



## Screening of mango (*Mangifera indica*) germplasm for identification of sources resistant to mango malformation

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### ABSTRACT

The study was carried out on 72 mango (*Mangifera indica* L.) cultivars and 107 mango F1 hybrids to group them based on degree of resistance to malformation during the period 2015-17. Intensity of malformation varied significantly among the mango cultivars and F1 hybrids under study. Out of 72 mango cultivars and 107 F1 hybrids studied, only three cultivars namely Bhadauran, Ilaichi and Arka Nilanchal were found to be completely free from the mango malformation disease (0%) and were categorised as resistant. Minimum disease incidence (<10%) was recorded in 11 mango cultivars, one mango species and in eight mango F1 hybrids, viz. H-2-6, H-2-14, H-3-6, H-4-10, H-5-14, H-8-4, H-8-2. and H-8-11 and were categorized as tolerant. Twelve mango cultivars and 21 mango F1 hybrids were moderately susceptible (10-20%), while another 27 cultivars and 43 F1 hybrids were susceptible (20-50%). The highest incidence of floral malformation intensity was recorded in 13 cultivars and 32 F1 hybrids which were categorized as highly susceptible (>50%) to mango malformation. The resistant and tolerant cultivars and F1 hybrids observed in the current study can be used as parents in future breeding programmes for developing a variety resistant to mango malformation.

**Key words:** Germplasm, *Mangifera indica*, Mango cultivar, Mango hybrids, Malformation, Resistant susceptible cultivar

According to NHB and FAOSTAT data, India leads in cultivation area (2.56 million ha) as well as production (19.27 million tonnes) of mango (*Mangifera indica* L.) which is contributing majorly to the total world production. Besides this India is also the largest exporter of fresh mango and mango pulp (NHB 2014). Though efforts had been made for increasing the production and productivity during the last four decades, but the productivity of mango orchards in India is still low as 7.50 t/ha. The main reasons for low productivity and poor fruit quality are mango malformation disease and irregular fruit bearing habit, which are of great concern causing enormous economic loss to the growers due to poor yield or failure of crop. This disease is widespread in flowers and vegetative shoots of mango. It has a crippling effect on mango production (Hiffny *et al.* 1978) bringing in heavy economic losses. It is estimated that in India, it causes approximately 50-80% loss every year (Kumar and Chakrabarti 1997) and causes gross deformation of vegetative and floral tissues in mango (Ploetz 2001). In the

past, breeding approaches have been utilized to overcome the mango malformation to get high yield and quality fruits.

The etiology of malformation has been a contentious issue, and a wide range of biotic and abiotic factors have been reported to cause the disease, including viruses, mites and nutritional deficiencies (Singh and Dhillon 1990, Kumar *et al.* 1993, Ploetz *et al.* 2002, Nailwal *et al.* 2006; Jouyban 2012). Several members of the genus *Fusarium*, including *F. mangiferae* (previously identified as *F. moniliforme* and later as *F. moniliforme* var. *subglutinans*), *F. mexicanum*, *F. sterilihyphosum*, *F. proliferatum*, *F. subglutinans*, *F. pseudocircinatum* and *F. tuiense*, are associated with this disease (Liu *et al.* 2016); with *F. mangiferae* being the major causal agent in most countries. The incidence of mango malformation varies from season to season, differences in cultivar, age of the plant and agro climatic conditions of the area (Azzous *et al.* 1978, Srivastava 1998). Several studies suggested that the density of *F. moniliforme* var. *subglutinans* reaches a maximum in mango shoot when temperature ranges between 12 to 27°C along with humidity over 80% (Nath *et al.* 1987, Misra and Singh 1998, Nagaraja *et al.* 2011). In our previous studies, the symptoms of malformation could be artificially induced under controlled conditions in phytotron at 27°C with high relative humidity (60-65%) in mango variety Amrapali. Majumdar and Sinha (1972) observed that other factors such as tree growth habit (time of flushing), physiology, rate of transpiration

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and cellular structure can affect malformation incidence in mango cultivars in different regions of mango production (Nafees *et al.* 2010).

All the commercial mono-embryonic varieties Dashehari, Malda, Langra, Safeda and Chausa and poly-embryonic varieties Carabao, Peach, Cecil, Turpentine are affected with the disease. Varieties in Lucknow and Uttar Pradesh showed 30 to 60% incidence of floral malformation, where as in Saharanpur 47.03% panicles were, affected (Nirvan 1953). Khan and Khan (1960) reported that the incidence of bunchy top in mango seedling may go upto 80%. The severity of malformation is more in seedling and juvenile grafted trees (91%) as compared to the bearing ones (9.6%). The present study was carried out to assess the intensity of floral malformation disease in different cultivars and hybrids to identify resistant or tolerant mango cultivars and hybrids from among the available mango germplasm at Indian Agriculture Research Institute, New Delhi for further use in mango breeding programs.

#### MATERIALS AND METHODS

The study was carried out at Division of Fruits and Horticultural Technology, ICAR-Indian Agricultural Research Institute, New Delhi which is located at 77°12'F longitude, 28°40'N latitude and having altitude of 228.6 m above mean sea level. The agro-climatic conditions of IARI, New Delhi is having Trans-Gangetic Plains Region. The climatic conditions are typical subtropical with hot and dry summer followed by cold winter. In summer the temperature varied from 41 to 44°C while in winter the minimum temperature varied from 3 to 7°C. The flowering season in mango at Delhi conditions is from February to March when the temperatures range from 22-30°C (Fig 1). In the current study, 72 mango cultivars and mango hybrids available in the collection block of the Indian Agricultural Research Institute, New Delhi were screened for the intensity of malformation disorder for last three years to group them into different categories according to their degree of resistance to malformation. Observations were recorded during flowering season in each year February and March at middle height of the tree canopy of each of the investigated mango tree as per the method described by Mishra (2004). The mango cultivars and hybrids selected for the study were growing under the same environmental conditions receiving same management practices. The results were compared by subjecting to one way ANOVA using the SPSS version 16. Based on floral malformation intensity the mango cultivars were categorized into five groups; (I) 0% (Resistant), (II) 1-10% (Tolerant), (III) 10.1-20% (Moderately Susceptible), (IV) 20.1-50% (Susceptible), (V) > 50% (Highly Susceptible).

#### RESULTS AND DISCUSSION

The intensity of mango malformation observed in various mango cultivars and hybrids measured under natural conditions during the years 2015-17 are presented in Tables 1&2. The results revealed a large variability for intensity

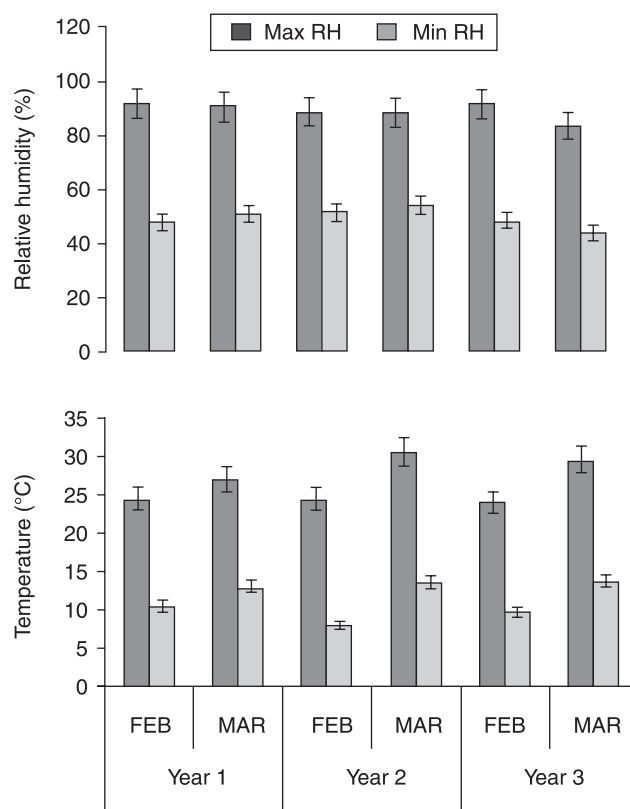


Fig 1 Mean maximum and minimum relative humidity and temperature prevailing in the months of February and March over the three experimental years.

of mango floral malformation in different mango cultivars and F1 hybrids under study. The mango varieties having extent of malformation more than 50 % are described in Fig 2. Out of 72 mango cultivars and 107 F1 hybrids studied, only three cultivars namely Bhadauran, Ilaichi and Arka nilanchal were found to be completely free from the mango malformation disease (0%) and were categorised as resistant (Fig 2). Mango hybrids having extent of malformation 10 % are H-8-2, H-3-6, H-2-14, H-5-14, H-8-4 and H-4-10 (Fig 2). Minimum disease incidence (<10%) was recorded in mango cultivars namely Mehmood bahar, Ratoul, Maya, Irvin, Ramkela, Vellai kolamban, Rosari, Creeper, Alpan, Kensington, Vanraj and in one mango species *Mangifera odorata* and in eight mango F1 hybrids namely H-2-6, H-2-14, H-3-6, H-4-10, H-5-14, H-8-4, H-8-2. and H-8-11 and were categorized as tolerant. Twelve mango cultivars (Sonatole, Hardil azeez, Kalepad, Olour, Gulabkhas green, Kala, Shah pasand, Himsagar, Safdar pasand, Pusa peetamber, Prabha shankar, Mombosa) and 21 mango F1 hybrids (H-1-2, H-1-3, H-1-6, H-1-16, H-2-2, H-3-7, H-3-11, H-3-14, H-4-1, H-4-2, H-4-3, H-4-7, H-4-8, H-5-11, H-6-13, H-7-1, H-9-6, H-10-3, H-10-8, H-11-6, H-12-9) were moderately susceptible (10 - 20%), while another 27 cultivars and 43 F1 hybrids were susceptible (20-50%). The highest incidence of floral malformation intensity was recorded in 13 cultivars and 32 F1 hybrids which were categorized as highly susceptible (>50%) to mango malformation (Tables

Table 1 Extent of mango malformation observed in different mango varieties

| Genotypes           | Extent of mango malformation |
|---------------------|------------------------------|
| Ratna               | 55                           |
| Swarnrekha          | 59                           |
| Mehmood bahar       | 6                            |
| Ratoul              | 8                            |
| Eturba              | 70                           |
| Maya                | 10                           |
| Nileshan            | 21                           |
| Surya               | 61                           |
| Irvin               | 9                            |
| Neelum              | 66                           |
| Kerala 3            | 69                           |
| Sonatole            | 18                           |
| Hardil azeez        | 18                           |
| Kurrakan            | 72                           |
| Husnara             | 34                           |
| Lucknow safeda      | 73                           |
| Kalepad             | 20                           |
| Olour               | 12                           |
| Gulabkhas green     | 19                           |
| Ilaichi             | 0                            |
| Zill                | 56                           |
| Chausa              | 36                           |
| Kala                | 15                           |
| Mallika             | 43                           |
| Machali             | 43                           |
| Totapari            | 60                           |
| Kerala1             | 46                           |
| Shah pasand         | 16                           |
| Pusa shreshtha      | 42                           |
| Bombay green        | 41                           |
| H-165               | 40                           |
| Pusa lalima         | 32                           |
| Khasul khas         | 32                           |
| Kesar               | 65                           |
| Ramkela             | 10                           |
| H-11-2              | 21                           |
| Sabri               | 31                           |
| Zardalu             | 22                           |
| H-12-5              | 28                           |
| Vellai kolamban     | 5                            |
| Janardan pasand     | 55                           |
| Pusa pratibha H-1-1 | 24                           |
| Tommy atkins        | 56                           |
| Himsagar            | 12                           |

Table 1 (Concluded)

|                     |      |
|---------------------|------|
| Arka nilanchal      | 0    |
| Rosari              | 5    |
| Safdar pasand       | 20   |
| Pusa peetamber      | 11   |
| Prabha Shankar      | 17   |
| Langra              | 24   |
| Pairi               | 25   |
| Kalapaddy           | 29   |
| Mombosa             | 19   |
| Samerbahist alibagh | 30   |
| Amrapali            | 92   |
| Mangifera odorata   | 10   |
| Keitt               | 26   |
| Arunima             | 45   |
| Bhadauran           | 0    |
| Creeper             | 2    |
| Indonesia           | 40   |
| Peach               | 40   |
| Movandan            | 42   |
| Alpan               | 8    |
| Mahmmoda vikarabad  | 46   |
| Extrema             | 73   |
| Sent alexandrina    | 25   |
| H-2-13              | 21   |
| Kensington          | 10   |
| Ametista            | 30   |
| Edward              | 46   |
| Vanraj              | 7    |
| LSD (P=0.05)        | 15.2 |

Table 2 Extent of mango malformation observed in different mango hybrids

| Lines  | Parent-age | Healthy panicles/tree | Mal-formed panicles/tree | Malformation percentage | Panicle type |
|--------|------------|-----------------------|--------------------------|-------------------------|--------------|
| H-1-1  | A × S      | 503                   | 162                      | 24.36                   | Compact      |
| H-1-2  | A × S      | 46                    | 8                        | 14.81                   | Compact      |
| H-1-3  | A × S      | 631                   | 117                      | 15.64                   | Compact      |
| H-1-5  | A × S      | 133                   | 96                       | 41.92                   | Compact      |
| H-1-6  | A × S      | 565                   | 93                       | 14.13                   | Compact      |
| H-1-8  | A × S      | 193                   | 103                      | 34.80                   | Compact      |
| H-1-9  | A × S      | 33                    | 11                       | 25.00                   | Compact      |
| H-1-10 | A × S      | 119                   | 38                       | 24.20                   | Compact      |
| H-1-11 | A × S      | 360                   | 97                       | 21.23                   | Compact      |
| H-1-13 | A × S      | 63                    | 27                       | 30.00                   | Compact      |
| H-1-14 | A × S      | 214                   | 173                      | 44.70                   | Loose        |
| H-1-16 | A × S      | 15                    | 2                        | 11.76                   | Loose        |

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Table 2 (Continued)

| Lines  | Parent-age | Healthy panicles/tree | Mal-formed panicles/tree | Malformation percentage | Panicle type |
|--------|------------|-----------------------|--------------------------|-------------------------|--------------|
| H-2-2  | A × LS     | 556                   | 131                      | 19.07                   | Loose        |
| H-2-3  | A × LS     | 16                    | 5                        | 23.81                   | Loose        |
| H-2-4  | A × LS     | 180                   | 103                      | 36.40                   | Loose        |
| H-2-5  | A × LS     | 59                    | 36                       | 37.89                   | Loose        |
| H-2-6  | A × LS     | 513                   | 56                       | 10.15                   | Loose        |
| H-2-7  | A × LS     | 60                    | 127                      | 67.91                   | Compact      |
| H-2-10 | A × LS     | 138                   | 59                       | 29.95                   | Loose        |
| H-2-13 | A × LS     | 284                   | 76                       | 21.11                   | Compact      |
| H-2-14 | A × LS     | 238                   | 20                       | 7.75                    | Both         |
| H-2-15 | A × LS     | 47                    | 24                       | 33.80                   | Compact      |
| H-3-1  | A × S      | 53                    | 39                       | 42.39                   | Compact      |
| H-3-2  | A × S      | 480                   | 185                      | 27.82                   | Loose        |
| H-3-3  | A × S      | 108                   | 386                      | 78.14                   | Compact      |
| H-3-4  | A × S      | 230                   | 182                      | 44.17                   | Both         |
| H-3-6  | A × S      | 213                   | 22                       | 9.36                    | Compact      |
| H-3-7  | A × S      | 468                   | 65                       | 12.20                   | Both         |
| H-3-8  | A × S      | 1                     | 96                       | 98.97                   | Compact      |
| H-3-9  | A × S      | 19                    | 11                       | 36.67                   | Loose        |
| H-3-11 | A × S      | 198                   | 33                       | 14.29                   | Loose        |
| H-3-14 | A × S      | 287                   | 63                       | 18.00                   | Compact      |
| H-3-15 | A × S      | 130                   | 55                       | 29.73                   | Loose        |
| H-4-1  | A × S      | 421                   | 88                       | 17.29                   | Loose        |
| H-4-2  | A × S      | 123                   | 22                       | 15.17                   | Loose        |
| H-4-3  | A × S      | 302                   | 63                       | 17.26                   | Loose        |
| H-4-5  | A × S      | 80                    | 32                       | 28.57                   | Compact      |
| H-4-6  | A × S      | 60                    | 29                       | 32.58                   | Loose        |
| H-4-7  | A × S      | 328                   | 57                       | 14.81                   | Both         |
| H-4-8  | A × S      | 90                    | 21                       | 18.92                   | Compact      |
| H-4-9  |            | 726                   | 286                      | 28.26                   | Compact      |
| H-4-10 | D × S      | 380                   | 26                       | 6.40                    | Compact      |
| H-4-11 | D × S      | 4                     | 19                       | 82.61                   | Compact      |
| H-4-12 | Lalima     | 815                   | 384                      | 32.03                   | Loose        |
| H-5-8  | A × LS     | 220                   | 338                      | 60.57                   | Compact      |
| H-5-11 | 470 N      | 411                   | 98                       | 19.25                   | Compact      |
| H-5-12 | A × LS     | 303                   | 124                      | 29.04                   | Loose        |
| H-5-14 |            | 386                   | 32                       | 7.66                    | Compact      |
| H-5-15 |            | 281                   | 82                       | 22.59                   | Loose        |
| H-6-1  | A × LS     | 189                   | 122                      | 39.23                   | Loose        |
| H-6-2  | A × Alp    | 92                    | 170                      | 64.89                   | Compact      |
| H-6-6  | A × Alp    | 68                    | 21                       | 23.60                   | Loose        |
| H-6-7  | A × Alp    | 53                    | 220                      | 80.59                   | Both         |
| H-6-8  | A × Alp    | 38                    | 163                      | 81.09                   | Loose        |
| H-6-9  | A × Alp    | 13                    | 7                        | 35.00                   | Compact      |
| H-6-10 | A × Alp    | 2                     | 6                        | 75.00                   | Compact      |
| H-6-13 | A × Alp    | 413                   | 56                       | 11.94                   | Loose        |
| H-7-1  | D × N      | 48                    | 9                        | 15.79                   | Loose        |
| H-7-2  | A × S      | 6                     | 25                       | 80.65                   | Compact      |
| H-7-3  | A × S      | 12                    | 16                       | 57.14                   | Compact      |

Contd.

Table 2 (Concluded)

| Lines   | Parent-age   | Healthy panicles/tree | Mal-formed panicles/tree | Malformation percentage | Panicle type |
|---------|--------------|-----------------------|--------------------------|-------------------------|--------------|
| H-7-4   | A × S        | 61                    | 99                       | 61.88                   | Both         |
| H-8-1   | A × LS       | 761                   | 248                      | 24.58                   | Loose        |
| H-8-2   | A × LS       | 633                   | 69                       | 9.83                    | Loose        |
| H-8-4   | A × LS       | 588                   | 44                       | 6.96                    | Both         |
| H-8-7   | A × LS       | 419                   | 239                      | 36.32                   | Loose        |
| H-8-8   | A × LS       | 188                   | 365                      | 66.00                   | Loose        |
| H-8-10  | A × LS       | 98                    | 179                      | 64.62                   | Compact      |
| H-8-11  | A × LS       | 549                   | 51                       | 10.59                   | Loose        |
| H-9-1   | A × S        | 59                    | 26                       | 30.59                   | Compact      |
| H-9-2   | Ratna        | 68                    | 23                       | 25.27                   | Compact      |
| H-9-4   | A × S        | 35                    | 86                       | 71.07                   | Compact      |
| H-9-5   | D × N        | 28                    | 72                       | 72.00                   | Both         |
| H-9-6   | A × S        | 43                    | 8                        | 15.69                   | Loose        |
| H-9-8   | A × S        | 259                   | 84                       | 24.49                   | Compact      |
| H-9-9   | D × N        | 17                    | 38                       | 69.09                   | Loose        |
| H-10-3  |              | 336                   | 66                       | 16.42                   | Compact      |
| H-10-4  | D 3KR        | 60                    | 350                      | 85.37                   | Loose        |
| H-10-5  | N OP<br>15KR | 46                    | 192                      | 80.67                   | Loose        |
| H-10-6  | D × N        | 21                    | 96                       | 82.05                   | Loose        |
| H-10-8  | SP × N       | 206                   | 36                       | 14.88                   | Both         |
| H-10-9  |              | 122                   | 170                      | 58.22                   | Both         |
| H-10-10 |              | 96                    | 346                      | 78.28                   | Both         |
| H-11-1  | A × S        | 2                     | 14                       | 87.50                   | Compact      |
| H-11-2  | A × S        | 225                   | 48                       | 22.32                   | Both         |
| H-11-3  | A × S        | 81                    | 168                      | 67.47                   | Compact      |
| H-11-4  | A × S        | 69                    | 193                      | 73.66                   | Compact      |
| H-11-5  | A × S        | 38                    | 65                       | 63.11                   | Loose        |
| H-11-6  | A × S        | 198                   | 15                       | 16.49                   | Loose        |
| H-12-1  | A × S        | 85                    | 33                       | 27.97                   | Loose        |
| H-12-3  | A × S        | 80                    | 43                       | 34.96                   | Loose        |
| H-12-4  | A × S        | 63                    | 116                      | 64.80                   | Both         |
| H-12-5  | A × S        | 172                   | 66                       | 27.73                   | Both         |
| H-12-6  | -            | 118                   | 38                       | 24.36                   | Loose        |
| H-12-7  | A × S        | 6                     | 53                       | 89.83                   | Compact      |
| H-12-8  | A × S        | 71                    | 48                       | 40.34                   | Loose        |
| H-12-9  | A × S        | 134                   | 23                       | 14.65                   | Loose        |
| H-12-10 | A × S        | 93                    | 185                      | 66.55                   | Both         |
| H-12-11 | -            | 280                   | 67                       | 19.31                   | Loose        |
| H-13-1  | A × S        | 78                    | 63                       | 44.68                   | Compact      |
| H-13-4  | -            | 59                    | 82                       | 58.16                   | Compact      |
| H-13-5  | 0            | 109                   | 48                       | 30.57                   | Both         |
| H-14-2  | A × S        | 12                    | 64                       | 84.21                   | Loose        |
| H-14-8  | A × S        | 42                    | 83                       | 66.40                   | Compact      |
| H-15-1  | A × S        | 4                     | 79                       | 95.18                   | Compact      |
| H-15-3  | A × S        | 338                   | 123                      | 26.68                   | Loose        |
| H-15-7  | -            | 912                   | 366                      | 28.64                   | Loose        |
| H-15-9  | -            | 7                     | 38                       | 84.44                   | Compact      |
|         |              | 104.8                 | 23.1                     | 15.7                    | -            |

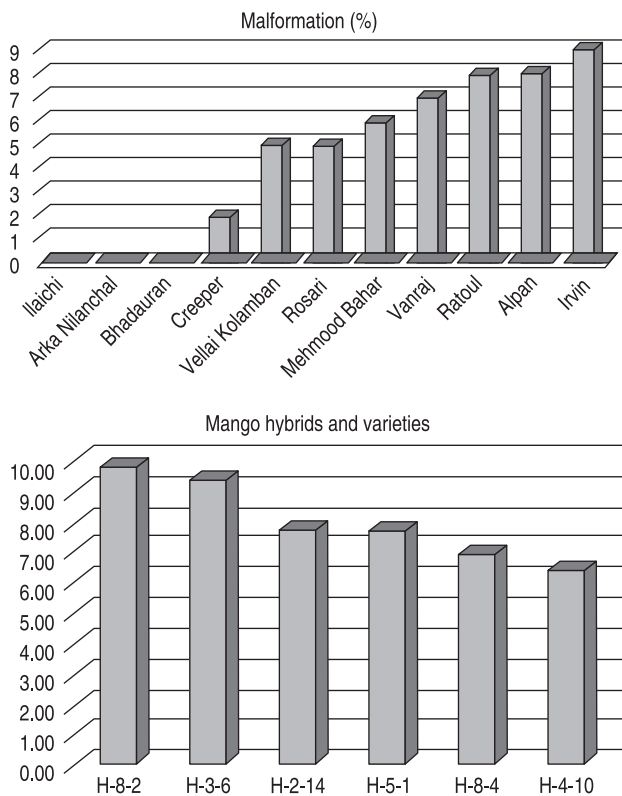


Fig 2 Mango varieties (top) and hybrids (below) having extent of malformation 10%.

1 and 2). While none of the mango hybrids were free of malformation, a few of the tested mango varieties exhibited zero malformation. On the other hand, some of the mango varieties and hybrids exhibited the extent of malformation in excess of ninety per cent and can form an important source for assessing the genetic variation, in comparison with the malformation free varieties, at the molecular level to improve our understanding of the molecular basis of the malformation malady in mango.

Similar observations were reported earlier (Hafiz *et al.* 2008, Kanpure *et al.* 2009). Chakrabarti *et al.* (2002) reported that in Uttar Pradesh in certain years, the disease flared up and caused sporadic epidemic damage to more than 80% of the mango crop. Studies conducted at CISH, Lucknow during 1978 and 1979 under conditions of natural infection in India on 122 Cvs revealed that Lucknow safeda had 98.0%, Dashehari 84.0%, Langra 72.0%, Malda 68.0%, Totapari 60.0% and Baramasi 20.0% infection. The polyembryonic varieties, Olour, Mylepian and *Mangifera cochinchinensis* were highly susceptible. While screening 102 cultivars against malformation only three of them namely Bhadayam dula, Samar bahist rampur and Mian saheb were totally free. Other cultivars found resistant to malformation were Bhadauran, Alib, Cherumani, Malda, Handle and Dudhia, Langra. Among 312 mango varieties/species evaluated for incidence of floral malformation, at CISH, Lucknow, cv. Elaichi (average fruit weight 54 g) was found to be free from the disease. Prasad *et al.* (1965) reported that cv. Bhadauran was not susceptible to

malformation. The temperature 27°C followed by 25°C with 65 percent relative humidity increased the incidence of mango malformation (Nagaraja *et al.* 2011)

### Conclusion

Recent studies reveal that the malformation occurrence is primarily influenced by weather conditions favorable for the growth and proliferation of casual organism. The potential impacts of climate change on mango malformation disease and lack of known commercial varieties free from mango malformation aggravates the need to develop varieties resistant to mango malformation to reduce economic losses. The existence of diversity in mango germplasm can be exploited to develop hybrids free of malformation malady. Resistant mango cultivars such as Bhadauran, Ilaichi and Arka nilanchalas well as tolerant cultivars Mehmood bahar, Ratoul, Maya, Irvin, Ramkela, Vellai kolamban, Rosari, Creeper, Alpan, Kensington, Vanraj and mango species *Mangifera odorata* and F1 hybrids namely H-2-6, H-2-14, H-3-6, H-4-10, H-5-14, H-8-4, H-8-2 and H-8-11 can be used as parents in mango breeding programmes to develop varieties resistant to mango malformation. The present study also provides updated information on the status of the disease intensity in different mango cultivars and F1 hybrids and will help in the future experimental planning.

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