 20, Kochuvithu, Karivennel, IR 1539, Ptb 33, ARC 6650, IR 1561 and modern varieties such as IR 8, IR 11, Triveni and Jaya were used in breeding programme. Promising selection were obtained from crosses IR 8/Ptb 33, IR 11/Kochuvithu, IR8/Karivennel, Triveni/IR1539, Jaya/Ptb 33, ARC 6650/Jaya and IR 1561/Ptb

33. Eight varieties were released during 1978-90 (Bai et *al.*, 1992). One hundred eighty-one accessions were found to be resistant to BPH from 4261 germplasm accessions tested (Ruifeng and Zoumin, 1992).

Manisegaran et *al.* (1993) Conducted laboratory studies to confirm the level of resistance of some selected cultivars against brown plant hopper, *Nilaparvata lugens* stal. (Homoptera :Delphacidae). The studies revealed that three wild species; *Oryza officinalis* Wall., *O. latifolia* J.S. Presl. and O. *minuta* Desv. are highly resistant to BPH (Score 1) , and recorded significantly least area and quantity of honey dew excreted. TNAUBPHR 831305 showed a good level of resistance, and it was on par with resistant check PTB 33. IR 64 and IR 36 showed moderate levels of resistance whereas IR 50 was susceptible.

Twenty-one IR varieties were tested against BPH at Raipur (M.P.) in 1991. Only IR 62 and IR 64 were resistant and IR 34, IR 36 and IR 56 moderately resistant (Pophaly and Rana, 1993a). Nine hundred MPRRI rice cultivars evaluated during 1990-92 at Raipur (M.P.) to locate better sources of BPH resistance, out of these sixty-nine cultivars were found resistant to BPH (Pophaly and Rana, 1993b). A collection of 58 IET rice genotype were studied for resistance to BPH, Gall midge (GM) and bacterial leaf blight (BLB) during 1988-92. Fifty-six varieties were resistant to BPH, 13 to GM and

12 to BLB. These varieties also evalauted against grain moth, only 8 were strongly resistant. R 650-1820 was the only variety resistant to BPH, GM, BLB and grain moth infestation (Rana *et al*., 1994).

A total of 4,380 IGKV rice germplasm evaluated against BPH at Raipur, India during 1992 to 1995. Out of these 172 entries were isolated as resistant donors and 168 found moderately resistant (Anonymous, 1995) .

The wild rice collected from Chhattisgarh region were evaluated for BPH resistant in 1993. Four varieties viz., VSR-23, MS-47, VSR-14 and VSR-8 were found resistant to Raipur BPH insect population and other three varieties viz. VSR-20, VSR-2, VS-19 were moderately resistant (Pophaly and Gupta, 1995) .

Reddy and Misra (1996) Screened thirty rice cultivars for resistance to *Nilaparvata lugens* in Uttar Pradesh, India, during the Kharif seasons of 1981 and 1982. Of these, culture 1, IR 28 and IR 8 were the least susceptible, but were significantly less resistant than the resistant check Ptb 33.

2.1.2 Mechanism of resistance :

The mechanism of resistance to brown planthopper (BPH) have been studied by several workers. The resistance of varieties to insects could be due to one or more factors

non-preference, antibiosis, or tolerance (Painter, 1951). Tolerance response are generally more influenced by environmental conditions than non preference and antibiosis (Painter, 1951; Pathak, 1970).

Pathak *et al*. (1969) reported that variety Mudgo is highly resistant to BPH at IRRI. The results indicated the lack of sustained feeding by BPH insect on this variety. Further studies showed that insects caged on these plants suffered high mortality, loss in weight, excreted little honeydew and had under developed ovaries.

Sogawa and Pathak (1970) reported the sugar content of susceptible and resistant plants was not significantly differrent but resistant plants contained smaller quantities of amino acids, particularly of asparagine. In separate tests, female showed strong attraction to this amino acid. Thus, lower asparagine content in Mudgo is suggested as a factor of resistance.

Samal and Misra (1979) reported five BPH resistant varieties, such as, Ptb 33, Ptb 18, Ptb 21, CR 57-MR 1523, ARC 14529 and two BPH susceptible varieties, such as Jaya and TN1 were taken for estimation of local soluble sugars, amino acids and phenols. It was found that total amino acids and phenolic compounds were high in resistant varieties and soluble sugar high in susceptible varieties. There was no difference in nitrogen content between resistant and

susceptible varieties.

Saxena and Pathak (1979) and Saxena and Puma (1979) determined the biochemical basis of suitability of rice varieties to BPH. The stem distillate extracts of resistant varieties and of the barnyard grass were repellent and when applied topically caused high mortalities even at low doses. Yoshihara *et al*. (1979; 1980) reported that soluble salicylic acid and oxalic acid in the rice plant acted as BPH sucking inhibitors. But soon it became apparent that salicylic acid was a general sucking inhibitor occurring in both susceptible and resistant varieties. Likewise, oxalic acid was found to occur in both resistant and susceptible varieties, although its concentration was slightly higher in some resistant varieties. Potassium and sodium oxalate at concentration of 0.1%-0.2% completely inhibited sucking on 15% sucrose solution.

IRRI (1980; 1981) reported moderately resistant varieties maintain insect populations equal to those on the susceptible TN1 but suffer less damage. As the damage rating of Triveni were lower than those of TN1 despite similar BPH population. The same was true on Mudgo (moderately resistant) when compared to IR 26, both of which are susceptible to biotype 2. Feeding on Triveni was half on TN1. This may be one reason that Triveni suffers less damage than TN1 at similar populations. Tolerance is the ability of

a plant to survive and grow despite insect feeding. In tolerant varieties the photosynthetic activities were continued despite severe plant damage, while this activity ceased in susceptible variety at same level of damage. The average concentration of oxalic acid was 0.24 mg/g fresh leaf sheath tissues in susceptible varieties and 0.45 to 0.59 in 5 resistant varieties. Likewise, the average percentage of oxalic acid in total organic acid was lower in susceptible (5-8%) than in resistant varieties (10.0-14.4%). The higher oxalic acid is one of the chemical factor governing resistance to the BPH.

Samal (1980) observed anatomical feature of the stem of 5 resistant and 2 susceptible varieties such as Ptb 33, T 1415, Ptb 18, CR 57-11-2, ARC 6650, Jaya and TN1. It was found that stem of resistant varieties have relatively smaller vascular bundles, 3-6 layers of sclerenchymatous hypodermis while, the stem of susceptible varieties have relatively larger vascular bundles and 2-4 layer of sclerenchymatous hypodermis.

Samal (1983) analysed the total silica content of leaf sheath of 45 days-old seedlings of four resistant varieties viz., CR57-11-2, MR1523, Ptb 33 and Ptb 21 and two susceptible varieties TN1 and Jaya was found to be 0.18, 0.14, 0.21, 0.14, 0.27 and 0.27 per cent respectively. As percentage of silica was less in leaf sheaths of both

resistant and susceptible varieties, there may not be any correlation between percentage of total silica and resistance to BPH in rice. The stem of these varieties also estimated for total soluble sugars, amino acids and Phenol (at 15, 30, 45, 60 DAT and boot leaf stage) . It was found that total soluble sugars were more in all stages of TN1 and three stages (30, 45 and 60 DAT) in Jaya. The total amino acids were more in susceptible varieties Jaya (30, 45 and 60 days) and TN1 (at 60 days and boot leaf stage) than resistant varieties at the same stages. While, total phenolic content were more in resistant varieties Ptb 33 (45 and 60 days) and CR 57-11-2 (30, 45 and 60 days) than the susceptible varieties Jaya and TN1 at same stage.

Saxena and Okech (1985) reported the topical application of the extracts of resistant varieties Mudgo, ASD7, Rathu Heenati, Babawee, Ptb 33 and ARC 6650 caused significantly higher mortality of females than the TN1 extract. The extract of 60 days-old resistant plants was more toxic than the extract of 30, 45 or 100 days-old plants.

Veronica (1985) studied the biochemical analysis of test varieties and indicated higher concentration of total sugars and total nitrogen content in susceptible varieties. Whereas, resistant varieties had higher phenolic compounds. Further, honeydew excreted by the BPH insect susceptible

variety TN1 had higher concentration of amino acids as compared to that on resistant varieties.

2.1.2.1 Feeding test :

Honeydew exreted by brown planthopper (BPH) ; *Nilaparvata lugens* (Stal) has been used as a criterion for determining the amount of sap ingested by the insect on resistant and susceptible rice cultivars (Sogawa and Pathak, 1970).

IRRI (1979) reported varieties with known BPH resistance gene and those with the bph 2 gene all had larger stained area than the Bph 1 varieties with resistance to biotype 3. The bph 2 gene varieties IR 32, IR 36, IR 38 and IR 42 fed less than those with no gene for resistance, but IR 40 was again the most susceptible of the bph 2 gene variety, as indicated by the extent of the stainded area. IRRI (1980) reported feeding on Triveni (moderately resistant) was half of that TN1. This may be one reason Triveni suffered less damage than TN1 at similar population. IRRI (1981) reported BPH moderately resistant varieties allowed an intermediate amount of feeding as compared to resistant and susceptible varieties. Feeding activity on moderate resistant varieties on moderate resistant varieties viz., IR 46, Triveni and Utri Rajapan measured against all biotypes. These varieties indicated lower feeding activity than on resistant variety IR 26.

Pathak et *al*. (1982) reported feeding activity on resistant varieties (Mudgo and ASD 7) were significantly less as compared to susceptible variety (TN1).

Cook et *al*. (1987) determined the honeydew production which was significantly lower on the resistant varieties though insect weight gains in 24 h were similar on IR 46 and IR 22 both being significantly greater than on the highly resistant variety. Gu et *al*. (1987) reported that the average food intake of brachypterous females was 6.33 times that of macropterous males during the first 8 days after hatching. It is suggested that the most suitable time for chemical control is during the adult stage.

Lee (1987) reported while conducting the honeydew excretion screening tests, that biotype 1 excreted 10-20 times more honeydew on the susceptible cultivars than the resistant ones while biotype 2 and 3 excreted 4-5 times more honeydew on the susceptible cultivars than on the resistant ones.

Padghan and Woodhead (1988) reported the major potential sources of variation in the feeding of *Nilaparvata lugens* which are not host dependent are those related i.e. age of the insect, length of time, insect is in association with the plant and the time of day. These parameters were investigated with a susceptible, a moderately resistant and a resistant rice variety using honeydew clocks for the

collection of honeydew excretion data. It is concluded that there are non-circadian patterns of honeydew excretion which are related to the degree of variety and that such feeding and excretion pattern can be used to characterize the relationship between insect populations and rice varieties.

Hasan and Kamal (1992) the susceptibility reaction to brown planthopper (BPH) in four rice varieties, Hotel Samba, Kurihondarawala, ARC 10550 and Swarnalata having four different BPH resistant genes along with resistant (T27A) and susceptible (TN1) checks was studied through varietal damage reaction, preference and honeydew tests. BPH feeding was low on Swarnalata and ARC 10550 and these showed resistant scores of 3 and 5 respectively. Swarnalata, a traditional Bangladeshi variety, developed some quality at the later growth stage which made it nonpreferable to BPH while Hotel Samba and Kuruhondarawala had BPH preference and feeding similar to that of Swarnalata and ARC 10550 but showed susceptibility scores of 9 in the damage reaction test, indicating their lack of tolerance.

Pophaly and Rana (1993b) reported the BPH feeding test on resistant cultivars viz. Hinga, Kapee, Dhouri 1043, Dhouri 1163, Jaybay Rang, Khatia Pati, Kanak, Ganja Kali, Hiranakhi and EB17. Feeding rate was ranged between 0.17 to 65 mm^2 per female in 24 hours, which was much lower than the feeding on TN1 (173.23 mm^2/q).

Pophaly and Rana (1995) evaluated the feeding rate of BPH on some selected ressistance varieties ranged between 0.96 mm^2/female in Chapdo to 65 mm^2/female in Hinga variety which exhibited 0.65 plant damage score. The standard seedling test showed Rathu Heenati (Bph3) and Balamawee (Bph 9) moderately resistant and Swarnalata (Bph 6) and ARC 10550 (bph 5) resistant. Honeydew excretion test confirmed these results.

2.1.2.2 Probing mark test :

The probing response of the BPH to the rice varieties and barnyard grass was also uniformly high, indicating the absence of mechanical barriers to insertion of stylets (Sogawa and Pathak, 1970).

The result of the probing behaviour indicated that the resistant varieties received more number of probing punctures than the susceptible ones (Reddy, 1979; Reddy and Kalode, 1985 and Veronica, 1985).

The electronic measurement system greatly facilitates the behavioural study of feeding and probing by piercing and sucking insects on susceptible and resistant plants (Kawabe et *al*., 1981; Velusamy and Heinrichs, 1986).

2.1.2.3 Ovipositional response :

Saxena (1976) reported the number of eggs produced on TN1, IR8 and IR20 varieties was very high compared to the

resistant varieties. A comparison of egg-production between Mudgo and IR20, IR8 and TN1 showed that the insect produced almost 100 to 200 times more eggs on the susceptible varieties.

Sekido and Sogawa (1976) reported that *N. lugens* oviposited preferably in salicylic acid media, while only a few eggs were laid in a salicylic acid-free control medium.

Pathak et *al*. (1982) observed that the fecundity in an adult female differed on resitant and susceptible plants in respect to the preoviposition period and number of eggs produced during its life. The preoviposition period was shortest on TN1. There were only marginal differences in the preoviposition period of selected population among the three varieties, the period being slightly longer on the varieties on which the insect had not been selected. The population selected on Mudgo had a higher fecundity rate on mudgo and TN1 as compared with ASD-7, but due to high variation the differences was not significant.

Lee (1987) reported the BPH resistant cultivars (RCs) less preferred for feeding than susceptible cultivars (SCs) but there was no significant difference between RCs and SCs in preference for oviposition.

Park and Song (1988) reported feeding and oviposition preferences of 3 biotypes on Dongjinbyeo (no resistance

gene) were greater than for cultivars with resistance genes. Preferences of biotype 2 for Cheongcheongbyeo (Bph 1 gene) and biotype 3 for Milyang 63 were relatively high but lower than those for Dongjinbyeo.

Misra *et al*. (1988) Studied the eggs nymphs and adults were in the laboratory on the resistant cultivars Daya, Pratap, Sinna Sivappu and IET 7575, tolerant Utri-Rajapan and susceptible Jaya. The values for adult longevity, fecundity, egg hatchability and growth index were significantly lower on the 4 resistant cultivars than the susceptible control.

Velusamy and Saxena (1989) reported the fecundity and egg viability higher on susceptible TN1, IR 747-B2-6 and ASD7 than on resistant Rathu Heenati, Babawee, ARC 10550, Swarnalata and Ptb 33.

Senguttuvan et *al*. (1991) reported highly resistant Ptb 33 was less preferred for settling and oviposition than susceptible TN1. Yu and Wu (1991) reported the BPH female laid significantly more eggs on susceptible Shan You 63 and Xiu Shui 48 than on other varieties. BPH fecundity at booting was higher than at tillering. BPH resistant varieties Shan You no. 6, Xiu Shui 63 and Bing 664 received less eggs of BPH than susceptible varieties. Rathu Heenati and TN1 were used as a resistant and susceptible check, respectively.

Velusamy et *al*. (1995) reported BPH resistant wild rices *Oryza officinalis, O. punctata* and *O. latifolia* had low fecundity as compared to cultivated resistant varieties.

2.7 Biochemical studies :

Kim et *al*. (1975) reported that brown planthopper could not survive on Barnyard grass which contain t-aconitic acid as putative antifeedant, when t-aconitic acid was included in the artificial diet, it inhibited the feeding of brown plant hopper.

Yoshihara et *al*.(1979) identified soluble salysilic and oxalic acid isolated from leaf sheath extracts of rice as potent sucking inhibitor for *N. lugens*.

Kawabe et *al*. (1980) reported that the brown plant hoppers fed mainly on the leaf sheath and the production and distribution of t-aconitic acid in the leaf sheath are considered to be adequate. It is therefore, suggested that BPH may be sensitive to the presence of an antifeedant in this cell and the probing is interrupted before the stylet locates the phloem. They further described that quantitative analysis of sugar in the phloem sap using thin layer chromatography and gas chromatography revealed that sucrose was the only phloem sugar present. Sucrose content in the sap was estimated to be 17% and remained constant during the reduction period.

Shigematsu et *al*. (1982) has analysed phloem exract of resistant and susceptible rice cultivars using gas liquid chromatography selected ion monitoring chromatography (GC-SIM) after trimethylsilylation technique and identified 6 sitosterol as a main sterol and its content in the phloem sap of (80R) resistant cultivars were several times more than that of susceptible (74S) rice cultivars.

Saxena and Okech (1985) reported that the incorporation of the extract of the susceptible TN1 cultivar into 10% sucrose solution stimulated significant greater intake by *N. lugens* female than that of sucrose solution alone or intake of the extract of the resistant cultivars mudgo, Ptb 33, ARC 6650. The resistant cultivars ASD-7 was an exception and *N. lugens* female feed as well on sucrose solution with ASD 7 extract as with TN1 extract. The extract of Ptb-33 and Rathu Heenati caused maximum inhibition of intake of sucrose solution.

Vishwanathan and Kalode (1990) reported that no apparent differences were observed in relation to sucrose, glucose and fructose. All the test varieties and *L. haxendra* weed had 3 sugar (sucrose, glucose and fructose) almost in comparable quantities, thereby suggesting no significant role of these sugar in resistance against the leaf hoppers. Sogawa and Pathak (1970) could not correlate the susceptibility (IR8 and TN1) and resistance mudgo of rice

varieties with sugar content. On the other hand, Peraiah et *al*. (1982) observed higher amount of sugar in brown plant hopper susceptible varieties (Telia Hamsu and Jaya) as compared to resistant variety.

Previous studies have shown that the feeding behaviour of BPH on different rice varieties is not related to the wide variety of so called resistant gene (Padgham et *al*., 1989) . There appear to be at least two major component of resistance. The most common, including that in the variety 'Pathu Heenati' is in the phloem. In the two other varieties studies BG 300 and BG 379/2 the mechanism is derived from Pathu Heenati thus one might expect it to be the same. The second component which is reported only for variety IR 46 is increased surface activity of BPH attributed to leaf surface waxes (Woodhead & Padgham, 1988). Previous studies have identified apigenin-c-glycosides e.g. schaftoside and isoschaftoside in whole leaf extracts (Besson et *al*., 1985) and in rice phloem (Grayer et *al*., 1994) and have suggested that they stimulate probing in BPH. Stevenson et *al*. (1996) provided evidence that there phloem derived compound apigenin-c-glycoside play an important role in rice resistance to BPH.

Vishwanathan and Kalode (1990) reported that the total phenol present were lowest in the susceptible varety TN1 while the resistant varieties had higher concentration on

the other hand L. hexandra, a susceptible host of *N. nigroprictus* had the highest quantity of total phenol. Probably, further analysis of individual phenol in test varieties may give some clue regarding to the role of such phenolic compounds in imparting resistance to green leaf hopper. Krishna (1977) found that phenolic in healthy samples of resistant and susceptible varieties were not indicative of any role played by these compound but upon infestation by brown plant hopper, resistant variety was found to react sharply in producing higher amount of phenols. In general, resistant varieties contained more phenolic compounds than susceptible varieties (Pathak & Kush, 1979).

Thayumanvan et *al*. (1990) resistant varieties possesed significantly higher content of total phenols. Salicylic acid was higher in susceptible varieties, but concentration of chlogogenic and gallic acids were higher in resistant varieties. Reducing sugars were significantly higher in susceptible varieties. Free amono acid content was generally higher in susceptible varieties.

Vishwanathan and Kalode (1990) Biochemical analysis of a rice varieties and a weed showed that the total free amino acid content was greater in the susceptible variety TN1 than in Ptb 2, Ptb 7 and ptb 18 wich are resistant to both the species of green leafhoppers. However, the weed *Leersia*

hexandra the most suitable host of *Nephotettix nigroprictus*, had the lowest amount of free amino acid. No apparant differences were observed in relation to sucrose, glucose and fructose content in the test varieties. Total phenol content was the highest in *Leersia hexandra* followed by resistant varieties, while it was the lowest in the susceptible rice variety.

Vishwanathan and Kalode (1990) several biochemicals like, phenols, oxalic acid, low molecular proteins fractions are reported to be associated with rice. While working with green leaf hopper, *Nephotettix virescens* (Distant) resistance, Vishwanathan and Kalode (1990) reported the less amount *of* free amino acid content in resistant varieties Ptb 2, Ptb 7 and Ptb 18. Resistant varieties also contain more phenol content than susceptible once.

Katsuhara *et al*. (1993) reported that a quantative analysis of organic acid in leaves of Barnyard grass revealed that the contents of trans aconitic acid were high, suggesting that this compound may act as an antifeedant against brown planthopper. However, trans aconitic acid could not be detected in the phloem sap which was considered to be main nutrient source for brown planthopper. Trans-aconitic acid was formed in vitro from sis-acotinic acid through the aconitatic isomerge activity which was detected only in the leaf sheath, but not in the leaf blade.

Mansour et *al*. (1994) reported that Phenolics as allelochemicals played a principal role in the control of *Ostrunia nubilalis.* Catechol and resorcinol as simple phenols when incorporated in a synthetic diet at 0.5 mg/g diet inhibited the larval growth by reducing the food consumption and increased excretion. There was a decrease in the efficiency of conversion of assimilated food. The overall efficiency of ingested and digested food was decreased, leading to a reduction in the pupal weight.

Phenolic acid and codensed tannin have been implicated in plant resistance to insect pest and disease (Lege et *al*., 1995). Such phenolic compound precipitate proteins (Swain, 1979) and have been reported as digestibility reducing agent and may act as a dosage dependent defence against insect pest feeding on plants (Levin, 1971, Rhodes & Cates, 1976). In chickpea, the malate and oxalate (Rambolt and Tober, 1985) and oxalic acid (Yoshida, 1995) have been reported to impart the host resistance against the *H. armigera*.

Li GuoQing et *al*.(1996) studied comparison with a moderately resistant rice variety IR 28, and the susceptible varieties NJ 11, Sy 63 and TN1, the resistance factors to brown planthopper *(Nilaparvatalugens)* in the blade of NJ 14, Fewer sucking-stimulatory amino acids were found in the blade of NJ 11 was the same, but NJ 14 had 93 times more oxalic acid in the phloem than NJ 11. The high concn of

oxalic acid may also have an antifeedant effect. An acetone extract of the blade of NJ 14 was a hydrophilic growth inhibitor and could significantly increase the mortality of *N. lugens*.

Ananthakrishnan (1997) reported that the role of phenolic compound i.e. gallic acid and sulycilic acid, synergic acid and resorcinol and phloro-glucinol has been known to have chronic effect on growth, ingestion and utilization of food against *Helicoverpa armigera*, BPH and phenolic compund localized and systemic signals are released at the site of insect feeding damage and the signals get translocated to other parts of the plant where they induce defence mechanism. Gallic and salicylic acid are known to play an important role in insect plant interaction and have considerable practical application in the area of biotechnology of crop protection.

Veeranna (1998) has reported that total phenol and tanin content was calculated by using chlorogenic acid and catachin as standard. The genotypes exhibited variation in the total phenol and tannin content with the tolerent genotype TVX-7 showing 0.96 of total phenol and 0.75% of total tannin of 0.54% and 0.41% respectively. Therefore, higher level of phenol and tannin content was found in tolerent genotypes than susceptible.

MATERIALS AND METHODS

CHAPTER - III

MATERIALS AND METHODS

The experimental material of 1100 rice accessions of late maturity group belonged to IGKV, Raipur rice germplasm bank. The experiments were carried out in the glass house, Department of Entomology, IGKV, Raipur and Biochemistry Laboratory, Department of Plant Breeding, IGKV, Raipur.

3.1 Isolation of resistant donors :

Mass-rearing : The brown planthopper (BPH) Nilparvata lugens (Stal) population is maintained thorughout the year in the glass house at 30°C ± 5°C on potted TN-1 susceptible variety. BPH were reared on 40-50 days old TN-1 rice plants inside a rearing cage of 75 x 75 x 75 cms (Fig.1) size consisting of wooden frame with small window on front side and fine wire mesh on top and other sides cages were placed on raised platform having water level of 7.5 cm.

Potted TN-1 plants were placed inside rearing cages for egg laying alongwith 60 pairs of BPH per pot. After 2-3 days, the females started egg laying inside the leaf sheath of rice plants. Later, an emergence of nymph from eggs of TN-1 susceptible rice plants. The released BPH pairs were transferred to another TN-1 rice plants pots with the help

Plate 3.1 : Mass rearing of brown planthopper second instar BPH population (nymphs)

of aspirator for egg laying when newly emerged nymphs reached to second instar they were used in screening of rice germplasm.

3.1.1 Screening of rice germplasm :

Screening of rice germplasm was conducted under controlled condition of glass house as per methodology suggested by Kalode and Krishna (1979) . The test and check varieties were pregerminated in petridishes (10 cm. diameter). The germinated seed was sown in rows 5 cm, apart in 60 x 40 x 15 cm wooden boxes, containing homogenous soil. Each tray accomodated 16 rows of test entries (each with 15 seedlings) along with 2 middle row of resistant check Ptb-33 and 4 border row of susceptible check TN-1.

The wooden trays were placed in 7.5 cm deep water on raised platform to maintain high humidity necessary for development of BPH population. First to second instar @ 8-10 nymphs per seedling gently were released uniformly on the 7-10 days old or 1-2 leaf stage of rice seedlings.

The observations were recorded on the basis of 0-9 scale when more than 90% of TN-1 seedlings were dead by the BPH infestation (Seshu and Kauffman, 1980). The reaction was completed between 7-10 days after inoculation of insects. Promising entries were re-evaluated 5-6 times to get consistent reactions.

Plate 3.2 : Screening of rice germ plasm against brown planthopper (BPH)

Plate 3.3 : Uninfested and infested rice varieties.

Fig. 3.1: Layout for screening of rice germplasm lines for resistance to the brown planthopper.

• • • Susceptible check
• • • Resistance check
— Test line

Scoring of seedlings were done on the basis of visual plant damage symptoms (0-9 scale) which is as follow :

BPH scoring symptoms on rice germplams.

Score	Rating	Symptoms
0	Highly resistant	No visible damage
1	Resistant	Partial yellowing for first leaf
3	Moderately resistant	First and second leaves partially yellow.
5	Moderately susceptible	Pronounced yellowing and some stunting or wilting
7	Susceptible	More than half of the plants are wilting or dead and ramaining plants severaly stunted.
9	Highly susceptible	All plants dead.

3.1.2 Mechanism of resistance :

1. **Feeding test** : Feeding test was assessed by quantifying the area of honeydew excreted by the insect on filter paper in 24 hours (h) of confinement on the test variety.

White Whatman's No. 1 filter papter (10 cm) were dipped in a solution of bromocreosol green (2 mg/ml ethanol) and allowed to dry in sunlight then filter papers turned yellowish orange (Pathak and Heinrich, 1982a). Bromocreosol green is a green indicator which is yellow at pH 3.8 and blue green at pH 5.4 (Anonymous, 1976).

Plate 3.4 : Feeding test of brown planthopper

The treated filter papers were placed on an inverted petridish (10 cm diameter) at the base of plant through a slit made in centre. After that each plant was covered with on inverted glass funnel (75 mm) alongwith two days old female allowed to feed on leaf sheath for 24 h. The insects were starved for three hours prior to conducting the test. Feeding activity was investigated at 30 days old potted plants. Ten replicates were used for each variety and each replications contain two females on each tiller of the plant.

Blue spots appeared on the treated filters papers by the honeydew secreted by female. As the concentration of the honeydew increased, the spots turned white in the centre with blue edges. The spots were traced on transparent filter paper and measured by keeping on milimeter square graph. The amount of feeding excreted by the insect on test varieties as well as susceptible and resistant check, expressed in terms of honeydew excretion per female in mm^2 unit per plant.

3.2 Probing mark test :

This test was carried out according to methodology suggested by Natio (1964). Seed of identified promising rice accessions and check varieties TN-1 and Ptb-33 were germinated separately in petridishes. Germinated seed was sown in the wooden trays containing well puddled soil. After

seven days, the seedlings of each variety were removed from trays and washed thoroughly with water and then transferred individually into 15 cm long test tubes containing a few drop of water. Two days old healthy single female was introduced individually into each test tube and allowed to make punctures on the seedling for one night (12 hours). Test tubes were plugged with sterlized cotton swab. Thereafter, the seedlings were transferred for staining in another tube containing 1.0% erythrosine dye aqueous solution. Insect probing marks were counted by necked eyes after 30 minutes of staining. Ten replications were used for each promising accessions and each replicate contain one seedling.

3.3 Ovipositional response :

Ovipositional response of BPH female was studied on some selected test entries. Two newly mature gravid females of BPH were caged on the basal portion of plant. This female was allowed to oviposit for two days on 50 days old potted plant. Thereafter female was removed and plant dissected for presence of BPH eggs which were counted in all treatments as well as TN-1 and Ptb-33 were used as susceptible and resistant check respectively. There were ten replications of all test entries and check varieties.

Plate 3.5 : Probing mark test : Staining with 1.0% erythrosine solution.

Plate 3.6 : Egg laying study of brown planthopper in resistant accession of rice germplasm.

3.4 Biochemical studies :

All glasswares required in the experiment were cleaned with potassium dichromate sulphuric acid solution then washed throughly with liquid detergent. Further, these were washed by ordinary tap water and then rinsed with distilled water and alchohol. Finally all these glasswares were sterilized at 80°C temperature for use. Glaxo sigma AR grade chemicals and solvent were used for making buffer standard solution and colour reagents.

3.4.1 Extraction procedure for phenol :

Thirty and sixty days old fresh BPH resistant plant sample of 23 rice accession were washed with distilled water and then dried at 50°C for 24 hours for phenol estimation. TN-1 susceptible and Ptb-33 resistant check varieties were also taken for estimation of total phenol. Fresh plant material (1.0 gm) was taken for extraction in 80% alcoholic borate buffer (0.2 M, pH *1.6)* at room temperature in dark with the help of pistal motor to homogenise the sample suspension, centrifuged at 3,000 rpm for 15 minutes twice. Supernatent was collected for estimation of phenols. The volume extracted sample was made to 5 ml with borate buffer and was used as a source of phenolic compound estimation.

3.4.2 Estimation of total phenols :

Total phenolic content was estimated by the method of Swain and Hills (1959). The reaction mixture was prepared in the following manner.

100 µl = 0.1 ml plant extract

800 µl = 0.8 ml distilled water

100 µl = 0.1 ml folin reagent (IN)

2000 ul = 2.0 ml sodium carbonate

The total volume of reaction mixture used was 3 ml. The absorbance of the blue solution was measured at 660 nm, after incubating it for 45 min. in order to develop the colour. Standard curve was prepared using different concentrations of chlorogenic acid stock solution 1 x 10^{-3} g/ml. Phenolic content was expressed as mg total phenol per gm fresh weight of plant sample. Three replications were made from each test sample.

3.4.2.1 Estimation of Monophenol :

Monophenols were determined by the method of Emerson (1943) . The reaction mixture consisted of in the following manner :

0.1 ul Plant extract

0.4 ul Distilled water

0.4 ul Sodium hydroxide (0.5 N)

0.5 ul Antepyrine

0.6 ul Sodium bi carbonate

0.5 ul Potassium fero cyanide.

The volume of reaction mixture was made up to 2.5 ul was measured at 620 nm. After incubating it for 45 minutes the pink coloured developed was measured at 620 nm spectrometer. Blank was used as a reference. Standard curve was prepared using different concentrations of phenol stock solution 1 x 10 g/ml. The phenolic content was expressed as mg monophenol per gm fresh weight of plant sample. Three replications were recorded from each test sample.

3.4.2.2 Estimation of **Diphenol** (O-Dihodroxy benzene) :

The O-dihodroxy phenolic content was assayed by the method of Mahadevan (1975). The reaction mixture consisted the following manner.

0.1 ul	Plant extract
0.4 ul	Distilled water
1.0 ul	Hydrochloric acid
0.5 ul	Arnous reagent
1.0 ml	Sodium hydroxide (IN)

The volume of reaction mixture was made up to 3 ml. After incubating it for 45 minutes, the pink colour developed. It was measured at 620 nm. Blank was used as a reference. Standard curve was prepared using different concentrations of catechcol (O-dilydroxy benzene) stock solution 1 x 10 g/ml. The phenolic content was expressed as mg diphenol per gm fresh weight of plant sample. Three replications were recorded from each test sample.

3.4.3 Extraction procedure for sugar :

Estimation *of* total soluble sugar in plant was done by the method proposed by Dubois (1956). The extraction of total soluble sugar in plant was done in phosphate buffer (0.05 M, pH 7.2) as per procedure given below.

Thirty days old fresh BPH resistant plant samples of 23 rice accession were washed with distilled water and then dried at 50°C for 24 h for soluble sugar estimation. TN1 susceptible and Ptb-33 resistant check, varieties were also taken for total sugar estimation. 0.1 gm each of this sample in 5 ml of buffer was taken and homogenised in glass pistal motor. The suspension was centrifuged at 3000 rpm for 15 minutes twice and supernatent was collected for estimation of total sugars.

3.4.4 : Estimation of total sugar :

Fifty micro liter plant extract supernatent was taken and 2.8 ml of anthrone reagent (0.2% anthrone in conc. sulphuric acid) was added to it. The volume was made up to 4 ml in all tubes by adding distilled water. The tubes were covered with glass ball on the mouth of each test tube to prevent the evaporation. These tubes were placed in boiling water both for 10 minutes. The test tubes were allowed to cool at room temperature, when the blue green coloured appeared and blank was also run simultaniously. The optical density of each sample was recorded at 625 mm spectrometer.

The standard curves were prepared with glucose solution at different concentrations of 2 x 10^{-} . Standard graphs were drawn by plotting concentration of the standard on the X axis verses absorbance on Y axis. The total sugar content was expressed as mg/gm fresh weight of plant sample.

3.4.5 Statistical Analysis :

Standard procedure of carrying out correlation analysis among different variables was adopted. Path coefficients were worked out as per the procedure suggested by Dewey and Lu (1959) .

RESULTS

CHAPTER - IV

RESULTS

Germplasm is a main basic unit in developing pest resistant varieties. It represents gene pool of a particular crop in the specific geographical area. In India, utilization of this germplasm to a fullest length is yet to be achieved for the development of pest resistant varieties.

Progress of the development of rice varieties resistant to brown planthopper (BPH) in Asia has been fast. The reasons for this is rich rice germplasm collection and availability of perfect screening techniques. Inspite of this, several estimates are available on yield losses due to the insect pests (Hinckley, 1963; Kulshreshtha *et al.*, 1974 and Gangrade, et *al.*, 1978). The reasons for this is break down in resistant varieties developed and evolution of more prolific virulent strains of BPH. (Pophaly and Rana, 1994). This insect biotypic variations limit the scope of resistant varieties.

Raipur IGKV rice germplasm is the second largest collection in the world (Sharma et *al.* 1987). Host plant resistance is the most preferred management strategy over insecticide application and it can phase out the use of insecticides to a great extent, thereby activating the cryptic natural enemies to exercise their potential or insect pests.

4.1 Isolation of resistant donors :

In all, 1100 accessions of rice germplasm were studied against BPH in glass house by adopting internationally accepted screening technique. Out of these genetic stock, 115 accessions (Table 1) were identified as promising resistant donors whereas 61 entries were found moderately resistant to BPH insect (Table 2) remaining susceptible entries are listed in appendix I.

Resistant accessions :

In-depth studies were carried out for 23 isolated BPH resistant donors, with respect to probing marks made by the insect and honey dew excreted by caging on individual resistant plants. Number of probes indicates the attempts made by insect for their nutritional requirement, and honey dew excretion is the indication of suitability of nutrition required for growth and development. Egg laying capacity of BPH females on these resistant donors was also studied. All these studies form the mechanism of resistance involved in these isolated resistant donors.

Further, various chemicals that are responsible for resistant mechanism phenomena in these resistant plants were also estimated.

Table 1: Plant damage score of isolated resistant donors of BPH *Nilaparvata lugens* (Stal).

S. No.	Accession No. of I.G.K.V.	Name of Cultivars	Average plant damage score	Rating
1.	C:108	CHITAKA	0.24	R
2.	A:64	ASAM CHUDI	0.37	R
3.	B:1458	BHAMASUR	0.57	R
4.	B:214 III	BADSHAH BHOG	0.83	R
5.	C:110 II	CHUDI	0.87	R
6.	B:1640	BADSHAH BHOG	0.88	R
7.	B:1409	BHIMSEN	0.98	R
8.	C:13 III	CHIRAI NAKHI	1.16	R
9.	C:561	CHIRAI PHOLA	1.16	R
10.	B:2040	BHAKUA	1.23	R
11.	BOT:57III	BARONDA OFF TYPE	1.25	R
12.	C:327	CHITAR BOTI	1.28	R
13.	B:2800	BUDHA BUDHI	1.29	R
14.	BOT:57II	BARONDA OFF TYPE	1.29	R
15.	B:236	BACHELI	1.30	R
16.	A:600	ASSAM CHUDI	1.31	R
17.	B:667	BADSHAH BHOG	1.32	R
18.	BOT:57IV	BARONDA OFF TYPE	1.33	R
19.	B:1049 N	BHAIS PATH	1.33	R
20.	A:206	ASSAM CHUDI	1.35	R
21.	C:629	CHALIS	1.38	R
22.	B:1672	BARMA TRIPAL	1.41	R
23.	C:443 II	CHAMELI	1.44	R
24.	B:1567	BADSHAH BHOG	1.48	R
25.	B:767	BHEJARI	1.56	R
26.	W:21 II	WISHUN BHOG	1.55	R
27.	C:650	CHUDI	1.59	R
28.	B:2175	BUDHA BUDHI	1.62	R
29.	C:651 II	CHUDI	1.66	R
30.	B:1409	BHIMSEN	1.69	R
31.	C:198 I	CHHATRI	1.71	R
32.	C:727	CHUDI	1.71	R
33.	B:448	BADSHAH BHOG	1.72	R
34.	A:584	ASSAM CHUDI	1.78	R
35.	B:542 I	BARMA CROSS TRIPLE	1.81	R
36.	BOT:6	BARONDA OFF TYPE	1.82	R
37.	B:430	BHADAILI	1.86	R
38.	B:543 II	BENISAR	1.86	R
39.	A:550	ASSAM CHUDI	1.87	R
40.	A:308	ASSAM CHUDI	1.89	R
41.	B:1567	BADSHAH BHOG	1.95	R
42.	N:65	NAWAB BHOG	1.98	R
43.	C:376 I	CHUDI	2.00	R
44.	C:463	CHUDI	2.03	R
45.	A:533	ASSAM CHUDI	2.04	R
46.	B:431 N	BHEJARI	2.05	R
47.	C:164 I	CHIRAI NAKHI	2.06	R
48.	C:435	CHINNOR	2.07	R
49.	B:98	BURDA	2.07	R

S. No.	Accession No. of I.G.K.V.	Name of Cultivars	Average plant damage score	Rating
50.	C:643	CHIRAI JIBHI	2.08	R
51.	C:750	CHUDI	2.08	R
52.	B:43	BARONDA OFF TYPE	2.08	R
53.	C:164 II	CHIRAI NAKHI	2.10	R
54.	C:652	CHUDI	2.11	R
55.	B:233 I	BHATA	2.12	R
56.	C:651	CHUDI	2.13	R
57.	B:1790	BYAPARI JHOPA	2.15	R
58.	B:2269	BUDHI BUDHA	2.16	R
59.	W:69 II	URAI BUTA	2.16	R
60.	C:762	CHUDI	2.17	R
61.	C:15 II	CHINA BAL	2.17	R
62.	C:13A II	CHIRAI NAKHI	2.18	R
63.	B:2028	BUDHA BUDHI	2.20	R
64.	C:265	CHHATRI	2.22	R
65.	C:235 I	CHHATRI	2.22	R
66.	A:583	AMERICA CHUDI	2.23	R
67.	C:676	CHHINDMOR	2.24	R
68.	C:746	CHUDI	2.27	R
69.	C:759	CHING PURI	2.28	R
70.	BOT:22	BARONDA OFF TYPE	2.30	R
71.	B:105	BHEJARI	2.31	R
72.	K:1223	KHIRABIJO	2.32	R
73.	B:1995	BHATHA BHUNDI	2.34	R
74.	C:383	CHHIND	2.36	R
75.	C:165 II	CHENDARA CHHAL	2.42	R
76.	B:1404 II	BARUNGI	2.43	R
77.	N:633	NAWAB BHOG	2.44	R
78.	C:443 I	CHAMELI	2.45	R
79.	T:13	TENDU BUTA	2.46	R
80.	A:379 II	ASSAM CHUDI	2.47	R
81.	C:803	CHINNOUR	2.48	R
82.	A:206	ASSAM CHUDI	2.48	R
83.	B:2257	BUDI DHAN	2.49	R
84.	C:288	CHIRAI NAKHI	2.49	R
85.	C:289	CHUDI	2.52	R
86.	BOT:20	BARONDA OFF TYPE	2.53	R
87.	B:294 II	BYORA	2.53	R
88.	B:465 I	BUDA BUDI	2.54	R
89.	B:323	BADSHAH BHOG	2.54	R
90.	B:467 II	BATRAJ	2.56	R
91.	B:2843	BHAGI	2.56	R
92.	BOT:59	BARONDA OFF TYPE	2.61	R
93.	B:2419	BAYKANA	2.61	R
94.	K:559	KANTH CHINNOR	2.63	R
95.	W:122 II	URAI BUTA	2.67	R
96.	B:1426 II	BHEJARI	2.67	R
97.	C:799	CHHATRI	2.69	R
98.	C:219	CHITAL CHINI	2.69	R
99.	BOT:21	BARONDA OFF TYPE	2.70	R
100.	C:747	CHUDI	2.74	R

S. No.	Accession No. of I.G.K.V.	Name of Cultivars	Average plant damage score	Rating
101.	U:106	URAI BUTA	2.74	R
102.	B:214	BADSHAH BHOG	2.75	R
103.	C:586	CHATIYA NAKI	2.75	R
104.	C:824	CHUDI	2.83	R
105.	U:146	URAI BUTA	2.83	R
106.	B:1638	BADSHAH BHOG	2.84	R
107.	C:806	CHINNOUR	2.85	R
108.	C:666	CHHIN GOPARI	2.85	R
109.	P:309	ASSAM CHUDI	2.87	R
110.	B:543I	BENISAR	2.89	R
111.	B:34	BADSHAH BHOG	2.89	R
112.	B:190II	BENIKATH	2.94	R
113.	BOT:38	BARONDA OFF TYPE	2.96	R
114.	B:2255	BHAGI	2.99	R
115.	C:30VII	CHINI KAPOOR	2.99	R
116.	(Susceptible check)	TN-1	9.00	S
117.	(Resistant check)	Ptb33	1.78	R

Plant damage score average of 5 replications.
Damage score based on 0-9 scale.
R = Resistant
S = Susceptible

Plate 4.3 : Resistant cultivars : 1-Benisar, 2-Nawab Bhog, A-TN-1 and B-Ptb-33.

Plate 4.4 : Resistant cultivars : 1-Bharda, 2-Bhejari, 3-Buda Budi, 4-Bhagi, A-TN-1 and B-Ptb-33.

Plate 4.1 : Resistant cultivars : 1-Bhamasur, 2-Badshah Bhog, 3-Badshah Bhog, 4-Bhimsen, A-TN-1 and B-Ptb-33.

Plate 4.2 : Resistant cultivars : 1-Chirai Nakhi, 2-Chitar Boti, 3-Budha Budi, A-TN-1 and B-Ptb-33.

Table 2 : Plant damage score of moderately resistant cultivars of BPH *Nilaparvata lugens* (Stal) isolated.

S. No.	Accession No. of I.G.K.V.	Name of Cultivars	Average plant damage score	Rating
1.	C:207	CHINNOR	3.13	MR
2.	B:1675	BODE	3.25	MR
3.	B:1020 I	BUI LEEM	3.25	MR
4.	D:531 I	DESHI BUDIYA	3.26	MR
5.	BOT:2	BARONDA OFF TYPE	3.28	MR
6.	C:318	CHITAR BOTI	3.30	MR
7.	C:205	CHIRAI KHAJA	3.33	MR
8.	B:542 II	BRAMHA CROSS TRIPLE	3.41	MR
9.	B:2147	KURSO BHOG	3.41	MR
10.	A:581	ASSAM CHUDI	3.43	MR
11.	A:464	ASSAM CHUDI	3.45	MR
12.	A:287	ASSAM CHUDI	3.45	MR
13.	C:366	CHINGAR	3.45	MR
14.	B:2274	BATASI	3.46	MR
15.	B:236 II	BADSHAH BHOG	3.46	MR
16.	A:501	ASSAM CHUDI	3.47	MR
17.	C:588	CHHIND	3.47	MR
18.	B:2777	BARMA	3.48	MR
19.	A:563	ASSAM CHUDI	3.49	MR
20.	A:605	ASSAM CHUDI	3.52	MR
21.	B:525	BIKONI	3.53	MR
22.	A: 159 II	ASSAM CHUDI	3.54	MR
23.	W:8	WRAI BUTA	3.55	MR
24.	M:l AIII	MUNI BHOG	3.56	MR
25.	B:1033	BENISAR	3.56	MR
26.	C:84	CHINNOUR	3.57	MR
27.	A:540	ASSAM CHUDI	3.57	MR
28.	B:41 I	BHADO KAKER	3.59	MR
29.	B:811	BYARANGI	3.60	MR
30.	A:580	ASSAM CHUDI	3.60	MR
31.	R:317	RUI BUTA	3.61	MR
32.	A:209	ASSAM CHUDI	3.61	MR
33.	B:1730	BHAISA NONI	3.61	MR
34.	C:494 II	CHINNOR	3.61	MR
35.	A:503	ASSAM CHUDI	3.62	MR
36.	B:879 II	BHUSKEL	3.64	MR
37.	C:72 II	CHINNOUR	3.66	MR
38.	C:827	CHUDI	3.68	MR
39.	B:889	BHEJARI	3.69	MR
40.	C:588	CHHIND	3.72	MR
41.	B:2132	BIRIJUA	3.72	MR
42.	C:480	CHINNOR	3.74	MR
43.	C:381	CHHINA BAI	3.80	MR
44.	A:441	ASSAM CHUDI	3.80	MR
45.	A:549	ASSAM CHUDI	3.81	MR
46.	B:467 I	BATRAJ	3.81	MR
47.	C:378 I	CHUDI	3.81	MR
48.	BOT:16	BARONDA OFF TYPE	3.82	MR
49.	A:615	ASSAM CHUDI	3.84	MR

S. No.	Accession No. of I.G.K.V.	Name of Cultivars	Average plant damage score	Rating
50.	A:602	ASSAM CHUDI	3.85	MR
51.	T:13 I	TENDU BUTA	3.96	MR
52.	BOT: 7 II	BARONDA OFF TYPE	3.97	MR
53.	C:515	CHINABAL	4.04	MR
54.	W:21 I	WISHUN BHOG	4.04	MR
55.	B:724	BHEJARI	4.04	MR
56.	C:492	CHINNOR	4.11	MR
57.	R:1763	BARMA	4.12	MR
58.	A:8	ASSAM CHUDI	4.12	MR
59.	B:2649	BHEJARI	4.18	MR
60.	BOT: 28 II	BARONDA OFF TYPE	4.21	MR
61.	C:778	CHIKO	4.28	MR
62.	(Susceptible check)	TN-1	9.00	S
63.	(Resistant check)	Ptb33	1.78	R

Plant damage score average of 5 replications.
Damage scoe based on 0-9 scale.
MR = Moderately resistant
R = Resistant
S = Susceptible

All 115 entries exhibited plant damage score which ranged between 0.24 to 2.99 (Table 1). As per the norms of International Scale for plant damage score, all these 115 entries are resistant, but keeping in view the involvement of donors in breeding programme lowest plant damage values i.e. 0.24 to 0.98 were exhibited by cultivars viz. Chitaka (C:108), Assamchudi (A:64), Bhamasur (B:1458), Badshah Bhog (B:214 III), Chudi (C:110 II), Badshah Bhog (B:1640) and Bhimsen (B:1409). This strains are more important by virtue of their lower biological values estimated for resistance parameter rather than other accessions of higher values in the resistant category.

4.2 Mark probing test :

Twenty three identified resistant donors were studied in-depth for probing mark test to find out the mechanism of resistance involved in these entries. All these twenty three resistant donors were exhibited plant damage score ranging between 0.57 to 2.56 and number of probing marks were in the range of 13.10 to 25.10/seedling/q. In susceptible check TN-1 variety (9.0 damage score) probing marks were 10.33/seedling/q. Resistant check variety ptb-33 showed plant damage score 1.78 with probing marks value 20.66/seedling/q. The lowest probing marks were observed in variety Chirai Nakhi (C:13AII) 13.10/seedling/q and highest probing marks in variety Bhawaile (B:430) 25.10/seedling/q. All these 23 resistant donors received more number of

probing marks (13.10 to 25.10/seedling/q) as compared to susceptible check TN-1 varieties (Table 3).

4.3 Ovipositional response :

In order to understand the role of ovipositional response of BPH females on resistant varieties these studies were carried out.

Twenty three resistant donors to BPH were exposed to BPH gravid female for egg laying. The average egg laying ranged between 51.88 to 173.77/plant/q. Four resistant accession were placed in 0.57 to 0.98 (First group) plant damage score, 12 accessions in 1.16 to 1.98 (Second group) and remaining seven accession in 2.03 to 2.56 (Third group). In general seven accessions in group 3 whose plant damage score ranged between 2.03 to 2.56 had shown more egg deposition rate (127.58 eggs/plant/q) than first group (77.82/plant/q) and second group (88.52/plant/q). Where these value are much low than third group. All these 23 selected resistant donors were observed less responsive to egg deposition by BPH female as compared to susceptible check TN-1 variety (199.11 eggs/plant/q). The lowest egg deposition was observed in variety Badhshah Bhog (B:214III) 51 eggs/plant/q and highest eggs in variety Bhagi (B:2843) with 173.77 eggs/plant/q (Table 3).

4.4 Feeding test :

Twenty three identified resistant donors were studied in-depth for honeydew secretion test to find out the mechanism of resistance involved in these donors. All these twenty three resistant donors were exhibited plant damage score between 0.57 to 2.56 and honeydew secretion in the range of 4.66 to 602.47 mm^2/plant/q. In susceptible check TN-1 variety (9.0 damage score) honeydew secretion was found highest 1015.44 mm^2/plant/q. But, the resistant check variety ptb-33 with damage score 1.78, honeydew secretion was observed 322.88 mm^2/plant/q. The lowest honeydew secretion were observed variety Badshah Bhog (B.448) 4.66 mm /plant/q and highest in variety Buda Budi (B:465 I) 602.47 mm^2/plant/q. All these twenty three resistant donors honeydew secretion were observed less as compared to susceptible check TN-1 variety (1015.44 mm^2/plant/q) (Table 3).

However, in order to throw more light on this aspects various parameters were also studied in 23 varieties. Plant damage score in these accessions ranged between 0.57 to 2.56. Honey dew excretion values varied from 4.66 to 602.42 mm^2/plant/q (Table 3). Whereas, number of probing marks were in the range of 13.10 to 25.10/seedling/q. Eggs laid in these varieties were ranged between 59.88 to 173.77/plant/q, corresponding egg laid on TN-1 susceptible check variety were 199.11/plant/q, whereas, on ptb 33 resistant check

Plate 4.6 : Honeydew excretion of BPH on resistant cultivars : 9-Bhejari, 10-Nawab Bhog and A-TN-1.

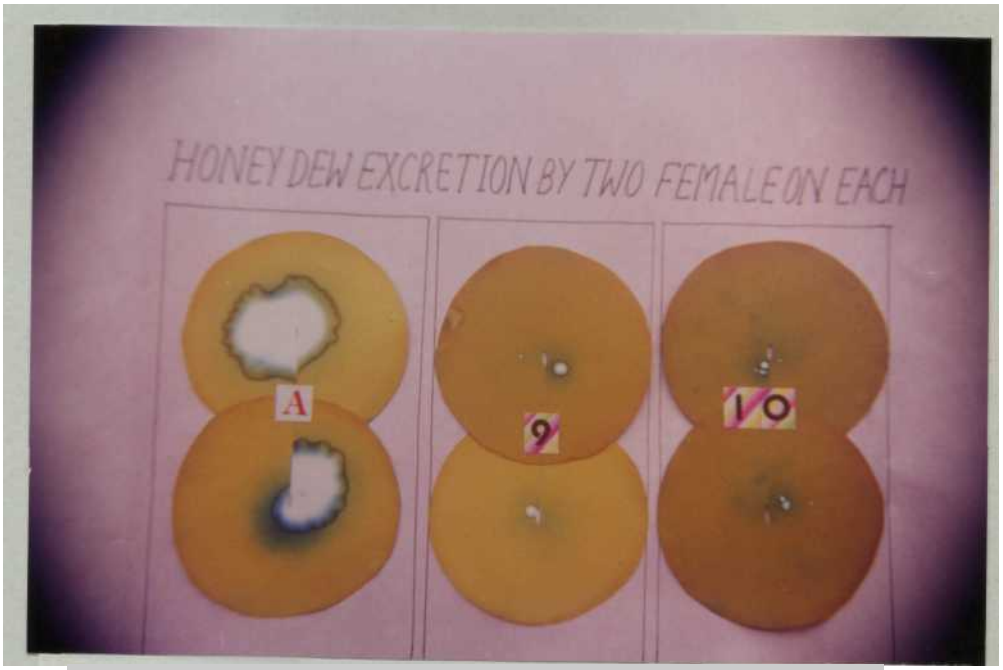


Plate 4.5 : Honeydew excretion of BPH on resistant cultivars : 7-Badshah Bhog, 8-Wishun Bhog and A-TN-1.

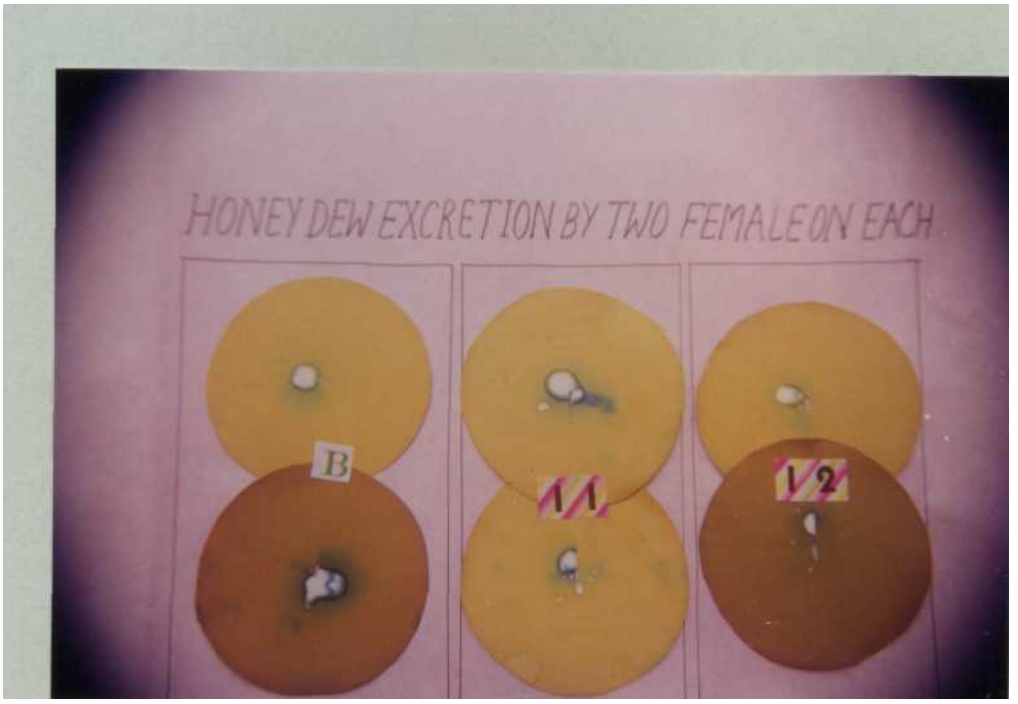


Plate 4.7 : Honeydew excretion of BPH on resistant cultivars : **11-Badshah** Bhog, **12-Chirai** Nakhi and B-Ptb-33.

Plate 4.8 : Honeydew excretion of BPH on resistant cultivars : **3-Barma Tripal,** 4-Benisar and B-Ptb-33.

variety 114.66 egg/plant/q were noticed. Honey dew excretion on TN1 was 1015.44 mm^2/plant/q and that of ptb33 was 322.88 mm^2/plant/q. Number of probes on susceptible TN1 variety were 10.33/plant/q which is much less than that of ptb33 resistant variety 20.66 probes/q/plant (Table 3). Thus, data indicated crystal clear difference between these two susceptible and resistant check variety.

All 23 test entries differ themselves with respect to their biological parameter. Critical analysis of these values depicts the existence of genetic variability and potential of these entries with respect to BPH resistance. There is no correlation between plant damage score, feeding and probing values obtained among these varieties. Therefore, these values indicated the presence of difference in genetic make-up of these donors.

For better understanding identified 23 BPH resistant accessions were further categorized in 3 groups depending on plant damage score values obtained. Four accessions were placed in 0.57 to 0.98 (first group) plant damage score, 12 entries in 1.16 to 1.98 (second group) and remaining seven entries in 2.03 to 2.56 (third group) plant damage score (Table 3).

In general, seven accessions in third group whose plant damage score ranged between 2.03 to 2.56, had shown more honey dew secretion (360.52 mm^2/plant/q), probing marks

18.58/seedling/q and more egg oviposition rate (127.58/plant/q) than first and second group, whereas these values are much less than the first group.

First group :

Four accessions in this first group has shown plant damage score between 0.57 to 0.98 but they differ from each other extremely with respect to honey dew secretion values. Among these four entries, Badshah Bhog (B:214 III) exhibited lowest feeding value (18.66 mm^2/plant/q) and corresponding probing marks were 21.10/seedling/q. This variety also received lowest egg (51.88/plant/q) indicating non-preference for egg laying, feeding and probing. Variety Bhimsen (B:1409) also followed more or less same trend, but feeding rate is more than Bhamasur (B:1458).

Astonishingly, variety Bhamasur (B:1458) with lowest plant damage score (0.57) exhibited more honeydew secretion 427.55 mm^2/plant/q and probing marks only 18.55/seedling/q (Table 3). This variety received only 80.77 egsg/plant/q in ovipositional response studies. Another variety Bhimsen (B:1409) followed the similar trend, indicating the ability of these genotype to recupate the plant losses inspite of more feeding rate. Thus, these two varieties had exhibited significant choice as a BPH resistant donor in breeding programme. Moreover, Badshah Bhog (B:214II) is a scented variety, an additional advantage it contributes.

Second group :

This includes 12 varieties with plant damage score ranged between 1.16 to 1.98. Variety Badshah Bhog (B:448) had given only 4.66 mm /plant/q feeding value which is lowest among all 23 varieties studied. Average probes were 15.10 and 82.99 eggs were received by these varieties in confined condition. Similar trend was also observed in Badshah Bhog (B:214 III) variety and occupy better choice as a BPH resistant donor. In the same group, variety Nawab Bhog (N:635) also received only 19.33 mm^2/plant/q honey dew secretion value with 19.33 probing marks/seedling/q (Table 3).

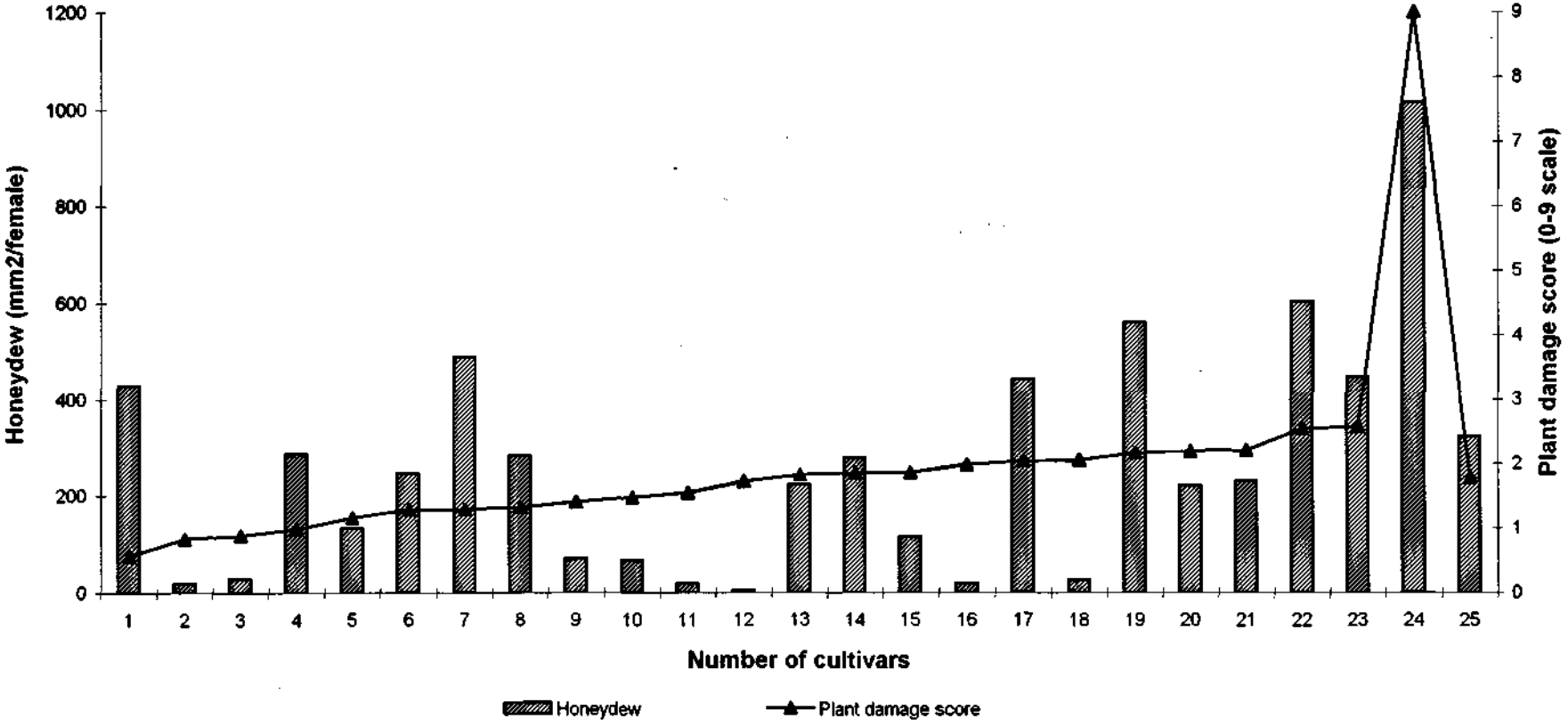
Variety Budha Budhi (B:2800) in this group yielded maximum feeding value 488.88 mm^2/plant/q, this is a characteristic feature of this variety having sustained heavy plant sap drainage, plant damage score value was only 1.29 with lower number of egg deposits (84.88/plant/q). This exhibits the unique genetic ability of this variety to recover, the losses at faster rate, consequently no apparent symptoms of plant damage were noticed. Variety Wishun Bhog (W:21 II) also expressed less feeding rate 18.77 mm /plant/q with 19 probing marks and only 59.88 egg deposits. Similar is the trend observed in variety Barma Tripal (B:1762). So these fine varieties are better donors. Remaining seven varieties followed trend with variability in feeding values.

Table 3 : Amount of honeydew excretion, probing marks, egg laying and plant damage score of BPH on selected resistant rice donors.

S. No.	Accession No.	Name of Cultivars	Honeydew mm / plant/q	Average probing marks/ seed-ling/q	Eggs laid/ plant/q	Plant** damage score
First group :						
1	B:1458	Bhamasur	427.55	18.55	80.77	0.57
2	B:214III	Badshah Bhog	18.66	21.10	51.88	0.83
3	B:1640	Badshah Bhog	29.44	17.55	86.55	0.88
4	B:1409	Bhimsen	287.44	18.88	92.10	0.98
Average			190.77	19.02	77.82	0.81
Second group :						
5	C:13 III	Chirai Nakhi	133.33	18.66	94.66	1.16
6	C:327	Chitar Boti	246.88	17.32	81.77	1.28
7	B:2800	Budha Budhi	488.88	17.66	84.88	1.29
8	B:1049	Bhais Path	283.55	14.33	92.88	1.33
9	B:1762	Barma Tripal	71.22	21.88	70.10	1.41
10	B:1567	Badshah Bhog	66.33	15.44	123.22	1.48
11	W:21 II	Wishun Bhog	18.77	19.44	59.88	1.55
12	B:448	Badshah Bhog	4.66	15.10	82.99	1.72
13	B:544	Budhram	222.44	23.44	93.10	1.82
14	B:430	Bhawaile	279.88	25.10	84.66	1.86
15	B:543	Benisar	115.44	21.77	103.33	1.86
16	N:635	Nawab Bhog	19.33	18.99	94.77	1.98
Average			162.55	19.09	88.85	1.56
Third group :						
17	B:98	Bharda	441.22	20.77	96.44	2.03
18	B:431	Bhejari	25.77	16.11	87.44	2.05
19	B:2269	Budhi Budha	558.44	20.77	141.11	2.16
20	C:13AII	Chirai Nakhi	220.10	13.10	103.22	2.18
21	B:2028	Budha Budhi	230.00	14.00	125.77	2.20
22	B:465 I	Buda Budi	602.47	21.77	165.33	2.54
23	B:2843	Bhagi	445.66	23.55	173.77	2.56
Average			360.52	18.58	127.58	2.24
Pooled average			227.71	18.92	98.72	1.64
24	(Susceptible check)	TN-1	1015.44	10.33	199.11	9.00
25	(Resistant check)	Ptb-333	322.88	20.66	114.66	1.78

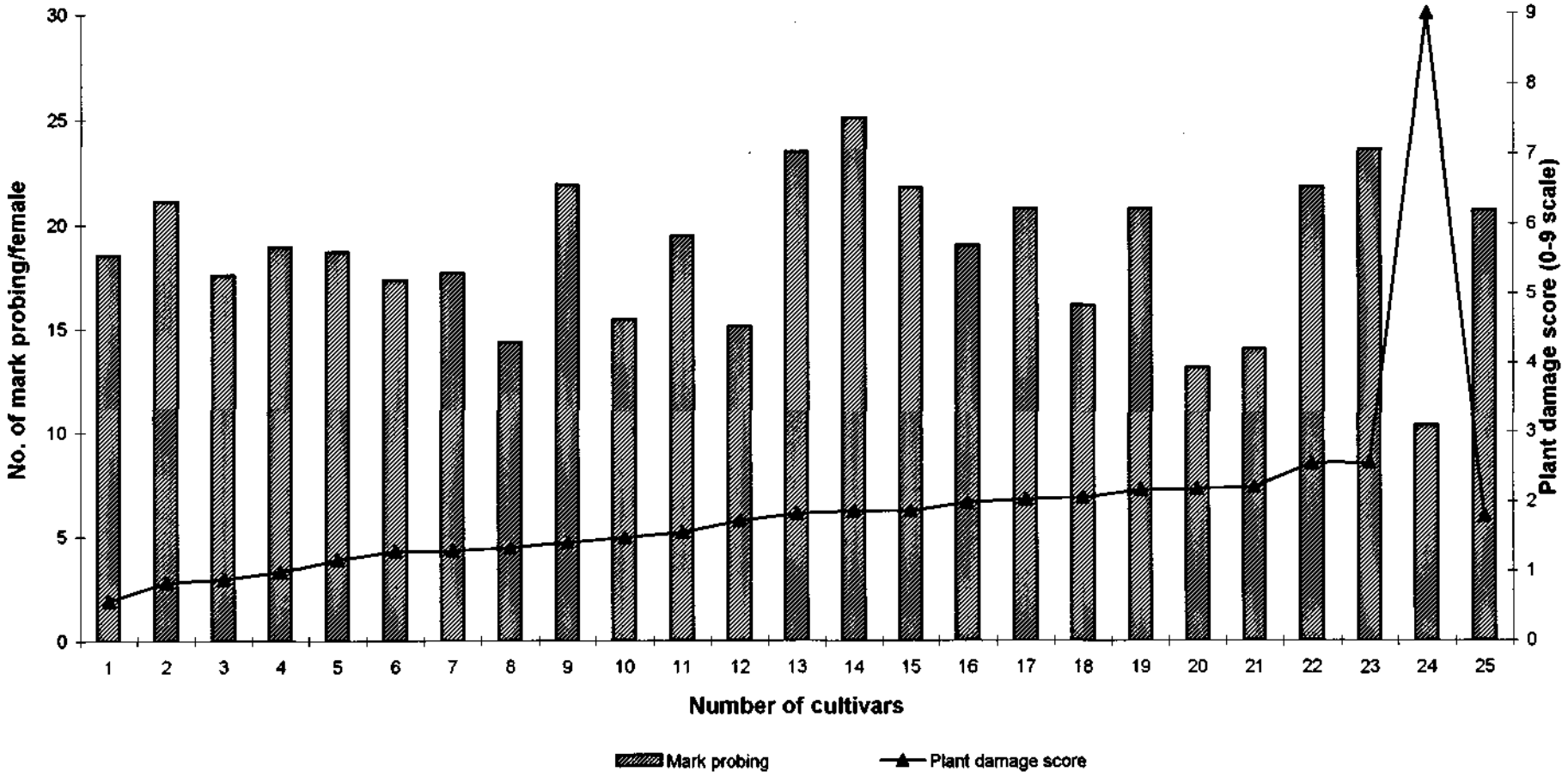
* Average of 10 replication
** Average of 5 replication
each replication contain 18-20 plants.

Fig.|2: Plant damage score and honeydew of *N. lugens* on resistant cultivars.



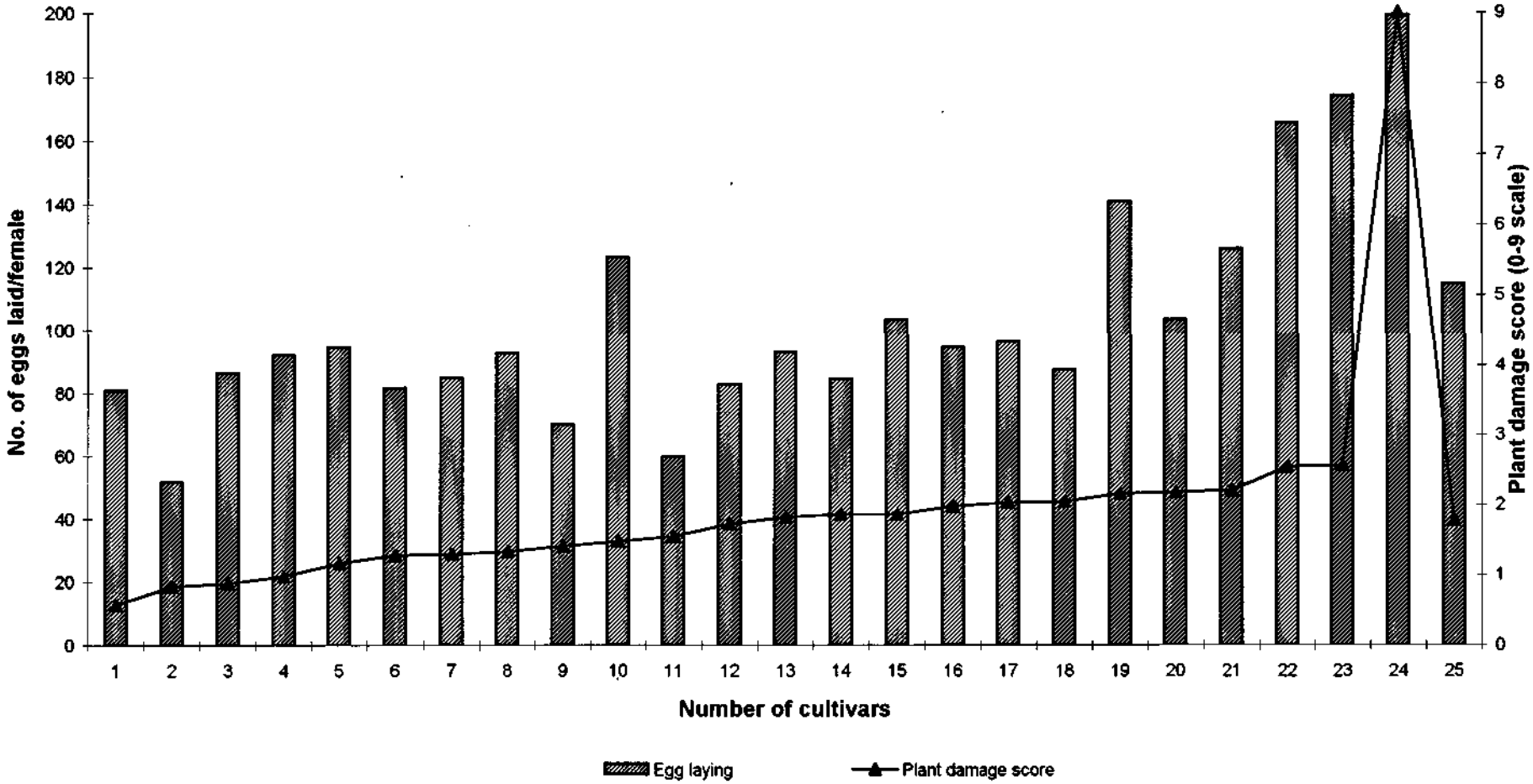
1 to 23 : No. of resistant cultivars, 24 : TN-1 (Susceptible), 25 : PTB-33 (Resistant check)

Fig. 3 : Plant damage score and mark probing of *N. lugens* on resistant cultivars.



1 to 23 : No. of resistant cultivars, 24 : TN-1 (Susceptible), 25 : PTB-33 (Resistant check)

Fig.4 : Plant damage score and ovipositional response of *N. lugens* on resistant cultivars.



1 to 23 : No. of resistant cultivars, 24 : TN-1 (Susceptible), 25 : PTB-33 (Resistant check)

Third group :

This group comprising seven varieties of which Bhejari (B:431) variety performed exceptionally better with respect to all biological parameters required as a resistant donor. This has given 25.77 mm^2/plant/q honey dew secretion and only 16.11 probing marks/q/seedling. This genotype possibility express, the feeding deterrent quality, and also comparatively received less number of eggs (87.44/plant/q). Accession with such character are of more value in breeding programme. Remaining varieties, exhibited variations, with feeding values ranged between 220.10 to 602.47 mm^2/plant/q (Table 3).

4.5 Biochemical Estimation :

The chemical profile of the host plant in determining its acceptance and utilization plant is extremely important in its acceptance and utilization by insects. Many scientists isolated chemical factors that play an important role to mediate negative responses to keep the insects away from feeding. Feeding deterrents and various toxicants has been isolated for various insects feeding on host plant. Phenols no doubt is responsible for such deterrents phenomena. Estimation of phenols contents and sugar in 23 BPH resistant isolated donors therefore, undertaken along with resistant (Ptb 33) and susceptible check (TN-1) (Table 4).

Total phenols were estimated in these resistant donors at 30 and 60 days old plants. In general at 60 days old plants phenol contents were more as compared to 30 days old plant, with some exceptional accession. At 30 days old plant, total phenol content in these test lines was ranged between 0.334 to 0.833 mg/gm of weight sample. Lowest value of 0.334 mg/gm is represented by varieties Badshah bhog (B:1567) and highest by Budha Budhi (B:2800) 0.833 mg/gm. At 60 days old plant also Badshah bhog (B:1567) showed lowest total phenol content 0.401 mg/gm while variety Bhagi (B:2843) exhibited 1.425 mg/gm total phenol highest amongst all 23 test varieties (Table 4).

Mono and diphenol content were also estimated both at 30 and 60 days old plant. Obviously quantity of these phenols was very less as compared to total phenols. In 30 days old plant variety Nawab bhog (N:635) monophenol content was highest (0.099 mg/gm) and lowest in the variety Chirai Nakhi (C:13AII) 0.22 mg/gm sample weight (Table 4). At 60 days old plant monophenol was highest in variety Bhagi (B:2843) 0.108 mg/gm while lowest in variety Badshah bhog (B:214III) 0.021 mg/gm.

Diphenol content was highest (0.250 mg/gm) in variety Benisar (B:543) while lowest (0.029 mg/gm) in variety Bhaispath (B:1049) at 30 days old plant. Diphenol content was higher (0.325 mg/gm) in variety Bhagi (B:2843) while lowest

(0.043 mg/gm) in variety Badshah Bhog (B:1567) at 60 days old plant. At 60 days old plant however, quantity of Diphenol was more as compared to 30 days old plant.

In general irrespective of varied plant damage score and other biological estimated parameter, all varieties did not show any regular feature or correlation with respect to phenol contents. Consequently, there is sufficient logic that totality of biochemical factors played a key role in some varieties, whereas in other varieties various factors are responsible for contribution of resistance.

Total sugar content in these varieties was also worked out. Ptb 33 resistant check exhibited least sugar content (4.93 mg/gm). Highest sugar content was noted in variety Badshah Bhog (B:1567) 18.44 mg/gm and lowest in Bhagi (B:2843) 2.59 mg/gm susceptible check (TN-1) variety contain 10.21 mg/gm sugar (Table 4). But test varieties even having higher sugar content observed resistant to BPH insect attack.

Most of the scented varieties, viz. Badshah Bhog (B:1567), Wishun Bhog (W:21II), Benisar (B:543) contain high amount of sugar. Nawab Bhog (N:635) exhibited comparatively less number of probes, honeydew secretion and moderate level of egg deposits amongst resistant varieties and total phenol content was 1.323 mg/gm and diphenol was 0.198 mg/gm at 60 days old plant.

Varieties Bhagi (B:2843) with lowest sugar content exhibited higher total phenols, monophenol and diphenol at 60 days old plant but egg deposition, honey dew deposition was more and number of probes less.

Total phenol contents though noted to be a best criteria for contribution of resistance to variety, but in present piece of research work, other factors together also played a significant role. Variety Bhamasur (B:1458) having least plant damage score had only 0.422 and 0.835 mg/gm total phenol content (Table 4) at 30 and 60 days old plant respectively. Mono and diphenol quantity was 0.050, 0.067, 0.177 and 0.198 mg/gm (Table 4) weight sample respectively at 30 and 60 days old plant. Inspite this fact the variety topped the list with respect to plant damage score (0.57) and apparently variety stand was best, also this variety had given 427.55 mm^2/q (table 3) honey dew secretion which is higher than Ptb 33 resistant check.

An interesting phenomena noted in variety Badshah Bhog (B:214III) comparatively at lower phenol content it could give only 18.663 mm^2/plant/q (Table 3) honey dew secretion and plant damage score of 0.836 which is second lowest score in all test varieties. Same is true for its sister line variety Badshah Bhog (B:1640). Bhimsen (B:1409) variety also followed the similar trend of variety Bhamasur (B:1458).

Table 4: Estimation of total, mono, diphenol and sugar contents in BPH resistant donors.

S. No.	Accession No.	Name of Cultivars	Total Phenol* (mg/gm)		Mono Phenol (mg/gm)		Diphenol* (mg/gm)		Total Sugar (mg/gm)
			30days plant	60days plant	30days plant	60days plant	30days plant	60days plant	30days plant
1	B:1458	Bhamasur	0.422	0.835	0.050	0.067	0.177	0.198	7.15
2	B:214III	Badshah Bhog	0.568	0.427	0.052	0.021	0.061	0.046	8.26
3	B:1640	Badshah Bhog	0.652	0.672	0.060	0.032	0.085	0.077	14.43
4	B:1409	Bhimsen	0.785	0.790	0.028	0.047	0.055	0.129	8.54
Average			0.606	0.681	0.047	0.041	0.094	0.112	9.59
5	C:13 III	Chirai Nakhi	0.595	0.581	0.063	0.036	0.089	0.080	13.89
6	C:327	Chitar Boti	0.525	0.741	0.043	0.032	0.092	0.075	8.73
7	B:2800	Budha Budhi	0.833	1.141	0.071	0.072	0.124	0.178	9.80
8	B:1049	Bhais Path	0.530	0.969	0.026	0.103	0.029	0.235	7.67
9	B:1762	Barma Tripal	0.368	0.919	0.040	0.065	0.057	0.180	8.65
10	B:1567	Badshah Bhog	0.334	0.401	0.052	0.025	0.072	0.043	18.44
11	W:21 II	Wishun Bhog	0.608	0.453	0.072	0.071	0.122	0.072	14.85
12	B:448	Badshah Bhog	0.478	0.525	0.053	0.037	0.054	0.093	18.30
13	B:544	Budhram	0.693	0.429	0.091	0.037	0.152	0.071	11.93
14	B:430	Bhawaile	0.618	1.004	0.073	0.078	0.114	0.182	7.98
15	B:543	Benisar	0.809	0.616	0.051	0.049	0.250	0.101	15.30
16	N:635	Nawab Bhog	0.735	1.323	0.099	0.074	0.167	0.198	17.97
Average			0.593	0.758	0.061	0.056	0.110	0.125	12.79
17	B:98	Bhrda	0.722	0.823	0.047	0.034	0.121	0.123	8.26
18	B:431	Bhejari	0.543	0.661	0.037	0.045	0.069	0.106	14.83
19	B:2269	Budhi Budha	0.485	0.720	0.078	0.046	0.103	0.118	5.85
20	C:13AII	Chirai Nakhi	0.472	0.651	0.022	0.058	0.037	0.096	17.94
21	B:2028	Budha Budhi	0.666	0.573	0.058	0.030	0.102	0.076	6.45
22	B:465 I	Buda Budi	0.650	0.654	0.062	0.064	0.123	0.128	12.40
23	B:2843	Bhagi	0.640	1.425	0.055	0.108	0.074	0.325	2.59
Average			0.596	0.786	0.051	0.055	0.089	0.138	9.76
Pooled average			0.600	0.753	0.055	0.053	0.101	0.127	11.29
24	(Susceptible check)	TN-1	0.425	0.299	0.040	0.016	0.060	0.019	10.21
25	(Resistant check)	Ptb-33	0.587	0.439	0.043	0.022	0.064	0.064	4.93

* Data based on average of 3 replications.

Table 5 : Estimation of total phenol, mono phenol, diphenol, sugar content and honey-dew exrection, probing marks, egg laying and plant damage score.

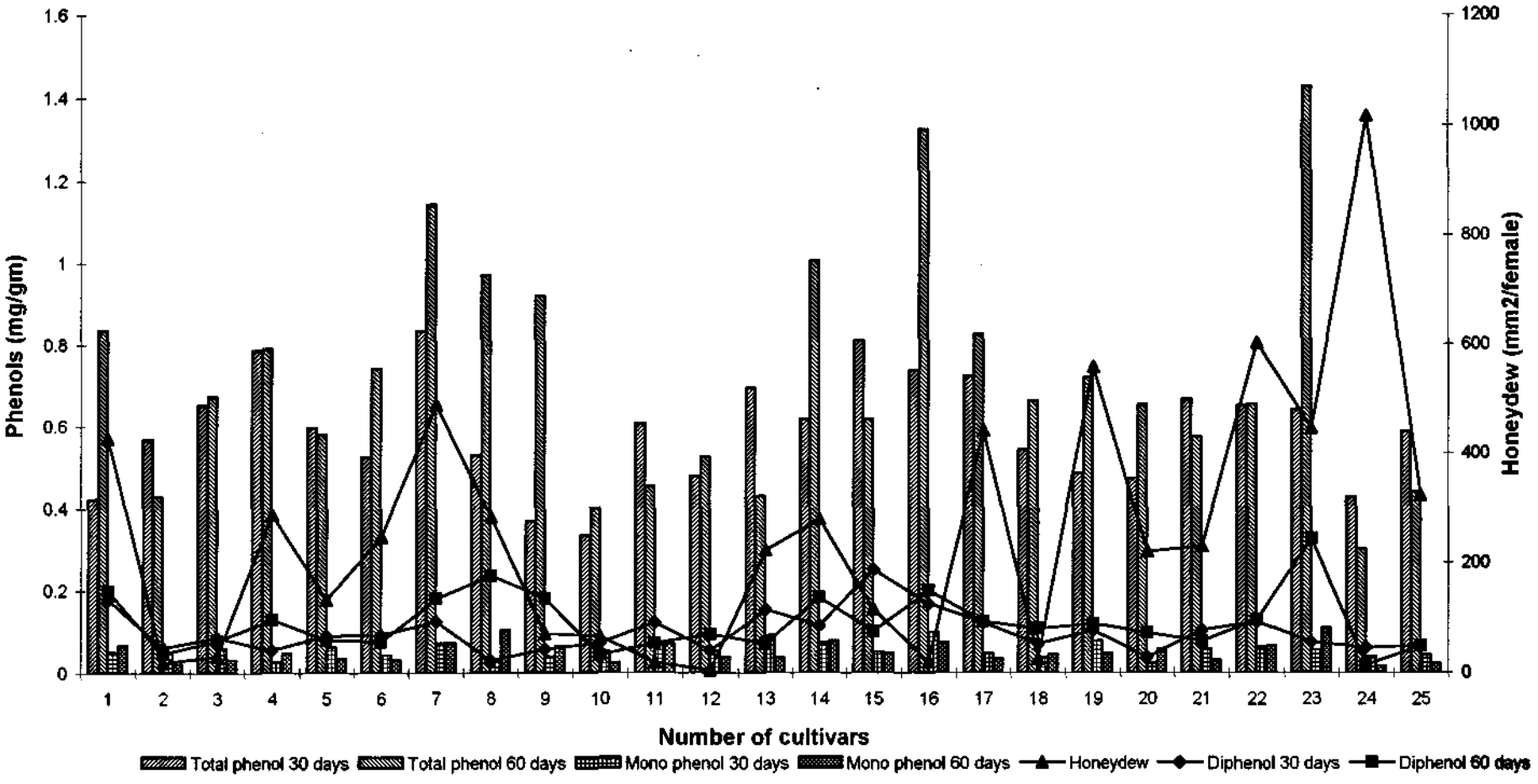
S. No.	Accession No.	Name of Cultivars	Total Phenol* days 30	Total Phenol* days 60	Mono Phenol* days 30	Mono Phenol* days 60	Diphenol* days 30	Diphenol* days 60	Sugar 10	Honey-dew**	Probing**	Ovi-position**	Damage score
1	B:1458	Bhamasur	0.422	0.835	0.050	0.067	0.177	0.198	7.15	427.55	18.55	80.77	0.57
2	B:214III	Badshah Bhog	0.568	0.427	0.052	0.021	0.061	0.046	8.26	18.66	21.10	51.88	0.83
3	B:1640	Badshah Bhog	0.652	0.672	0.060	0.032	0.085	0.077	14.43	29.44	17.55	86.55	0.88
4	B:1409	Bhimsen	0.785	0.790	0.028	0.047	0.055	0.129	8.54	287.44	18.88	92.10	0.98
Average			0.606	0.681	0.047	0.041	0.094	0.112	9.59	190.77	19.02	77.82	0.81
5	C:13 III	Chirai Nakhi	0.595	0.581	0.063	0.036	0.089	0.080	13.89	133.33	18.66	94.66	1.16
6	C:327	Chitar Boti	0.525	0.741	0.043	0.032	0.092	0.075	8.73	246.88	17.32	81 .77	1.28
7	B:2800	Budha Budhi	0.833	1.141	0.071	0.072	0.124	0.178	9.80	488.88	17.66	84.88	1.29
8	B:1049	Bhais path	0.530	0.969	0.026	0.103	0.029	0.235	7.67	283.55	14.33	92.88	1.33
9	B:1762	Barma Tripal	0.368	0.919	0.040	0.065	0.057	0.180	8.65	71.22	21.88	70.10	1.41
10	B:1567	Badshah Bhog	0.334	0.401	0.052	0.025	0.072	0.043	18.44	66.33	15.44	123.22	1.48
11	W:21 II	Wishun Bhog	0.608	0.453	0.072	0.071	0.122	0.072	14.85	18.77	19.44	59.88	1.55
12	B:448	Badshah Bhog	0.478	0.525	0.053	0.037	0.054	0.093	18.30	4.66	15.10	82.99	1.72
13	B:544	Budhram	0.693	0.429	0.091	0.037	0.152	0.071	11.93	222.44	23.44	93.10	1.82
14	B:430	Bhawaile	0.618	1.004	0.073	0.078	0.114	0.182	7.98	279.88	25.10	84.66	1.86
15	B:543	Benisar	0.809	0.616	0.051	0.049	0.250	0.101	15.30	115.44	21.77	103.33	1.86
16	N:635	Nawab Bhog	0.735	1.323	0.099	0.074	0.167	0.198	17.97	19.33	18.99	94.77	1.98
Average			0.593	0.758	0.061	0.056	0.110	0.125	12.79	162.55	19.09	88.85	1.56
17	B:98	Bhrda	0.722	0.823	0.047	0.034	0.121	0.123	8.26	441.22	20.77	96.44	2.03
18	B:431	Bhejari	0.543	0.661	0.037	0.045	0.069	0.106	14.83	25.77	16.11	87.44	2.05
19	B:2269	Budhi Budha	0.485	0.720	0.078	0.046	0.103	0.118	5.85	558.44	20.77	141.11	2.16
20	C:13AII	Chirai Nakhi	0.472	0.651	0.022	0.058	0.037	0.096	17.94	220.10	13.10	103.22	2.18
21	B:2028	Budha Budhi	0.666	0.573	0.058	0.030	0.102	0.076	6.45	230.00	14.00	125.77	2.20
22	B:465 I	Buda Budi	0.650	0.654	0.062	0.064	0.123	0.128	12.40	602.47	21.77	165.33	2.54
23	B:2843	Bhagi	0.640	1.425	0.055	0.108	0.074	0.325	2.59	445.66	23.55	173.77	2.56
Average			0.596	0.786	0.051	0.055	0.089	0.138	9.76	360.52	18.58	127.58	2.24
Pooled average			0.600	0.753	0.055	0.053	0.101	0.127	11.29	227.71	18.92	98.72	1.64
24(Susceptible check)		TN-1	0.425	0.299	0.040	0.016	0.060	0.019	10.21	1015.44	10.33	199.11	9.00
25(Resistant check)		Ptb-33	0.587	0.439	0.043	0.022	0.064	0.064	4.93	322.88	20.66	114.66	1.78

* Data based on average of 3 replications

** Data based on average of 10 replications

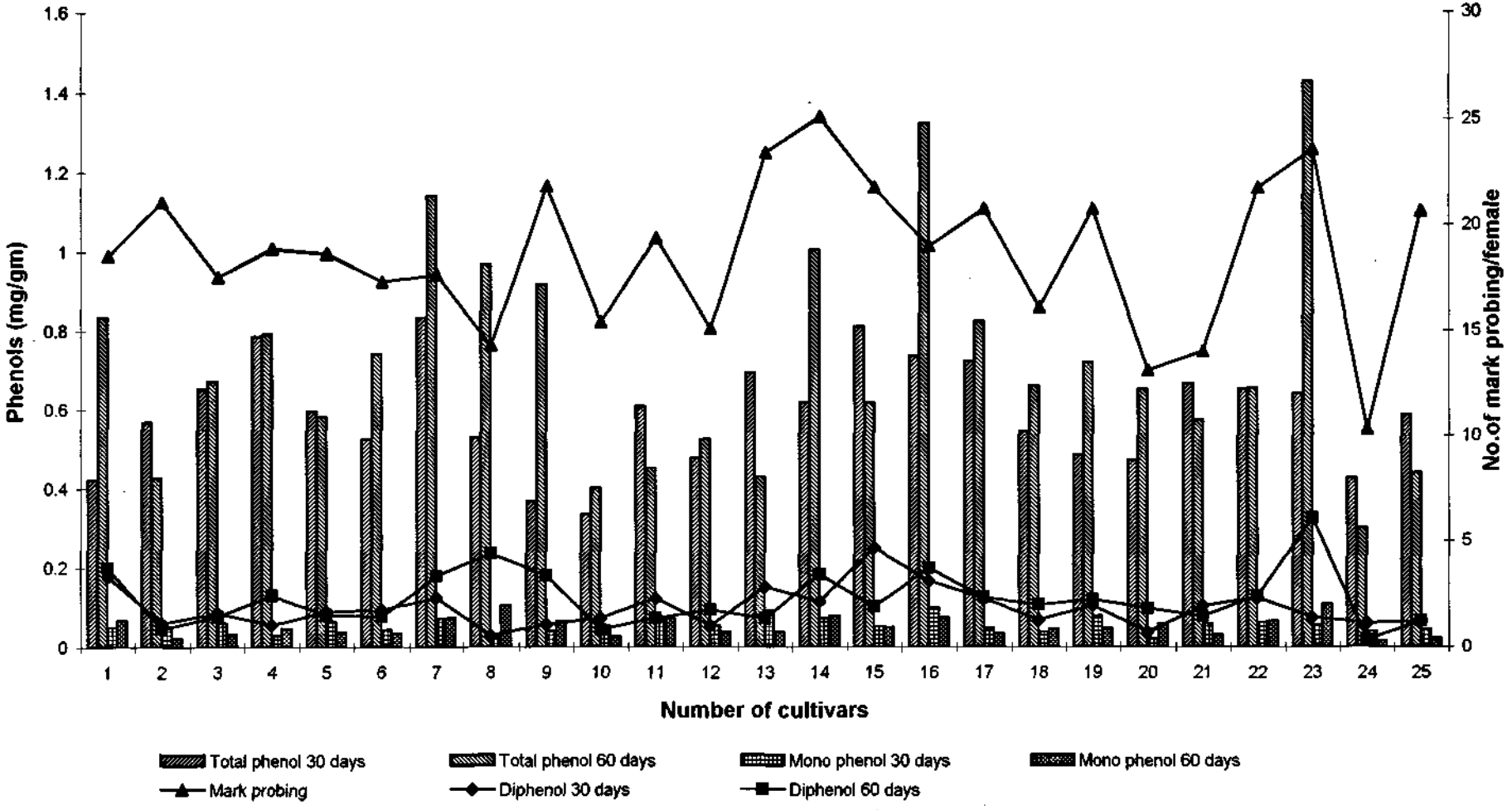
*** Data based on average of 5 replications

Fig. 5: Total, mono, diphenol and honeydew of *N. lugens* on resistant cultivars.



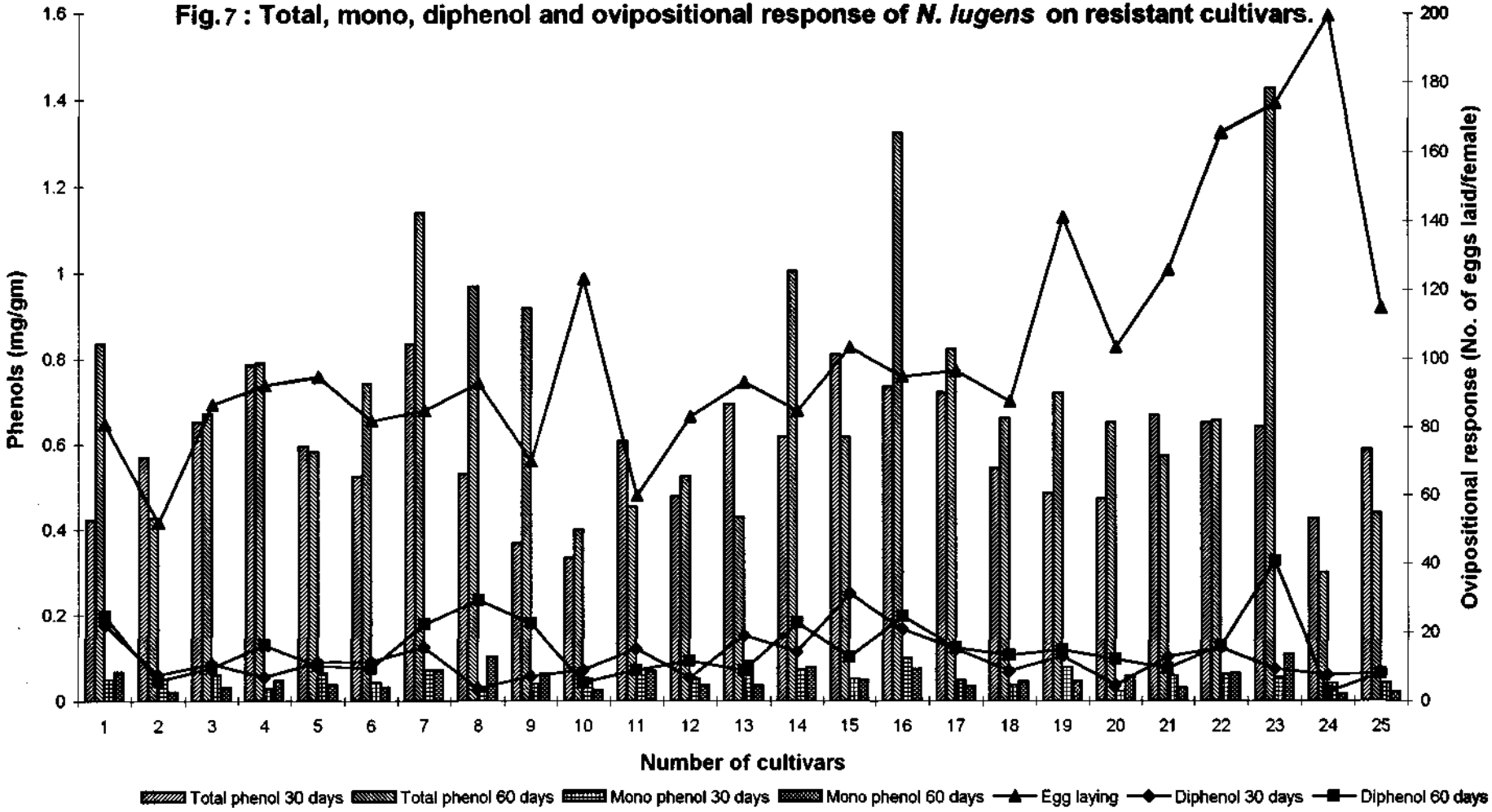
1 to 23 : No. of resistant cultivars, 24 : TN-1 (Susceptible), 25 : PTB-33 (Resistant check)

Fig.6 : Total, mono, diphenol and mark probing of *N. lugens* on resistant cultivars.



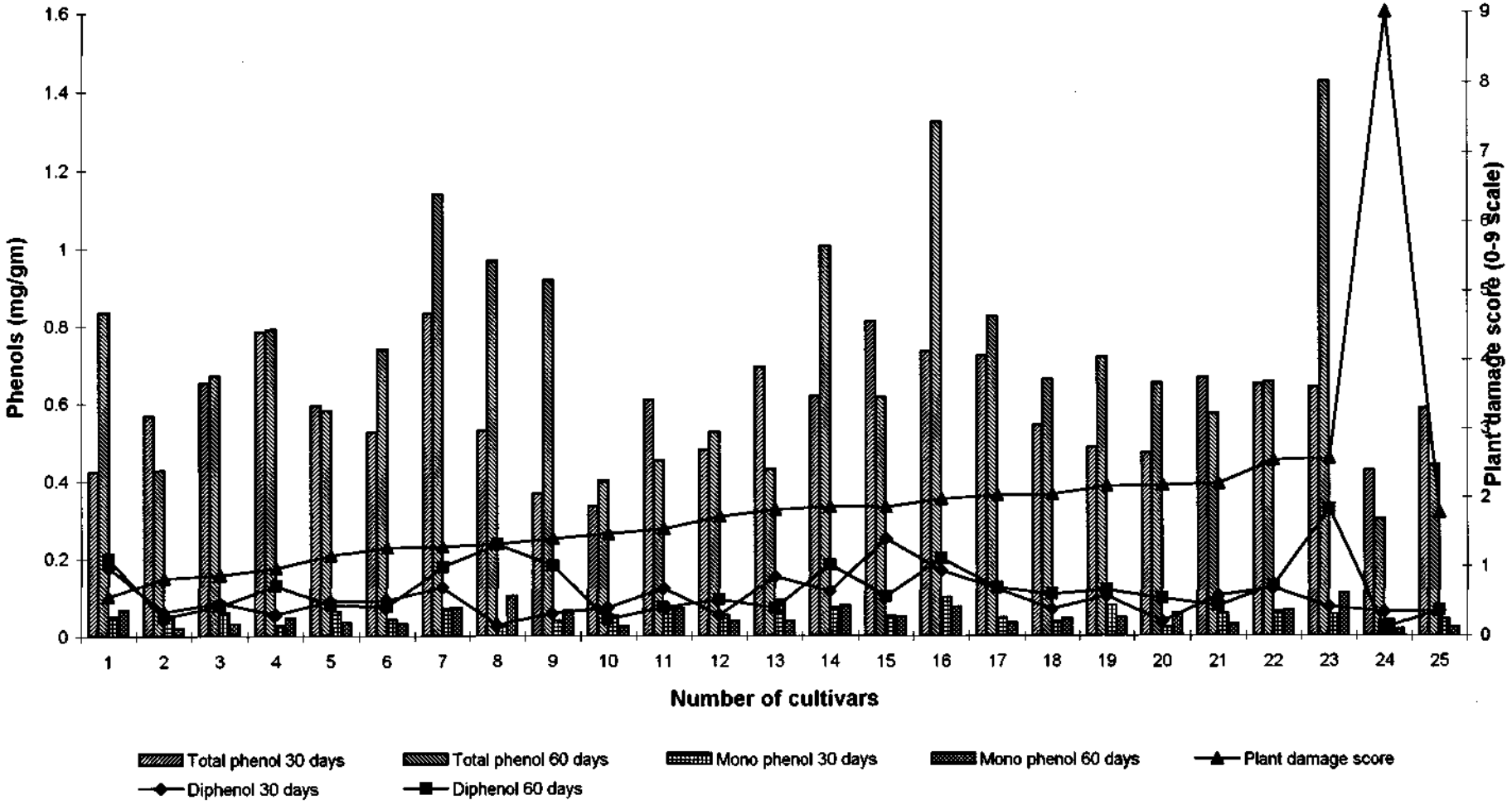
1 to 23 : No. of resistant cultivars, 24 : TN-1 (Susceptible), 25 : PTB-33 (Resistant check)

Fig.7 : Total, mono, diphenol and ovipositional response of *N. lugens* on resistant cultivars.



1 to 23 : No. of resistant cultivars, 24 : TN-1 (Susceptible), 25 : PTB-33 (Resistant check)

Fig. 8 : Total, mono, diphenol and plant damage score of *N. lugens* on resistant cultivars.



1 to 23 : No. of resistant cultivars, **24** : TN-1 (Susceptible), **25** : PTB-33 (Resistant check)

Biochemical estimation in all the test varieties differ, themselves and also their respective performance in various studies viz. oviposition, probing number, quantity of honeydew secretion and plant damage score. Thereby, overall correlation coefficient of direct contribution of independent variable on dependent variable, thus indicated that monophenol and diphenol at 60 days old plant had direct effect on honeydew secretion. Total phenol at 60 days old plant on honey dew secretion is negative but indirect effect on other characters are correlated except diphenol at 60 days (Table 6) . Insect probes seems to be positively correlated with diphenol at 60 days, and thus has direct relationship (Table 7) . Monophenol at 30 days and diphenol at 60 days exhibited true relationship on oviposition effect. As these two characters showed true relationship. The direct effect of Di-phenol 60 days are positive and high but correlation is negative (Table 8). The characters like total phenol had negative correlation and had with damage score (Table 9).

Probing is the only character correlated with total phenol (60 days) monophenol (30 and 60 days), diphenol (30 and 60 days) except total phenol, but negative correlation with the total sugar (Table 10).

Table 6 : Path coefficient showing direct and indirect effect of phenol and sugar on honeydew secretion.

Characters	Total Phenol		Mono Phenol		Diphenol		Total Sugar	r
	30 days	60 days	30 days	60 days	30 days	60 days		
Total Phenol (30 days)	0.0959	-0.0124	0.0252	0.0106	0.0638	-0.0205	0.0632	0.2257
Total Phenol (60 days)	0.0187	-0.0630	0.0077	0.1799	0.0035	-0.2496	0.1536	0.0427
Mono Phenol (30 days)	0.0295	-0.0050	0.0814	0.0016	0.0681	0.0040	-0.0451	0.1338
Mono Phenol (60 days)	0.0045	-0.0478	0.0006	0.2269	-0.0010	-0.2422	0.0902	0.0340
Di-Phenol (30 days)	0.0423	-0.0015	0.0384	-0.0015	0.1445	0.0062	-0.0599	0.1685
Di-Phenol (60 days)	0.0700	-0.0560	0.0012	0.1954	0.0032	0.2813	0.2120	0.0728
Total Sugar	-0.0106	0.0170	0.0064	-0.0358	0.0151	0.1043	-0.5716	-0.4751

Residual effect = 0.6877 Bold figure = direct effect

Table 7 : Path coefficient showing direct and indirect effect of phenol and sugar on probing marks.

Characters	Total Phenol		Mono Phenol		Diphenol		Total Sugar	r
	30 days	60 days	30 days	60 days	30 days	60 days		
Total Phenol (30 days)	-0.0710	-0.0177	0.0612	-0.0040	0.0830	0.0270	0.0193	0.0980
Total Phenol (60 days)	0.0140	-0.0898	0.0186	-0.0654	0.0045	0.3286	0.0468	0.2294
Mono Phenol (30 days)	-0.0220	-0.0840	0.1977	-0.0006	0.0886	-0.0093	-0.0137	0.2363
Mono Phenol (60 days)	-0.0033	-0.0680	0.0014	-0.0863	-0.0012	0.3188	0.0275	0.1889
Di-Phenol (30 days)	-0.0313	-0.0021	0.0932	0.0060	0.1880	-0.0082	-0.0183	0.2219
Di-Phenol (60 days)	-0.0052	-0.0797	-0.0028	-0.0743	0.0042	0.3702	0.0646	0.2687
Total Sugar	0.0078	0.0241	0.0156	0.0136	0.0197	-0.1373	-0.7430	0.2307

Residual effect = 0.8157 Bold figure = direct effect

Table 8 : Path coefficient showing direct and indirect effect of phenol and sugar on oviposition.

Characters	Total Phenol		Mono Phenol		Diphenol		Total Sugar	r
	30 days	60 days	30 days	60 days	30 days	60 days		
Total Phenol (30 days)	0.1071	-0.0596	0.0653	-0.0028	-0.0170	0.0214	0.0201	0.1345
Total Phenol (60 days)	0.0211	-0.3030	0.0199	-0.0461	-0.0090	0.2607	0.0489	0.0005
Mono Phenol (30 days)	0.0331	-0.0285	0.2111	-0.0004	-0.0181	-0.0042	-0.0143	0.1787
Mono Phenol (60 days)	0.0050	-0.2295	0.0014	-0.0608	0.0003	0.2529	0.0287	0.0020
Di-Phenol (30 days)	0.0473	-0.0072	0.0995	-0.0004	-0.0384	-0.0065	-0.0191	0.0020
Di-Phenol (60 days)	0.0078	-0.2689	0.0030	0.0524	0.0009	0.2937	0.0674	0.0445
Total Sugar	-0.0118	0.0814	0.0166	0.0096	-0.0040	-0.1090	-0.1818	-0.1989

Residual effect = 0.9013 Bold figure = direct effect

Table 9 : Path coefficient showing direct and indirect effect of phenol and sugar on plant damage score.

Characters	Total Phenol		Mono Phenol		Diphenol		Total Sugar	r
	30 days	60 days	30 days	60 days	30 days	60 days		
Total Phenol (30 days)	0.1347	-0.0325	0.0433	0.0690	0.0028	-0.0196	0.0182	0.1536
Total Phenol (60 days)	0.0265	-0.1654	0.0132	0.1150	0.0002	-0.2381	0.0442	-0.2081
Mono Phenol (30 days)	0.0417	-0.0156	0.1398	0.0010	0.0030	0.0038	-0.0130	0.1608
Mono Phenol (60 days)	0.0063	-0.1253	0.0010	0.1471	0.0000	-0.2311	0.0259	0.1761
Di-Phenol (30 days)	0.0595	-0.0040	0.0659	-0.0010	0.0063	0.0059	-0.0172	0.1154
Di-Phenol (60 days)	0.0098	-0.1468	-0.0020	0.1267	-0.0001	0.2683	0.0610	-0.2198
Total Sugar	-0.0149	0.0445	0.0110	-0.0232	0.0007	0.0995	-0.1644	-0.0468

Residual effect = 0.8809 Bold figure = direct effect

Table 10 : Correlation coefficient of Phenol, sugar, honeydew, probing mark, egg laying and plant damage score.

Characters	Total Phenol		Mono Phenol		Diphenol		Sugar	Honey	Probing	Ovipo.	Damage
	30 days	60 days	30 days	60 days	30 days	60 days					
Total Phenol (30 days)	1.0000	0.1960**	0.3094	0.0466	0.4415**	0.7290	0.1105	0.2257*	0.0978	0.1345	0.1536
Total Phenol (60 days)		1.0000	0.9410**	0.7575**	0.2390*	0.8870**	0.2680*	0.0427	0.2294*	0.0005	0.2087
Mono Phenol (30 days)			1.0000	0.0068	0.4713*	-0.0143	0.0788	0.1338	0.2363*	0.1787	0.1608
Mono Phenol (60 days)				1.0000	-0.0066	0.8612	-0.1578	0.0311	0.1889	0.0020	0.1761
Di-Phenol (30 days)					1.0000	-0.0222	0.1048	0.1685	0.2219	0.0760	0.1154
Di-Phenol (60 days)						1.0000	-0.3710**	0.0728	0.2687*	0.0455	0.2198
Total Sugar							1.0000	-0.4751**	-0.2307*	-0.1989	-0.0468
Honeydew								1.0000	-0.0812	-0.1352	-0.2946
Probing									1.0000	-0.1352	-0.2946
Oviposition										1.0000	0.6017
Damage											1.0000

* = Significant at 5% level ** = Significant at 1% level

DISCUSSION

CHAPTER - V

DISCUSSION

The brown planthopper, *Nilaparvata lugens* (stal) belongs to the family Delphacidae and order Hemiptera. Till now 14 species were identified and 2 unidentified species as a member of genus *Nilaparvata* (Mochida 1977), of which *N.lugens* is a serious pest of rice and being monophagous threat to rice production is more. Moreover, occurrence and evalution of more prolific biotypes of BPH is a constant threat to the stability of present pest resistant varieties. BPH resistance in IR 42 varieties broken down in Indonesia (Khush, 1984). Krishna *et al*. (1976) reported that IR 26 became susceptible to BPH in Philippines. So present studies were aimed to identify better resistant donors taking into consideration, the Raipur BPH population which is more virulent than elsewhere (Pophaly and Rana, 1994).

5.1 Isolation of resistant donors :

Availability of vast rice germplasm and systematic genetic evaluation against pest forms the backbone for utilization in breeding programme to develop pest resistant varieties. Genotypic differences among land races/varieties in agroecosystem was not always enough if the cytoplasm is entirely of one kind. Both genetic diversity and cytoplasmic variability are essential for agroecosystem stability.

Sufficient work on insect resistant gene identification in resistant donors and their inheritance studies has been documented in literature like Khush et *al*. (1986), Kabir and Kush (1988), Nemoto et *al*. (1989) and Jena and Khush (1990). Even though, breakdown of resistant varieties simultaneously alone is going on. Expression of resistant gene in particular donor, is not sufficient. Though many worker till now realised upon it. Biochemical estimation in relation to gene expression are two components to be studied simultaneously. Taking into consideration this view, 115 rice accessions out of 1100 genetically were found resistant to BPH insect. Various biological parameters in relation to resistant criteria were studied in 23 selected BPH donors out of 115 isolated donors. Variability in various biological values studied clearly indicated the difference in their genetic make-up. At national and international level, various workers identified BPH resistant donors and resistant varieties were released for commercial cultivation (Khush, 1979).

Stapley (1974) has screened a total of 515 AC varieties against BPH at Cuttack. 21 lines were found resistant (CRRI 1977; 1978 annual report). At Coimbatore 22 lines identified as BPH resistant donor by Balasubramanian (1978) and 112 varieties were observed resistant (Misra, et *al*., 1978, 1983 and Misra, 1982). At DRR Hyderabad, 35000, rice accession were screened against BPH since 1973. So far,

600 resistant donors were identified.All these material were used in breeding programme (Kalode *et al*., 1979, 1983, Pathak & Khush, 1979).

At international level Heinrich (1984) and Pathak (1970) contributed significantly towards BPH screening and breeding work for BPH insect. Out of which many IR varieties were developed, of which IR 36 with bph-2 gene is being widely cultivated in Asian countries.

Out of 21,000 rice germplasms from IGKV, Raipur (M.P.) India genetic stock, approximately 5000 rice varieties were evaluated against BPH and better resistant varieties are being used in breeding work.

Painter (1951) described various types of resistance of which antibiosis is being considered as a biological parameters in genetic, evaluation system. Thus, in present studies, twenty three BPH donors were studied for their mechanism of resistance out of 115 entries isolated. In all, eight varieties viz. Badshah Bhog (B:214 III) Badshah Bhog (B:1640), Barma Tripal (B:1762) Badshah Bhog (B:1567), Wishun Bhog (W:21II), Badshah Bhog (B:448), Nawab Bhog (N:635) and Bhejari (B:431) were observed to possess lower feeding value. Variety Badshah Bhog (B:214III) was observed to yield lowest feeding value of 18.66 mm^2/plant/q and also

received lowest eggs 51.88/plant/q with 21.10/seedling/q probing marks (Table 3). Similar trend was also observed in its sister line Badshah Bhog (B:1640). Both the lines probably contain feeding deterrent thereby restricted feeding activity by BPH, consequently number of probes were also found reduced. Nutritional requirement of insect if not fulfilled, insect will not continue to feed, but in such varieties even presence of feeding deterrent is probably the main factor. These characters of the variety no doubt is inherited, so while taking into consideration, the selection of donors in breeding programme, such type of lines impart significant contribution. Barma Tripal (B:1762), Badshah Bhog (B:1567), Wishun Bhog (W:21II) and Nawab Bhog (N:635) are the varieties followed this trend. Saxena and Pathak (1979) in their indepth studies noticed the mortality of BPH insect population when stem distillate of extracts of resistant varieties applied topically. Also similar results were noticed by Yoshihara *et al*. (1979, 1980). BPH sucking inhibitors in resistant varieties. Further, potassium and sodium oxalate at 0.1 to 0.2% concentration also found responsible for complete inhibition of sucking by BPH.

All the way, these resistant factors in these eight varieties represent inbuilt genetic resources. Secretion of chemicals and their quantity in a particular cultivar is ultimately governed by genes. Amongst eight varieties this qualitative differences will represent more true picture.

Few varieties viz. Bhamasur (B:1458), Bhimsen (B:1409), Budhi Budha (B:2269), Buda Budi (B:465 I) and Bhagi (B:2843) however, on the contrary produced highest honey dew secretion inspite of these fact plant stand observed to be resistant.

5.2 Feeding test :

Great variations in BPH feeding pattern on various identified BPH resistant line can be explained in the light of various chemicals that particular variety possesses and non-circadian pattern of honey dew excretion related to the degree of variety and that such feeding and excretion pattern can be used to characterize the relationship between insect and rice varieties (Padghan and Woodhead, 1988). Feeding activity on resistant varieties were significantly less as compared to susceptible check TN-1.

Pathak et *al*. (1982) in his work pointed out this differences, further Gu et *al*. (1987) also confirmed these facts in the light of macropterous and brachypterous form of insect population. Lee (1987), studied great variations in feeding value of different BPH biotypes on the same resistant variety.

However, more feeding on these resistant test lines compared to Ptb 33, may be due to the more BPH virulent strain available at Raipur (Pophaly and Rana, 1994). At this

location even on differential donors the feeding value of BPH insect was much more (Pophaly and Rana, 1994).

Genetics of resistance to BPH was studied by many worker viz. Khush *et al.*, (1986), Nemoto et *al.*(1989) and Jena and Khush, (1990). They identified number of recessive and dominant genes. But, their corresponding mechanism in selection to secretion of chemicals as a defense mechanism is still an awaited work.

This area of research will prove worthy in biotechnology work to produce good resistant varieties, merely on the basis of recessive and dominant gene identification and in breeding programme now enlighted its consequences utilization as break down in resistant varieties were now frequent.

5.3 Probing mark test :

In general, number of probes received by twenty three resistant varieties were high as compared to susceptible check TN-1 variety. But there is a variation in probe number, in test lines. Thus, indicating the absence of mechanical barriers to insertion of stylets by insects. Review in this respect clearly indicated the same view and as per the literature cited, it is the uncontroversial issue, as many workers viz. Sogawa and Pathak (1970) Veronica (1985), Reddy (1979), Reddy and Kalode (1985) are of opinion that resistant varieties receive high number of probes than

susceptible variety TN-1. However, electronic measurement system greatly facilitate, the behaviour studies for piercing and probing by insect stylets (Kawabe *et al*. 1980, Velusamy and Heinrich, 1986). In this regard, piercing the stylets and holding it for long time depend upon the nutritional fulfilment contact of sap being drained by insect through stylets.

Detheir (1947), Thorsteinson (1958) and Beck (1965) very well enumerated the theory of host selection by insect, which involves various steps viz., orientation, biting response and continuous feeding. Ultimately selection of proper host is dependent on sustained feeding by insect. In this process, nutritional requirements if not provided by host plant then insect tries often and often to meet the nutritional requirement in these varieties. BPH insect could not get proper nutritional response and hence these varieties were unfit for feeding due to lack of proper nutritional response.

Samal (1980) also noticed, anatomical feature of stem of resistant varieties which play a major role to impart resistance. In such varieties presence of smaller vascular bundles were documented, hence in these 23 varieties, the possibility of presence of much mechanism of resistance can not be ignored.

5.4 Ovipositional response :

Various aspects of insect mechanism also involved the egg laying preference by BPH female. Eggs laid by BPH female on 23 resistant varieties were less as compared to susceptible check TN-1 (Table 3). Misra et *al*. (1988) also documented that on four resistant varieties viz. Daya, Pratap, Sivappu and IET-7575 received significantly less number of eggs than susceptible Jaya. Fecundity of BPH eggs were lower on resistant Rathu Heenati, Babawee, ARC 10550, Swarnalata and Ptb 33 (Velusamy and Saxena, 1989). Similarly BPH female laid significantly less eggs on resistant varieties which identified on the basis of plant damage score also reported by Lee (1987) and Senguttuvan *et al*. (1991).

By and large non-preference for oviposition and feeding are governed by various factors. Oviposition involve plant characters for oviposition including stimuli by plant and chemoreceptible mechanism (Painter, 1951).

5.5 Biochemical studies :

Control of insect pest has been an integral part of the development of agricultural practices. A built-up of pest species can be reduced by making the plant community more diverse. Plant and insect have been co-existing and evolving under selection pressure. It is therefore, plants have adopted to release variety of bio-chemicals as defenses

mechanism against insect, and protected by combination of chemical mechanism.

Insect gustatory receptor react to amino acid and sugar. Toxins and antimetabolite inside the plant tissue forms a second line of defense even cause poor nutrient imbalance.

In present studies, phenol and sugar contents were estimated for 23 BPH resistant donors. Total phenol content was more on 60 days as compared to 30 days old plants. Phenol contents have been estimated on resistant donors earlier by various workers, viz. Vishwanathan and Kalode (1990), Thyumanvan *et al*. (1990), Mansour et *al*. (1994) and Pathak and Kush (1979) pointed out higher amount of phenol content in resistant varieties as compared to susceptible one which is responsible to impart resistance to BPH insect. Total phenols were lowest in susceptible variety whereas in resistant the concentration was more. But Krishna (1977) clearly pointed out that phenolic compound in resistant and susceptible varieties were not of indicative of any role played by these compounds but upon infestation by BPH, resistant varieties were found to react sharply in producing higher amount of phenols, similarly in present studies, all 23 resistant donors possess varying degree of phenols but certainly more than TN-1 susceptible check, however, as such, there is great likelihood to increase the

BPH and content of phenol at both age group was higher "Even diphenol content at 60 days old plant was higher as compared to other variety except Bhais path (B:1049) and Bhagi (B:2843) variety. Total phenol content in other varieties at 60 days *of* course was found to be much higher as compare to susceptible TN-1 variety, even though amount was much than that of Ptb 33 resistant variety. Thus, all these varieties comparatively upon BPH infestation reacted sharply to produce more phenol contents, as a defense mechanism. Phenotypically, this phenomenon is seen as the plant stand apparently was good in infested BPH test seed boxes.

All the way, not only the phenol content, but also other parameters like quality of sap in plant, their nutritional value for insect together played an important role, for rejection of variety by insect. This integrating expression ofcourse is very difficult job in estimating the role played by each component due to varying degree of parameters observed in each variety.

However, Ananthakrishna as early in 1997, pointed out the role of various phenolics viz. gallic acid, salicylic acid, synergic acid, resorcinol and phloro-glucinol on the growth of insect ingestion and utilization of food content of these compound upon insect feeding provokes systemic signals and made available at the site of insect feeding damage, and further these signals get translocated to other

contents of these phenolic compound, on infestation of BPH. This increased response in these varieties is a matter of more concern. Total phenol group contents many chemical in rice plant.

This was reported by various workers that, rice contain variety of phenol viz. coumaric acid, P-hydroxybenzoic acid, ferulic acid, vanillic acid, chlorogenic acid and several flavonoids, Kuwatsuka and Oshima (1961). However, recently Vishvanathan and Kalode (1990) had given list of about 15 phenolic compounds present in the rice plants, viz. benzoic acid, caffeic acid, catechol, cinnamic acid, coumaric acid, hydroquinone, hydrobenzoic acid, phloroglucinol, protocate chuic acid, pyrogallol, quinon, salicylic acid, sulfanilic acid, vanillic acid, and vanillin, responsible for BPH resistance.

In present studies variety viz. Budha Budhi (B:2800), Bhawaile (B:430), Nawab Bhog (N:636) and Bhagi (B:2843) had given higher amount of total phenol content at 60 days old plant followed by Bhais Path (B:1049), Barma Tripal (B:1762), Bhamasur (B:1458) and Bharda (B:98) whereas at 30 day old plant variety Bhuda Bhudi (B:2800) had given highest phenol content followed by Benisar (B:543).

At both age of crop plant 30 and 60 days, variety Budha-budhi (B:2800) reacted sharply to the infestation of

part of the plant where they induce defense mechanism. All the way gallic and salicylic acid are known to play important role in insect plant interaction, and now is a area of biotechnology of crop protection.

Many scientist Lege et *al*. (1995), Swain (1979), Levin (1971), Rhodes and Cates (1976), Yoshida (1995), Rambolt and Tober (1985) and Veeranna (1998) reported that phenolic acid and tannin were responsible for plant resistance to insect, because of digestibility of reducing agent and even act as dosage dependent defense against insect. Therefore, in present studies, variations in phenol contents of various varieties itself is an indication of such type integrating reactive responsible which, ultimately become dose dependent due to different genetic make-up of varieties.

In ion-exchange chromatography quantitative measurement of oxalic acid estimated in mudgo variety was responsible for resistance to BPH.

5.5.1 Mono and **diphenol** :

Quantity of total phenols in resistant plants though more than susceptible varieties, even though it does not give a true picture about the exact role of compound there in responsible for resistance. As such in these studies, only mono and diphenol total contents were estimated. However in the literature presented no reference was

noticed. Data presented (Table 4) on mono and diphenol contents in different varieties does not pose any significant role in relation to resistant characters expressed phenotypically, because variation in the estimates are very small but diphenol content in varieties viz. Benisar (B:543) was highest in 30 day old plant followed by Bhamasur (B:1458), Budha Budhi (B:2800), Nawab Bhog (N:635), Bharda (B:98), Budhi budha (B:2269) and Buda budi (B:465 I) as compared to other test entries.

Diphenol content at 60 days old plant is highest in variety Bhagi (B:2843), Bhaispath (B:1409) and some other varieties viz. Bhamasur (B:1458), Budha Budhi (B:2800), Barma tripal (B:1762), Bhawale (B:430), Budha budi (B:2028) and Bhagi (B:2843).

In general diphenol content was much more than mono phenol content in test varieties thus giving possibility of linkage between resistance and diphenol contents.

5.5.2 Sugar :

Total sugar contents in all 23 test entries were worked out, to see any correlation between feeding by insect and content of sugar in the varieties. But no such correlation was observed, Kalode *et al.* (1989) also found no difference in sugar contents (sucrose, glucose and fructose) and susceptibility. Similar observations were also noticed by Sogawa and Pathak (1970), Peraiah *et al.* (1982) in Telia

Homsu and Jaya. However, Kawabe et *al*. (1980) and Liu et *al*. (1995) observed variations in sugar content at different plant growth stages.

It is not merely a sugar content, but presence of other chemicals in plant sap such as B-sitosterol, amino acid, exceeding 4% may cause sucking inhibition. Even though antifeedent activity of BPH insect was noticed as apigenin-c-glycosides content is high (Stevenson et *al*., 1996). In this situation, sugar content alone can not make impact on insect feeding behaviour.

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

CHAPTER - VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

In the present studies, 115 rice accessions were isolated as BPH resistant donors out of 1100 rice germplasm. However, in depth studies in relation to various biological parameters and total phenol contents were carried out in twenty three resistant donors. Critical analysis of these varieties showed the existence of genetic variability amongst these donors. However, taking into consideration different components on various biological values and total phenol contents, the following varieties performed better.

Bhamasur variety (B:1458) exhibtied lowest plant damage score, less number of eggs were deposited by BPH female and had moderate total phenol contents at 60 day old plants. Another variety Budha Budhi (B:2800) posses most desirable parameter as total phenol contents is higher both at 60 and 30 day old plant, with low number of probes and plant damage score. Varieties viz. Nawab bhog (N:635), Bhais path (B:1049) had given higher amount of total phenol contents at 60 days old plants. Benisar (B:543) and Bhimsen (B:1409) had given higher amount of total phenols at 30 days old plant and variety Bhagi (B:2843) has also given higher mono-phenol and di-phenol content at 60 days old plant with maximum number of probes. Badshah bhog (B:448) exceptionally had shown lower feeding rate by BPH insect. So taking into

consideration over all various biological and chemical parameters these varieties performed better and can be apted for better BPH resistant donor in breeding programme. Varieties viz. Badshah Bhog (B:214 III) Badshah bhog (B:1640) and Bhejari (B:431) performed exceptionally better with respect to all biological parameters required as a resistant donor. These varieties have given low quantity of honeydew secretion, moderate probing marks and were least responsive to egg deposition except Badshah bhog (B:214 III). It is therefore seems that these genotypes, possibility possess the feeding deterrent thus, expression of these characters in these genotypes Bhejari (B:431) are of more value in breeding programme.

Egg deposition in all twenty three resistant varieties were less as compared to TN-1 susceptible check. However, amongst 23 varieties, egg deposition in Badshah bhog (B:214 III) variety was lowest where as variety Bhagi (B:2843) received maximum eggs/plant/q. In general those varieties exhibited plant damage score upto 1.55 received an average 88.85 egg/plant/q as compared to 127.58 eggs/plant/q with plant damage score between 2.03 to 2.56 low egg deposition, may be due to various plant characters which induced stimuli emitted by plant and chemoreceptive mechanism.

Conclusion :

1. All 23 BPH resistant donors identified in the present research work, mostly represent genetic variability amongst themselves.

2. In general due to feeding of BPH insect, number of probes received by twenty three resistant varieties were in higher proportion as compared to susceptible TN-1 check variety, however, highest feeding marks were observed in variety viz. Bhawaile (B:430), Budhram (B:544), Bhagi (B:2843) which indicates the presence of feeding detrrent response in these varieties.

3. Feeding behaviour of BPH in twenty three selected resistant donors were observed. The lowest honeydew excretion were noticed in varieties viz. Badshah Bhog (B:214III), Badshah Bhog (B:1640) and Badshah Bhog (B:448). Same varieties also showed least plant damage score, and therefore, these genetic material are of more value in breeding programme.

4. Egg deposition in all twenty three resistant varieties were less as compared to susceptible check TN-1 variety. But in varieties viz. Badshah Bhog (B:214III), Wishun Bhog (W:21II) were received lowest egg deposition with less honeydew excretion and probing marks which indicates the induced stimuli emitted by plant and chemoreceptive mechanism.

5. Total phenol content at 60 day of plant were high in all the varieties thereby indicating the 9 important component responsible for BPH resistance.

6. Solely total phenol content is not a criteria for BPH resistance but in some varieties, low phenol contents also exhibited resistance phenomenon.

7. Mono and diphenol estimation however, has given little indication of correlation in these varieties between ovipositional response and BPH resistant donors.

Suggestions for further work :

1. Genetic variability expressed in all 23 resistant lines, can be visualized on the basis of molecular level studies. Molecular weight fraction will indicate the inhibition action on feeding of BPH insect.

2. RFLP and RAPD's analysis of resistant line will help to identify the genes present in these donors.

3. Estimation of individual component of phenol content will focus more light on the resistance criteria in the present work.

4. Cytoplasmic variability of 23 BPH resistant lines should be worked out to have crystal clear variation amongst these identified donors.

ABSTRACT

MECHANISM OF RESISTANCE INVOLVED IN BROWN PLANTHOPPER (BPH) *Nilaparvata lugens* (Stal.) RESISTANT DONORS OF IGKV, RICE GERMPLASM

By

Dhanendra Kumar Rana

ABSTRACT

The investigation was carried out in glass house, Department of Entomology and Biochemistry laboratory Department of Plant Breeding IGKV, Raipur during 1997-98. The main objectives were isolation of *Nilaparvata lugens* (Stal.) donors on the basis of screening of rice germplasm, probing and feeding behaviour, egg laying response and estimation of the total, mono and diphenol in resistant donors.

Eleven hundred accessions of rice germplasm were screened against BPH insect and out of these genetic stock 115 accessions were found resistant to BPH insect. Sixty one accessions were identified as moderately resistant to BPH.

Out of these 115 promising accessions, 23 donors differ themselves with respect to their biological parameters and phenol contents. Critical analysis of these values depicts the existence of genetic variability and potential as a best BPH resistant donors. There is no correlation obtained between plant damage score, feeding amount, probing numbers, ovipositional response and total phenol content. Therefore, these values indicated the presence of difference in genetic make up of these donors.

In general, in 60 days old plants, phenol content was more as compared to 30 days old plants. There is sufficient logic that integration of phenol content and various biological values played a key role in imparting the resistance, rather than one single factors.

Mono and diphenols were estimated in 30 and 60 days old plant. Obviously, quantity of these phenols was very less as compared to total phenol but amount of diphenol was greater than monophenol both at 30 and 60 days old plant stages.

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APPENDICES

Appendix 1 : Reaction of 924 IGKV rice germplasm against brown planthopper in glass house.

S.N.	ACC.NO.	NAME OF CULTIVARS	RATING	S.N.	ACC.NO.	NAME OF CULTIVARS	RATING
1	B:91	BARMA	S	51	B-2870	BHADO RANRER	S
2	B:1276	BARMA CROSS	S	52	B:1619	BHAGAL PUR	S
3	B:1373	BARUGI	S	53	B.1621	BHAGAL PURI	S
4	B:488	BASANPALI	S	54	B:1926	BHAGAL PURI	S
5	B:219	BASANTI	S	55	B:2867	BHAGAL PURI	S
6	B:427	BASBHIRA	MS	56	B-2255	BHAGI	S
7	B:403	BASIN	S	57	B:2255II	BHAGI	S
8	B:2035	BASTA	S	58	B-499	BHAINS PAT	S
9	B:701	BATASHFEN	S	59	B:1824	BHAINS PAT	S
10	B:6	BATASI	S	60	B*2111	BHAINS PAT	MS
11	B:6	BATRAJ	S	61	B:2498	BHAINS PAT	S
12	B:467II	BATRAJ	S	62	B:2648	BHAINS PAT	S
13	B:467III	BATRAJ	S	63	B•999I	BHAINS PAT	S
14	B:412	BATRO LOCAL	S	64	B:999II	BHAINS PATH	S
15	B:412II	BATRO LOCAL	S	65	B-1049I	BHAIS PATH	S
16	B:2810	BAYKONA	S	66	B:1049II	BHAIS PATH	S
17	B:64	BEDRO	MS	67	B:1049III	BHAIS PATH	S
18	B:2366	BEDRO	S	68	B•2276	BHAINSARA	S
19	B:2827	BEDRO	NG	69	B:1730B	BHAISA NINI	S
20	B:2833	BEDRO	S	70	B:2336	BHAISA PUCHHI	S
21	B:2700I	BEGANHUDI	S	71	B:765	BHARUWA	S
22	B:2700II	BEGANHUDI	S	72	B:233II	BHATA	S
23	B:2700III	BEGANHUDI	S	73	B:233III	BHATA	S
24	B:1474	BEL MUDARI	S	74	B:709	BHEDA RABAR	S
25	B:390	BENGLA	S	75	B:1217II	BHEDWA	S
26	B:390II	BENGLA	S	76	B;1460III	BHEJARI	MS
27	B:1295I	BENIGIRI	S	77	B:202	BHEJARI	S
28	B:1295II	BENIGIRI	S	78	B*210	BHEJARI	S
29	B:1665	BENIGIRI	MS	79	B:217N	BHEJARI	S
30	B:389I	BENIRACH	S	80	B-225	BHEJARI	NG
31	B:389II	BENIRACH	S	81	B-225I	BHEJARI	S
32	B:389III	BENIKACH	S	82	B:271	BHEJARI	S
33	B:172	BENIKAT	S	83	B:289	BHEJARI	MS
34	B:181II	BENIKAT	S	84	B;289II	BHEJARI	S
35	B:449	BENIKAT	S	85	B:431I	BHEJARI	S
36	B:1502I	BENIKAT	S	86	B*431II	BHEJARI	S
37	B:1502II	BENIKAT	S	87	B:431III	BHEJARI	S
38	B:190I	BENIRAT	S	88	B:516	BHEJARI	S
39	B:737	BENISAR	S	89	B:518	BHEJARI	S
40	B:292	BENISAR	S	90	B»565	BHEJARI	S
41	B:543III	BENISAR	S	91	B:565VI	BHEJARI	S
42	B:737	BENISAR	S	92	B:565II	BHEJARI	S
43	B:980	BENISAR	S	93	B:565V	BHEJARI	S
44	B:1356I	BENISAR	S	94	B:565III	BHEJARI	S
45	B:1356II	BENISAR	S	95	B:565N	BHEJARI	S
46	B:1569I	BEOLO	S	96	B:555V	BHEJARI	S
47	B:256	BEWARA	S	97	B:601	BHEJARI	S
48	B:774	BEWARA (DESHI)	S	98	B•601	BHEJARI	S
49	B:41II	BHADO RARER	S	99	B:611II	BHEJARI	S
50	B:651	BHADO RANRER	S	100	B:646I	BHEJARI	S

S.N.	ACC.NO.	NAME OF CULTIVARS	RATING	S.N.	ACC.NO.	NAME OF CULTIVARS	RATING
101	B:744	BHEJARI	S	151	B:2850	BHEJARI	S
102	B:778	BHEJARI	S	152	B:2915	BHEJARI	S
103	B:789	BHEJARI	S	153	B:1672	BADE BHEJARI	S
104	B:893I	BHEJARI	S	154	B:1905I	BADE BHEJARI	S
105	B:1039I	BHEJARI	S	155	B:1905II	BADE BHEJARI	S
106	B:1039II	BHEJARI	S	156	B:2594	BHODU PAREWA	S
107	B:1100	BHEJARI	S	157	C:344	CHHOTE BHEJARI	S
108	B:1102	BHEJARI	S	158	B:1362II	BHOELIM	S
109	B:1197I	BHEJARI	S	159	A:482I	AMRIT BHOG	S
110	B:1197II	BHEJARI	S	160	A:482II	AMRIT BHOG	S
111	B:1215	BHEJARI	S	161	A:647	AMRIT BHOG	S
112	B:1291I	BHEJARI	S	162	B:1209	BADSHAH BHOG	S
113	B:1386I	BHEJARI	S	163	B:801II	BADSHAH BHOG	S
114	B:1336II	BHEJARI	S	164	B:801	BADSHAH BHOG	S
115	B:1365I	BHEJARI	S	165	B:13	BADSHAH BHOG	S
116	B:1422II	BHEJARI	S	166	B:13II	BADSHAH BHOG	S
117	B:1422III	BHEJARI	S	167	B:25	BADSHAH BHOG	S
118	B:1422N	BHEJARI	S	168	B:42	BADSHAH BHOG	S
119	B:1426I	BHEJARI	S	169	B:42I	BADSHAH BHOG	S
120	B:1493I	BHEJARI	S	170	B:42II	BADSHAH BHOG	S
121	B:1493II	BHEJARI	MS	171	B:54I	BADSHAH BHOG	S
122	B:1493III	BHEJARI	S	172	B:54II	BADSHAH BHOG	S
123	B:1500II	BHEJARI	S	173	B:54	BADSHAH BHOG	S
124	B:1500	BHEJARI	S	174	B:173I	BADSHAH BHOG	S
125	B:1534	BHEJARI	S	175	B:173II	BADSHAH BHOG	S
126	B:1536I	BHEJARI	S	176	B:173	BADSHAH BHOG	S
127	B:1536II	BHEJARI	S	177	B:189II	BADSHAH BHOG	S
128	B:1558	BHEJARI	S	178	B:189III	BADSHAH BHOG	S
129	B:1571	BHEJARI	S	179	B:189I	BADSHAH BHOG	S
130	B:1577I	BHEJARI	S	180	B:189II	BADSHAH BHOG	S
131	B:1577II	BHEJARI	S	181	B:214II	BADSHAH BHOG	S
132	B:1673	BHEJARI	MS	182	B:220	BADSHAH BHOG	S
133	B:1875	BHEJARI	S	183	B:220	BADSHAH BHOG	S
134	B:1891	BHEJARI	S	184	B:227II	BADSHAH BHOG	MS
135	B:1937	BHEJARI	S	185	B:227III	BADSHAH BHOG	S
136	B:1938	BHEJARI	S	186	B:236II	BADSHAH BHOG	S
137	B:1954	BHEJARI	S	187	B:236	BADSHAH BHOG	S
138	B:1954I	BHEJARI	S	188	B:254II	BADSHAH BHOG	S
139	B:2010	BHEJARI	NG	189	B:254	BADSHAH BHOG	S
140	B:2083	BHEJARI	S	190	B:254	BADSHAH BHOG	S
141	B:2436	BHEJARI	S	191	B:306II	BADSHAH BHOG	S
142	B:2438	BHEJARI	S	192	B:323	BADSHAH BHOG	S
143	B:2443	BHEJARI	S	193	B:323	BADSHAH BHOG	S
144	B:2518	BHEJARI	S	194	B:323I	BADSHAH BHOG	S
145	B:2520	BHEJARI	NG	195	B:371	BADSHAH BHOG	S
146	B:2523	BHEJARI	S	196	B:323II	BADSHAH BHOG	S
147	B:2524	BHEJARI	S	197	B:381	BADSHAH BHOG	S
148	B:2652	BHEJARI	S	198	B:381II	BADSHAH BHOG	S
149	B:2741	BHEJARI	S	199	B:381	BADSHAH BHOG	S
150	B:2742	BHEJARI		200	B:405	BADSHAH BHOG	

S.N.	ACC.NO.	NAME OF CULTIVARS	RATING	S.N.	ACC.NO.	NAME OF CULTIVARS	RATING
201	B:411	BADSHAH BHOG	S	251	B:2355	BADSHAH BHOG	S
202	B:440II	BADSHAH BHOG	MS	252	B:2364	BADSHAH BHOG	S
203	B:440I	BADSHAH BHOG	S	253	B:2402	BADSHAH BHOG	S
204	B:440III	BADSHAH BHOG	S	254	B:2461	BADSHAH BHOG	S
205	B:440N	BADSHAH BHOG	S	255	B:2495	BADSHAH BHOG	NG
206	B:448II	BADSHAH BHOG	S	256	B:2504	BADSHAH BHOG	S
207	B:448III	BADSHAH BHOG	S	257	B:2716	BADSHAH BHOG	S
208	B:448	BADSHAH BHOG	S	258	B:2717	BADSHAH BHOG	S
209	B:457	BADSHAH BHOG	S	259	B:2788	BADSHAH BHOG	S
210	B:484	BADSHAH BHOG	S	260	B:2812	BADSHAH BHOG	S
211	B:491I	BADSHAH BHOG	S	261	B:2814	BADSHAH BHOG	S
212	B:491II	BADSHAH BHOG	S	262	B:167	BASA BHOG	S
213	B:497II	BADSHAH BHOG	S	263	B:167II	BASA BHOG	NG
214	B:497III	BADSHAH BHOG	S	264	B:167III	BASA BHOG	S
215	B:497	BADSHAH BHOG	S	265	B:506	BASA BHOG	S
216	B:528	BADSHAH BHOG	S	266	B:506	BASA BHOG	S
217	B:562	BADSHAH BHOG	S	267	B:506I	BASA BHOG	S
218	B:562	BADSHAH BHOG	S	268	B:506II	BASA BHOG	S
219	B:562II	BADSHAH BHOG	S	269	B:656I	BASA BHOG	S
220	B:674	BADSHAH BHOG	S	270	B:656II	BASA BHOG	S
221	B:769I	BADSHAH BHOG	S	271	B:1092	BASA BHOG	S
222	B:769II	BADSHAH BHOG	S	272	B:1756	BASA BHOG	S
223	B:799I	BADSHAH BHOG	S	273	B:2456	BASA BHOG	MS
224	B:799II	BADSHAH BHOG	S	274	B:459	BASA BHOG	S
225	B:973	BADSHAH BHOG	S	275	B:1801	BASA BHOG	S
226	B:987	BADSHAH BHOG	S	276	B:1717	BASHA BHOG	S
227	B:1005	BADSHAH BHOG	S	277	B:2376	BASHA BHOG	S
228	B:1010	BADSHAH BHOG	S	278	B:2599	BASHA BHOG	S
229	B:1029	BADSHAH BHOG	S	279	B:2604	BASHA BHOG	S
230	B:1043	BADSHAH BHOG	S	280	B:2469	BASSA BHOG	S
231	B:1118	BADSHAH BHOG	S	281	B:1112	BASTA BHOG	S
232	B:1257I	BADSHAH BHOG	S	282	B:2775	BASTA BHOG	S
233	B:1257II	BADSHAH BHOG	S	283	B:38ii	BAYASA BHOG	S
234	B:1307	BADSHAH BHOG	S	284	B:38III	BAYASA BHOG	S
235	B:1322	BADSHAH BHOG	S	285	B:2219	BAYASA BHOG	S
236	B:1340	BADSHAH BHOG	S	286	B:1094II	BISNU BHOG	S
237	B:1370	BADSHAH BHOG	S	287	B:1094IV	BISNU BHOG	S
238	B:1389	BADSHAH BHOG	S	288	B:1049III	BISNU BHOG	S
239	B:1427	BADSHAH BHOG	S	289	B:664	BISNU BHOG	S
240	B:1687	BADSHAH BHOG	S	290	B:678II	BISNU BHOG	S
241	B:1693	BADSHAH BHOG	S	291	B:678III	BISNU BHOG	S
242	B:1727	BADSHAH BHOG	S	292	B:1378	BISNU BHOG	S
243	B:1731	BADSHAH BHOG	S	293	B:671A	BISNU BHOG	S
244	B:1743	BADSHAH BHOG	S	294	B:671II	BISNU BHOG	S
245	B:1819	BADSHAH BHOG	S	295	B:671	BISNU BHOG	S
246	B:1850	BADSHAH BHOG	S	296	G:194II	GOPAL BHOG	S
247	B:2094	BADSHAH BHOG	S	297	G:194II	GOPAL BHOG	S
248	B:2297	BADSHAH BHOG	MS	298	G:194IV	GOPAL BHOG	S
249	B:2354	BADSHAH BHOG	S	299	G:194V	GOPAL BHOG	S
250	B:2354	BADSHAH BHOG	S	300	G:194VI	GOPAL BHOG	S

S.N.	ACC.NO.	NAME OF CULTIVARS	RATING	S.N.	ACC.NO.	NAME OF CULTIVARS	RATING
301	G:741	GOPAL BHOG	S	351	S:1683	SHITAL BHOG	S
302	G:585	GOVIND BHOG	S	352	S:1684	SHITAL BHOG	S
303	B:136	JOGI BHOG	S	353	S:1685	SHITAL BHOG	S
304	B:186	JOGI BHOG	S	354	T:114	THAKUR BHOG	S
305	K:1724	KAPUR BHOG	S	355	T:114	THAKUR BHOG	S
306	K:1930	KAPOOR BHOG	S	356	T:232	THAKUR BHOG	S
307	K:2019	KAPOOR BHOG	S	357	V:7II	VISHNOO BHOG	S
308	K:415II	KATARNI BHOG	S	358	V:9	VISHNOO BHOG	S
309	K:415III	KATARNI BHOG	S	359	V:10I	VISHNOO BHOG	S
310	K:1603	KURSO BHOG	S	360	V:10II	VISHNOO BHOG	S
311	K:1637	KURSO BHOG	S	361	V:10	VISHNOO BHOG	S
312	K:1936	KURSO BHOG	S	362	V:15I	VISHNOO BHOG	S
313	K:2149	KURSO BHOG	S	363	V:15II	VISHNOO BHOG	S
314	K:2151	KURSO BHOG	S	364	V:15III	VISHNOO BHOG	S
315	L:985	LAHSUN BHOG	S	365	V:15IV	VISHNOO BHOG	S
316	L:359	LAXMI BHOG	S	366	V:26I	VISHUN BHOG	S
317	L:708	LAXMI BHOG	S	367	V:26III	VISHUN BHOG	S
318	L:711	LAXMI BHOG	S	368	V:29	VISHUN BHOG	S
319	L:1238	LAXMI BHOG	MS	369	W:15	WISHNOO BHOG	S
320	L:1238	LAXMI BHOG	S	370	W:15I	WISHNOO BHOG	S
321	M:868	MADAN BHOG	S	371	W:15II	WISHNOO BHOG	S
322	M:520	MOHAN BHOG	S	372	W:26I	WISHNOO BHOG	S
323	M:1A	MUNI BHOG	S	373	W:26II	WISHNOO BHOG	S
324	M:1B	MUNI BHOG	S	374	W:28	WISHNOO BHOG	S
325	M:66I	MUNI BHOG	S	375	W:21	WISHUN BHOG	S
326	N:633	NAWAB BHOG	S	376	W:21III	WISHUN BHOG	S
327	N:197II	NIRANJAN BHOG	S	377	W:21IV	WISHUN BHOG	S
328	N:634	NIRPUTI BHOG	S	378	W:21V	WISHUN BHOG	MS
329	P:680	PARSAD BHOG	S	379	W:21VI	WISHUN BHOG	S
330	P:917	PARSAD BHOG	S	380	W:24II	WISHUN BHOG	S
331	P:4	PARSADI BHOG	S	381	W:24II	WISHUN BHOG	S
332	P:4I	PARSADI BHOG	S	382	B:997	BHOJ NEEM	S
333	P:4II	PARSADI BHOG	S	383	B:639	BHOJALI	S
334	P:4IV	PARSADI BHOG	S	384	B:187	BHOJANI	S
335	P:4V	PARSADI BHOG	MS	385	B:187	BHOJANI	S
336	P:4VI	PARSADI BHOG	S	386	B:665	BHOJANI	S
337	P:94B	PARSADI BHOG	S	387	B:2271	BHOJANI	S
338	P:94II	PARSADI BHOG	S	388	B:2271	BHOJANI	NG
339	P:94III	PARSADI BHOG	S	389	B:2745	BHOJNIN	S
340	P:132	PARSADI BHOG	S	390	B:571II	BHOJAIN	S
341	P:132I	PARSADI BHOG	S	391	B:600	BHUJANI	S
342	P:132II	PARSADI BHOG	S	392	B:275II	BHUJNIN	S
343	R:508	RAJA BHOG	S	393	B:1351	BHUJNIN	S
344	R:508	RAJA BHOG	S	394	B:1793	BUI LEEM	S
345	R:509	RAJA BHOG	S	395	B:1027	BUI LEEM	S
346	R:69I	RAM BHOG	S	396	B:682	BHUNJNIN	S
347	R:495A	RUKHMANI BHOG	S	397	B:458	BHUDKUD	S
348	R:40	RUKHMANI BHOG	S	398	B:2034	BHUDU	S
349	S:1224	SHITAL BHOG	S	399	B:1123	BHUDO	MS
350	S:1279	SHITAL BHOG	S	400	B:168	BHUNDU	S

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S.N.	ACC.NO.	NAME OF CULTIVARS	RATING	S.N.	ACC.NO.	NAME OF CULTIVARS	RATING
401	B:180II	BHULAU	S	451	K:497	KAKDI BIJA	S
402	B:281	BHULAU	S	452	K:497I	KAKDI BIJA	S
403	B:407	BHULAU	S	453	K:43	KAKARI BIJA	S
404	B:541I	BHULAU	NG	454	K:2086	KAKARI BUJA	S
405	B:541II	BHULAU	S	455	K:1319II	KANKAR BIJA	S
406	B:541III	BHULAU	S	456	K:1223II	KHIRA BIJA	MS
407	B:712	BHULAU	S	457	P:323	PARSA BIJA	S
408	B:1274II	BHULAU	S	458	B:72	BIJO	S
409	B:1274II	BHULAU	S	459	B:2248	BAHALI BIJO	S
410	B:1274IV	BHULAU	S	460	B:155	BALBIJO	S
411	B:1545	BHULAU	S	461	B:1741	BAHAL BINJO	S
412	B:1688	BHULAU	S	462	B:525	BIKONI	S
413	B:2054	BHULAU	S	463	B:525III	BIKONI	S
414	B:2084	BHULAU	S	464	B:525IV	BIKONI	S
415	B:2108	BHULAU	S	465	B:525V	BIKONI	S
416	B:2159	BHULAU	S	466	B:1599	BILAI MECHHA	S
417	B:2055	BHULAU	S	467	B:2148	BIROMANI	S
418	B:2853	BHULAU	S	468	B:1299I	BISANI	S
419	B:2871	BHULAU	S	469	B:1299II	BISANI	S
420	B:1866	BHULAU DHAN	S	470	B:1299III	BISANI	MS
421	B:481	BHAGEU BHLILAU	S	471	B:1683	BODA	S
422	B:1993	BHATHA BHULAU	S	472	B:1175	BODA BHEJ	S
423	K:1135II	KANTH BHULAU	S	473	B:1787	BODELA BIJ	S
424	K:1135	KANTH BHULAU	S	474	B:20A	BODA BICHA	S
425	K:1135III	KANTH BHULAU	S	475	B:629II	BODA KABRO	S
426	K:2547	KANTH BHULAU	S	476	B:629I	BODA KABRO	S
427	K:2572	KANTH BHULAU	S	477	B:2569	BODA MUNJA	S
428	K:2578	KANTH BHULAU	S	478	B:2477	BODA SAPUR	S
429	B:2199	BHUNDA	S	479	B:1041	BODE	S
430	B:1987	BHURI MATIA	S	480	B:2618	BODEL	S
431	B:1716	BHUR KUND	S	481	B:1024I	BODELI	S
432	B:1928	BHURKUND	S	482	B:2559	BODI	S
433	B:452	BHUR KUR	S	483	B:556I	BOHITA	S
434	B:1858	BHURSI	S	484	B:556II	BOHITA	S
435	B:2431	BHURSI	S	485	B:128	BOHITA	S
436	B:2779	BHUSI	S	486	B:135III	BOHITA	S
437	B:2787	BHUSI	S	487	B:182II	BOHITA	S
438	B:1618	BHUSI	S	488	B:1205II	BOHITA	S
439	B:1666	BHUSI	S	489	B:1641	BOIRMAL	S
440	B:2036	BHUSI	S	490	B:322	BOKDEL	S
441	B:1622	BHUSI	S	491	B:782II	BORA	MS
442	B:2790	BHUS BHUSI	S	492	B:453	BOROMAL	S
443	B:2432	BHUYALIM	S	493	B:2295	BOROMAL	S
444	B:1008	BAHAL BIJA	S	494	B:1924	BOUIRAS	S
445	B:982	BODA BIJA	S	495	B:2847	BOURSA	S
446	B:1822	BODA BIJA	MS	496	B:542II	BRAMHA CROSS TRIPLEES	
447	B:1015	BODAL BIJA	S	497	B:1759	BUCHCHI	S
448	B:2473	BODELA BIJA	S	498	B:1767	BUCHCHI	S
449	B:2339	B.D. KANKARI BIJA	S	499	B:2249	BUCHCHI	S
450	B:2340	B.D. KANKARI BIJA	S	500	B:2823	BUCHCHI	S

S.N.	ACC.NO.	NAME OF CULTIVARS	RATING	S.N.	ACC.NO.	NAME OF CULTIVARS	RATING
501	B:2677	BADE BUCHHI	S	551	U:135	URAI BUTA	S
502	B:565	CHHOTA BUCHHI	S	552	U:136	URAI BUTA	NG
503	B:572	CHHOTA BUCHHI	MS	553	U:158I	URAI BUTA	S
504	B:787	CHIND BUCHHI	S	554	U:158II	URAI BUTA	S
505	B:626	PETA BUCHHI	S	555	U:168II	URAI BUTA	S
506	B:889	PETA BUCHHI	S	556	U:234	URAI BUTA	S
507	B:2819	BUCHCHO	S	557	U:ll	URAI BUTA	MS
508	B:465II	BUDA BUDI	S	558	B:994.	BYA BANDA	S
509	B:425	BUDELA	S	559	B:461	BYALO	S
510	B:819II	BUDELA	S	560	B:1636	BYOLO	S
511	B:819II	BUDELA	S	561	B:294II	BYORA	S
512	B:819III	BUDELA	S	562	B:255I	BYORA	S
513	B:1509II	BUDELA	S	563	B:255II	BYORA	MS
514	B:11	BUNDELA	S	564	B:2903	B/5	S
515	B:132	BUDA BUDHI	S	565	B:2901	B/3	S
516	B:1888	BUDHI BUDHA	S	566	B:2135	BAROUNDA-26	S
517	B:1116I	BUDHA BUDHI	S	567	BOT:3II	BARONDA OFF TYPE	S
518	B:1116II	BUDHA BUDHI	S	568	BOT:3I	BARONDA OFF TYPE	S
519	B:1381	BUDHA BHUDHI	S	569	BOT:4	BARONDA OFF TYPE	S
520	B:2803	BUDHA BUDHI	S	570	BOT:5	BARONDA OFF TYPE	S
521	B:2284	BUDHI BUDHA	S	571	BOT:7II	BARONDA OFF TYPE	S
522	B:599III	BUDIYA	S	572	BOT:8I	BARONDA OFF TYPE	S
523	K:347I	KANTH BUDIYA	S	573	BOT:8II	BARONDA OFF TYPE	S
524	K:347II	KANTH BUDIYA	MS	574	BOT:8III	BARONDA OFF TYPE	S
525	B:2702	BUDHIYA	S	575	BOT:12I	BARONDA OFF TYPE	MS
526	B:544	BUDHRAM	S	576	BOT:13	BARONDA OFF TYPE	S
527	B:1445	BURSO	S	577	BOT:15	BARONDA OFF TYPE	S
528	B:2356	BUTAMALI	S	578	BOT:18	BARONDA OFF TYPE	S
529	A:204II	AURAI BUTA	S	579	BOT:24	BARONDA OFF TYPE	S
530	T:13II	TENDU BUTA	S	580	BOT:25V	BARONDA OFF TYPE	S
531	T:209III	TENDU BUTA	MS	581	BOT:27	BARONDA OFF TYPE	S
532	U:147II	URA BUTA	S	582	BOT:33	BARONDA OFF TYPE	S
533	U:7BII	URAI BUTA	S	583	BOT:34	BARONDA OFF TYPE	S
534	U:34	URAI BUTA	S	584	BOT:36	BARONDA OFF TYPE	S
535	U:51	URAI BUTA	S	585	BOT:41	BARONDA OFF TYPE	S
536	U:54	URAI BUTA	S	586	BOT:44	BARONDA OFF TYPE	S
537	U:55II	URAI BUTA	NG	587	BOT:45	BARONDA OFF TYPE	S
538	U:55	URAI BUTA	S	588	BOT:48	BARONDA OFF TYPE	MS
539	U:55	URAI BUTA	S	589	BOT:49II	BARONDA OFF TYPE	S
540	U:55III	URAI BUTA	S	590	BOT:51	BARONDA OFF TYPE	S
541	U:74	URAI BUTA	S	591	BOT:51II	BARONDA OFF TYPE	S
542	U:94I	URAI BUTA	S	592	BOT:51III	BARONDA OFF TYPE	S
543	U:94II	URAI BUTA	MS	593	BOT:51IV	BARONDA OFF TYPE	S
544	U:105I	URAI BUTA	S	594	BOT:53	BARONDA OFF TYPE	S
545	U:105II	URAI BUTA	S	595	BOT:55	BARONDA OFF TYPE	S
546	U:106II	URAI BUTA	S	596	BOT:56I	BARONDA OFF TYPE	S
547	U:117I	URAI BUTA	S	597	BOT:57V	BARONDA OFF TYPE	S
548	U:119II	URAI BUTA	S	598	BOT:59	BARONDA OFF TYPE	S
549	U:120II	URAI BUTA	S	599	BOT:59	BARONDA OFF TYPE	S
550	U:134II	URAI BUTA	S	600	BOT:60	BARONDA OFF TYPE	S

S.N.	ACC.NO.	NAME OF CULTIVARS	RATING	S.N.	ACC.NO.	NAME OF CULTIVARS	RATING
601	BOT:61I	BARONDA OFF TYPE	NG	651	C:233III	CHHATRI	S
602	BOT:61I	BARONDA OFF TYPE	S	652	C:233II	CHHATRI	S
603	BOT:61II	BARONDA OFF TYPE	S	653	C:233IV	CHHATRI	S
604	BOT:62	BARONDA OFF TYPE	S	654	C:266AI	CHHATRI	S
605	BOT:64I	BARONDA OFF TYPE	S	655	C:267	CHHATRI	S
606	BOT:64II	BARONDA OFF TYPE	S	656	C:267II	CHHATRI	S
607	BOT:64III	BARONDA OFF TYPE	S	657	C:278I	CHHATRI	S
608	BOT:76	BARONDA OFF TYPE	S	658	C:278II	CHHATRI	S
609	B-R-9I	B-R-9I	S	659	C:278III	CHHATRI	NG
610	B-R-9II	B-R-9II	S	660	C:278	CHHATRI	S
611	C:496	CHAKA BENI	S	661	C:278IV	CHHATRI	S
612	C:98	CHAKIYA-59(I)	S	662	C:354II	CHHATRI	S
613	C:98I	CHAKIYA-59(I)	S	663	C:354III	CHHATRI	S
614	C:98II	CHAKIYA-59(I)	S	664	C:364I	CHHATRI	S
615	C:98IV	CHAKIYA-59(I)	S	665	C:364II	CHHATRI	S
616	C:98V	CHAKIYA-59(I)	S	666	C:365II	CHHATRI	MS
617	D:159	CHAKIYA-59(I)	S	667	C:354II	CHHATRI	S
618	C:439	CHAMELI	S	668	C:484II	CHHATRI	S
619	C:648	CHAMELI	S	669	C:388I	CHHATRI	S
620	C:670	CHANA CHUR	S	670	C:388II	CHHATRI	S
621	C:581	CHELTA	S	671	C:393	CHHATRI	S
622	C:165I	CHENDARA CHHAL	S	672	C:401	CHHATRI	S
623	C:167	CHENDRA JHAL	S	673	C:406	CHHATRI	S
624	C:544	CHENDRA JHAL	S	674	C:414	CHHATRI	MS
625	C:602	CHENDRA JHAL	MS	675	C:568	CHHATRI	S
626	C:363	CHEPDA	S	676	C:380	CHHIDKA	S
627	C:35II	CHHATRI	S	677	C:380	CHHIDKA	S
628	C:36II	CHHATRI	S	678	C:382I	CHHIND BAHNI	S
629	C:42II	CHHATRI	S	679	C:382II	CHHIND BAHNI	S
630	C:54I	CHHATRI	S	680	C:386	CHHIND JHOMPHA	S
631	C:55II	CHHATRI	S	681	C:455	CHHIND JHOPA	S
632	C:90	CHHATRI	S	682	C:562	CHHIND JHOPA	S
633	C:92III	CHHATRI	S	683	C:562	CHHIND JHOPA	S
634	C:129III	CHHATRI	MS	684	C:676	CHHIND MOR	S
635	C:132II	CHHATRI	S	685	C:166	CHHIND MOUR	S
636	C:134I	CHHATRI	S	686	C:671	CHHIND MOUR	S
637	C:137	CHHATRI	S	687	C:696	CHHIND MOUR	S
638	C:138	CHHATRI	S	688	C:708	CHHIND MOUR	NG
639	C:157I	CHHATRI	S	689	C:541	CHHIND MOURI	S
640	C:157III	CHHATRI	S	690	C:617	CHHIND MOURI	S
641	C:157IV	CHHATRI	S	691	C:633	CHHIND MOURI	S
642	C:192I	CHHATRI	MS	692	C:635	CHHIND MOURI	S
643	C:192II	CHHATRI	S	693	C:653	CHHIND MOURI	S
644	C:192III	CHHATRI	S	694	C:554	CHHIND MOURI	MS
645	C:198II	CHHATRI	S	695	C:20	CHHIND WAYA	S
646	C:208II	CHHATRI	S	696	C:448	CHIN MAURI	S
647	C:208	CHHATRI	S	697	C:343III	CHIN MAURI	S
648	C:210II	CHHATRI	S	698	C:258II	CHHIND MOUR	S
649	C:233	CHHATRI	MS	699	C:258II	CHHIND MOUR	S
650	C:233II	CHHATRI	S	700	C:444	CHHIND MOURI	S

S.N.	ACC.NO.	NAME OF CULTIVARS	RATING
701	C:547	CHIDA MAL	S
702	C:785	CHIDIYA DORA	S
703	A:406II	ASSAM CHIDIYA	S
704	A:406	ASSAM CHIDIYA	S
705	C:470III	CHIKHALA KOTI	S
706	C:814	CHIKO	S
707	C:11B	CHILKAT	MS
708	C:702	CHILLA KORMA	S
709	C:583	CHILPUR BANDA DESHI	S
710	C:837	CHINA	S
711	C:837	CHINA	S
712	E:48	EUTBAL CHINA	S
713	C:370	CHINA WAL	S
714	C:169	CHINA MAL	S
715	C:21	CHIND BAYNIL	S
716	C:367II	CHINGAR CHOPA	S
717	C:579	CHING BAL	S
718	C:412	CHINGO	S
719	C:30I	CHINI KAPOOR	S
720	C:30II	CHINI KAPOOR	S
721	C:30III	CHINI KAPOOR	S
722	C:30IV	CHINI KAPOOR	MS
723	C:30V	CHINI KAPOOR	S
724	C:30VI	CHINI KAPOOR	S
725	C:30VII	CHINI KAPOOR	S
726	C:30IV	CHINI KAPOOR	S
727	C:30XI	CHINI KAPOOR	S
728	C:30XII	CHINI KAPOOR	S
729	C:30XIII	CHINI KAPOOR	S
730	C:339	CHINI KAPOOR	S
731	C:340	CHINI KAPOOR	S
732	C:701	CHHINNA BAL KOSAWARI	S
733	C:564	CHINNA KOMA	S
734	C:312	CHINNA MAL	S
735	C:31II	CHINNOR	S
736	C:84II	CHINNOUR	S
737	C:84III	CHINNOUR	S
738	C:84IV	CHINNOUR	S
739	C:102	CHINNOUR	MS
740	C:113I	CHINNOUR	S
741	C:113II	CHINNOUR	S
742	C:174	CHINNOUR	S
743	C:174I	CHINNOUR	S
744	C:174II	CHINNOUR	S
745	C:185	CHINNOUR	S
746	C:197	CHINNOUR	S
747	C:236	CHINNOUR	S
748	C:334I	CHINNOUR	S
749	C:334III	CHINNOUR	S
750	C:353	CHINNOUR	MS
751	C:390	CHINNOUR	S
752	C:392	CHINNOUR	S
753	C:395II	CHINNOUR	S
754	C:395B	CHINNOUR	S
755	C:397	CHINNOUR	S
756	C:399	CHINNOUR	S
757	C:423	CHINNOUR	MS
758	C:425I	CHINNOUR	S
759	C:425II	CHINNOUR	S
760	C:426	CHINNOUR	S
761	C:435I	CHINNOUR	S
762	C:435II	CHINNOUR	S
763	C:491	CHINNOUR	S
764	C:494I	CHINNOUR	S
765	C:566	CHINNOUR	S
766	C:604	CHINNOUR	MS
767	C:606	CHINNOUR	S
768	C:801	CHINNOUR	S
769	C:805	CHINNOUR	S
770	C:828	CHINNOUR	S
771	C:839	CHINNOUR	S
111	S:837	SUKUL MUNDI	S
773	S:1267	SUKUL MUNDI	S
774	S:1308	SUKUL MUNDI	S
775	S:1520	SUKUL MUNDI	S
776	S:1003	SUKUL MUNDI	S
111	K:559	KANTH CHINNOUR	S
778	K:2573	KANTH CHINNOUR	S
779	C:577	CHINTA KOMA	S
780	C:563	CHINTA KOMMA	S
781	C:756	CHINTA MANI	S
782	C:229	CHIPADA	MS
783	C:569	CHIPDA	S
784	C:13AI	CHIRAI NAKHI	S
785	C:751II	CHIRAI NAKHI	S
786	C:751	CHIRAI NAKHI	S
787	C:148II	CHI ROUNJ	S
788	C:659	CHITAR BOTI	S
789	C:660	CHITAR BOTI	S
790	C:684	CHITAR CHINI	MS
791	C:203II	CHITAR CHINI	S
792	C:711	CHITAR KANTH	S
793	C:705	CHITAR SINGH	NG
794	C:735	CHITAR SINGH	S
795	C:25I	CHIT MUCHCHI	S
796	C:792	CHIT MUCHI	S
797	C:631	CHITRA	S
798	C:418II	CHITRAKUT	S
799	C:24	CHUDI	S
800	C:311	CHUDI	S

S.N.	ACC.NO.	NAME OF CULTIVARS	RATING	S.N.	ACC.NO.	NAME OF CULTIVARS	RAT IN
801	C:322	CHUDI	S	851	A:475III	AMERIKA CHUDI	S
802	C:323	CHUDI	S	852	A:472	AMERIKA CHUDI	S
803	C:328	CHUDI	S	853	A:27	ASSAM CHUDI	S
804	C:328II	CHUDI	S	854	A:148	ASSAM CHUDI	S
805	C:374	CHUDI	S	855	A:148I	ASSAM CHUDI	S
806	C:374I	CHUDI	MS	856	A:238	ASSAM CHUDI	S
807	C:374II	CHUDI	S	857	A:268	ASSAM CHUDI	NG
808	C:376II	CHUDI	S	858	A:281	ASSAM CHUDI	S
809	C:377	CHUDI	S	859	A:285	ASSAM CHUDI	S
810	C:451	CHUDI	S	860	A:300	ASSAM CHUDI	S
811	C:451II	CHUDI	S	861	A:301	ASSAM CHUDI	S
812	C:451III	CHUDI	S	862	A:310	ASSAM CHUDI	S
813	C:451III	CHUDI	S	863	A:312	ASSAM CHUDI	S
814	C:454	CHUDI	S	864	A:314	ASSAM CHUDI	S
815	C:460	CHUDI	S	865	A:329	ASSAM CHUDI	S
816	C:462	CHUDI	S	866	A:337	ASSAM CHUDI	S
817	C:473II	CHUDI	S	867	A:342	ASSAM CHUDI	MS
818	C:532	CHUDI	S	868	A:357	ASSAM CHUDI	S
819	C:570	CHUDI	S	869	A:368	ASSAM CHUDI	S
820	C:573	CHUDI	MS	870	A:377	ASSAM CHUDI	S
821	C:576	CHUDI	S	871	A:382	ASSAM CHUDI	S
822	C:464	CHUDI	S	872	A:383	ASSAM CHUDI	S
823	C:587	CHUDI	S	873	A:384	ASSAM CHUDI	S
824	C:589	CHUDI	S	874	A:395	ASSAM CHUDI	S
825	C:592	CHUDI	S	875	A:400	ASSAM CHUDI	NG
826	C:693II	CHUDI	S	876	A:401	ASSAM CHUDI	S
827	C:693	CHUDI	S	877	A:411	ASSAM CHUDI	S
828	C:699	CHUDI	S	878	A:430	ASSAM CHUDI	S
829	C:703	CHUDI	S	879	A:436	ASSAM CHUDI	S
830	C:755	CHUDI	S	880	A:462	ASSAM CHUDI	MS
831	C:760	CHUDI	S	881	A:463	ASSAM CHUDI	S
832	C:737	CHUDI	S	882	A:476	ASSAM CHUDI	S
833	C:742	CHUDI	MS	883	A:477	ASSAM CHUDI	S
834	C:743	CHUDI	S	884	A:479	ASSAM CHUDI	S
835	C:744	CHUDI	S	885	A:481	ASSAM CHUDI	S
836	C:754	CHUDI	S	886	A:492	ASSAM CHUDI	NG
837	C:761	CHUDI	S	887	A:494	ASSAM CHUDI	S
838	C:776	CHUDI	S	888	A:500	ASSAM CHUDI	S
839	C:789	CHUDI	S	889	A:514	ASSAM CHUDI	S
840	C:809	CHUDI	S	890	A:514	ASSAM CHUDI	S
841	C:817	CHUDI	S	891	A:516	ASSAM CHUDI	S
842	C:823	CHUDI	S	892	A:542	ASSAM CHUDI	S
843	C:826	CHUDI	S	893	A:548	ASSAM CHUDI	S
844	C:590	CHUDI	S	894	A:557	ASSAM CHUDI	S
845	C:4A	CHUDI	MS	895	A:559	ASSAM CHUDI	S
846	C:4AII	CHUDI	S .	896	A:562	ASSAM CHUDI	S
847	C:704	CHUDI DESHI	S	897	A:563	ASSAM CHUDI	S
848	C:307	CHUDI DHAN	NG	898	A:572	ASSAM CHUDI	S
849	C:306	CHUDI DHAN	S	899	A:582	ASSAM CHUDI	S
850	A:475II	AMERIKA CHUDI	S	900	A:585	ASSAM CHUDI	S

S.N.	ACC.NO.	NAME OF CULTIVARS	RATING
901	A:596	ASSAM CHUDI	S
902	A:600II	ASSAM CHUDI	S
903	A: 607	ASSAM CHUDI	S
904	A:610	ASSAM CHUDI	S
905	A:611	ASSAM CHUDI	S
906	A:612	ASSAM CHUDI	S
907	A:613	ASSAM CHUDI	MS
908	A:613	ASSAM CHUDI	S
909	A: 614	ASSAM CHUDI	S
910	A:618	ASSAM CHUDI	S
911	A:619	ASSAM CHUDI	S
912	A:622	ASSAM CHUDI	S
913	A:624	ASSAM CHUDI	S
914	A:626	ASSAM CHUDI	S
915	A:632	ASSAM CHUDI	S
916	A:633	ASSAM CHUDI	S
917	A:635	ASSAM CHUDI	S
918	A:636	ASSAM CHUDI	S
919	A:638	ASSAM CHUDI	S
920	A:639	ASSAM CHUDI	S
921	A:640	ASSAM CHUDI	S
922	A:642	ASSAM CHUDI	S
923	A:645	ASSAM CHUDI	S
924	A:660	ASSAM CHUDI	S

MS - Moderately susceptible,
S - Susceptible,
NG - No germination