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Mango (*Mangifera indica*) germplasm screening against burl disease and its effect on fruit yield and quality

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ABSTRACT

The present field study was undertaken at ICAR-Directorate of Medicinal and Aromatic Plants Research, Anand, Gujarat during 2016–17 to know the susceptible germplasm of mango (*Mangifera indica* L.) to burl disease under western part of India. Burl is an outgrowth on main trunk and lower branches of mango tree, having different sizes and shapes. This study represents the results of a survey conducted on more than 200 mango germplasm against burl disease in Gujarat state of India. In the survey it was found that 20 mango germplasms were susceptible or express symptoms of burl disease. Highest incidence was observed in Mehmud Vikarabad, Arka Aruna, Badami Modal, Mankurad, Joshipura Junagadh, Elite Ditla and seedling from four locations (repositories). Maximum burl size was observed in Langra cultivar. Highest burl incidence, burl size and fruit yield loss were found at Pariya location with maximum relative humidity, temperature flux and rainfall. Age of tree also showed positive relationship with burl incidence, burl size and fruit yield loss in Langra. The burl infected tree fruits had maximum content of TSS, total sugar, reducing sugar, non-reducing sugar and ascorbic acid content as compared to non-infected fruit pulp, this may be due to change in sugar metabolism.

Key words: Burl disease, Fruit yield loss, Incidence, Mango, Shelf-life

Mango (*Mangifera indica* L.) is one of the most important fruit crops of India and is known as the king of fruits (Majumdar and Sharma 1990). It has a natural distribution throughout South-East Asia and is grown in tropical and sub-tropical regions of the world (Litz *et al.* 1995). Poly-embryonic cultivars are predominately grown mainly in South-East Asia, Central America, Haiti and USA, Australia, and South Africa, whereas, mono-embryonic cultivars are grown in India, South America, Africa and Florida (USA) (Mathews and Litz 1992).

It is a national fruit of India, grown over an area of 2.22 M ha with production of 185.0 MT and in Gujarat, it is cultivated on an area of 0.14 M ha with production of 1.12 MT with productivity of 7.90 tonnes per ha (NHB 2015). Due to nutritious values, unique test, high quality fiber and delicious taste, it is popular all over the world (Singh *et al.* 2005). Fruit quality and yield are often affected by several diseases and disorders (Prakash 1998). One of the lesser studied woody disorders of mango called "burl" is observed throughout India (Saran and Kumar 2010, Saran *et al.* 2011). It is abnormal swelling or outgrowth of the trunk and lower branches, variation in color, site of burl formation, surface, side of burl formation, branching pattern, site of gummosis, appeared as warty and corky on stem and branches of mango and canopy of tree is also affected by burl. Burl disorder in three mango cultivars, viz. Langra, Chausa and Gulab Jaman was reported and highest incidence (80.3%) and largest burl size was reported in Langra cultivar under Doon Valley conditions (Saran *et al.* 2011).This disorder is observed as woody galls of various sizes and number that affect the trees of various varieties such as Langra, Pairi, Gulab Jaman, cultivars in Malda, Hessarghatta, and Uttar Pradesh (Prakash and Srivastava 1987). Mango burls have also been recorded from USA (Cook *et al.* 1971, Ploetz and Prakash 1997). Similar reports are available from Mexico (Angulo and Villapudua 1982). Trees of all ages may be affected by burl and may occurs singly or in groups (Peterson 1961, White and Millington 1954). Burl disease and galls do not kill the plants completely but negatively influence the growth and vigor of trees (Saran *et al.* 2020). Therefore, attempt was made to screen out susceptible germplasm, relationship between meteorological parameters with burl incidence, age of trees with burl incidence under different localities, yield loss and fruit quality under western parts of India.

MATERIALS AND METHODS

Field screening: The experiment was conducted during two years (2016–17 and 2017–18) at the ICAR-Directorate of Medicinal and Aromatic Plants Research

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(DMAPR), Boriavi, Anand, Gujarat, India. A survey for burl incidence was conducted at western part of country and approximately 200 germplasm were screened against burl disease. Different observations were recorded at different agro-ecological zones of western part of India, viz. Anand, Datiwada, Junagadh and Pariya. The survey was conducted in orchards of Gujarat State Agricultural Universities, other State Government Institutes and farmer's orchard. The morphological information was observed including shape, color, presence of gummosis and the surface features of the burl. Quantitative data were also recorded including burl size and first burl height from ground level. The incidence of burl in these germplasms was assessed in commercial orchards. Fruit yield was observed in burl infected plants and non-infected plants at same age as per standard methodology (Saran *et al.* 2011).

Relationship studies in Langra: Relationship between burl incidence, burl size, fruit yield, temperature, relative humidity and rainfall was observed. Burl parameters were calculated by using standard units like counting, measuring and weighing, respectively. The meteorological parameters were collected from concerned observatories of that particular location. The age of trees was measured through official records and interviewing the concern orchardists. Average five years of meteorological data were collected from different Langra growing agro-ecological zone of Gujarat for the relationship studies. The relationship between burl size, burl incidence and age of the trees was also investigated using four different age groups, viz.10-20, 21-30, 31-40 and 41-80-years-old trees of Langra cultivar from each location. The five blocks at each location as a replication and 10 plants in each block had been selected for the study. The relationship of burl incidence and fruit yield loss were observed based on age of trees affected with burl disease. Relative study of fruit yield loss with different location was also observed. Different age of Langra cultivar was screened from different mango orchard located in different regions of Gujarat. Fruit yield were observed during first week of June from five blocks at each location (replication) and 10 plants in each block as per standard methodology (Saran *et al.* 2011).

Chemical analysis of Langra fruits: The Langra cultivar collected from same age of trees of same orchard was undertaken for this present investigation. The experiment consisted of two factors (normal fruit and burl infected fruit) with 22 replicates. Fruits were harvested in first week of June at physiological maturity stage and stored at room temperature for 10 days to ripen. Pulp sample (1 g) was taken for each observation and dissolves in different solution according to chemical observations given below.

Estimation of total soluble solids: Total Soluble Solids (TSS° brix) from fruit juice was recorded by using hand refractometer. Drops of extracted mango juice were kept on the hand refractometer prism (Erma Tokyo Aº32) and reading was recorded. The readings of three different samples were taken in each treatment and their average value was calculated.

Estimation of total sugar: Total sugar was estimated by using 1 g fruit pulp dissolved in 10 ml buffer solution (80% alcohol). It was centrifuged for 10 min at 1000 RPM by using C 24 REMIA. About 50 µl supernatant was taken followed by 2.95 ml distilled water and 1.0 ml (5%) phenol was added and this was incubated for 3 min at room temperature (Nelson 1944, Somogyi 1952). After incubation 5 ml concentrated H_2SO_4 was added to make up 10 ml final volume and incubated for 10 min at room temperature followed by water bath above 90°C for 30 min, respectively. Readings were taken using UV-VIS Spectrophotometer at 490 OD. The total sugar content was calculated by using following formula.

$$\text{Total sugar (\%)} = \frac{\text{Graph factor} \times \text{reading} \times \text{total volume} \times 1}{\text{Aliquot taken for estimation} \times \text{sample weight}} \times 10^{-4}$$

Estimation of reducing sugar: Reducing sugar was also estimated (Nelson 1944, Somogyi 1952) by using 1 g of fruit pulp dissolved in 10 ml buffer solution (80% alcohol) and centrifuged for 10 min at 1000 RPM. Supernatant (0.2 ml) was taken and final 2 ml volume was made with distilled water. Then 1 ml of alkaline copper tartrate reagent was added and incubated for 10 min in water bath. Arsenomolybdate reagent was added after cooling at room temperature and final volume (10 ml) was made with distilled water. Readings were taken using UV-VIS Spectrophotometer at 620 nm OD after 10 min. The reducing sugar content was calculated by using the formula given above.

Ascorbic acid: One gram of fruit pulp was taken and dissolved in 10 ml of oxalic acid (4%) and centrifuged for 10 min at 1000 RPM. Total 2.0 ml of supernatant was taken and final 10 ml volume was made with oxalic acid. Sample titration was completed against the standardized freshly prepared dye (2, 6-dichlorophenol indophenol) and the dye factor was calculated. Titration was continued till the light pink colour persisted. The vitamin C content was calculated by using the following formula (Ranganna 1979).

$$\text{Ascorbic acid (\%)} = \frac{\text{Titrate value} \times \text{dye factor} \times \text{volume made up}}{\text{Aliquot taken for estimation} \times \text{weight of sample taken}} \times 100$$

Acidity: One gram of the fruit pulp was taken and transferred to a 100 ml volumetric flask and final 10 ml volume was made with distilled water. The solution was centrifuged and the clear supernatant aliquot was taken in a beaker and titrated against standard 0.1 N NaOH using phenolphthalein as an indicator. The titrable acidity was expressed in terms of percentage citric acid equivalent by adopting following formula (Garner *et al.* 2008).

$$\text{Acidity (\%)} = \frac{\text{mls NaOH used} \times 0.1 \text{ N NaOH} \times \text{milliequivalent factor}}{\text{Grams of sample}} \times 100$$

Statistical analysis: Each tree of different selected germplasm was observed carefully for morphological

parameters, burl incidence, burl size, fruit yield, tree age and burl height. The values of different field observations from sample trees were averaged to get the mean value. The analysis of variance was done in randomized block design for various observations using statistical software SAS 9.2. The results were presented at 5% level of significance (P=0.05). The critical difference (CD) values were calculated to compare various treatment means.

RESULTS AND DISCUSSION

Morphological characters: Morphological parameters of burl in different mango germplasms were observed for shape, colour, surface of burl, side of burl formation and presence of gummosis. The burl shape in Langra and Rajapuri was globose. Globose to semi elongated shape was observed in Mehmud Vikarabad, Elide Ditla, Joshipura Junagadh, Arka Aruna, Arka Punit, Neelphonso and Suvarna Rekha. The different variations in shape of burl were also reported in Langra cultivar (Saran *et al.* 2011). The warty trunk character in Mahmud Vikarabad was also reported (Chand and Rao 1954, Saran *et al.* 2020). The colour of burl among all germplasms was grey to light brownish at early stage of burl development but after burl maturity it became light brown to dark brown and black. Surface of

Fig 1 Morphology, relationship between age of trees (10-80 years), burl size and burl number in Langra mango.

burl was rough in Langra, Arka Aruna, Arka Punit, Joshipura Junagadh, Elite Ditla, Mankhurad and Neelphonso, while Rajapuri, Mahmud Vikarabad and Sindhu having medium rough surface (Fig 1). In early stage of burl development in Mahmud Vikarabad and Badami Modal smooth surface was observed but after burl development as tree aged it became rough. Burl formation in Rajapuri, Mahmud Vikarabad, Badami Modal, Joshipura Junagadh, Arka Aruna, Arka Punit and Mankhurad was on both sides (upper and lower), whereas in Langra, Elite Ditla and Neelphonso it was observed on lower side. In the early stage of burl development gummosis did not appear except in Langra, whereas after burl development gummosis could be seen on almost all germplasms. Similar morphological observations were also reported under different parts of the country (Saran *et al.* 2020). Sizable galls were occurring on main branches and trunks of affected trees, whereas small galls were found on the secondary branches (Prakash 1998). In various coniferous trees size differences of tumour was reported from tiny protuberances to globose masses nearly a meter in diameter (Sinclair *et al.*1993).

Screening of mango germplasm for burl incidence: Mango germplasm were screened for burl incidence per cent, burl size, and first burl formation height (Table 1). Maximum incidence percent (almost 100%) was observed in Arka Aruna, Seedling, Mehmud Vikarabad, Badami Modal, Mankurad, Joshipura Junagadh, Elite Ditla, Banganpalli × Alphonso followed by Langra (81.81%), Suvarna Rekha (80%) and Arka Puneet (77.77%) while minimum incidence percent was found in Rajapuri × Kesar (2.00%). Maximum burl size was observed in Langra (0.36 m^2), followed by Desi (0.32 m^2), whereas minimum was observed in Mankurad (0.01 m^2). Likewise, the highest incidence percent and burl size was reported in Langra (80.3%, 31.8 cm diameter), Chausa (17.5, 16.4 cm) and Gulab Jaman (7.5%, 4.0 cm) under Doon Valley regions of India (Saran *et al.* 2011). Other cultivars of mango were also found susceptible by this disorder as reported from various parts of the world (Angulo *et al.* 1982, Cook *et al.* 1971, Ploetz and Prakash 1997). Maximum height of first burl formation was found in Mahuda Golkeri (210 cm) followed by Desi (180 cm) whereas minimum in Arka Aruna (23.33 cm).

Relationship studies in Langra: Effect of different meteorological parameters (RH, temperature and rainfall) on burl incidence and burl size were examined in the four agro-ecological zones of Gujarat. The maximum incidence, burl size, yield loss, RH and rainfall were observed at Pariya (91.98%, 0.87 m^2, 24.64%, 69.91% and 153.26 mm, respectively) location, whereas the minimum incidence, burl size and RH were observed in Junagadh (55.49%, 0.04 m^2,17.88% and 60.99%, respectively) (Table 2). Highest incidence, burl size and yield loss were found in Pariya might be due to the maximum relative humidity and temperature flux which favours burl development. Abiotic factors such as soil quality, weather, humidity, and others factors affect the structure of galls and their direct or indirect effects must not be ignored. Parasitoids depend on a series of adaptations to the ecology and physiology of their hosts

Table 1 Screening of mango germplasm against burl incidence under Gujarat conditions

Germplasm	Burl size (m^2)	First burl height (cm)	Incidence (%)
Langra	0.36^{a}	31.23^{j}	81.81^{b}
Arka Aruna	0.17^{c}	23.33^{k}	100.00^{a}
Arka Punit	0.10^{cde}	78.75^{h}	77.77^{b}
Rajapuri	0.04^{e}	102.23^{f}	16.17^{fg}
Mohammad Vikarabad	0.17^{c}	88.33^{g}	100.00^{a}
Neelphonso	0.03^{f}	98.33^{f}	23.33^{ef}
Suvarna Rekha	0.04^{e}	157.00^{c}	80.00^{b}
Khodi	0.05^{de}	72.50^{h}	6.25^{gh}
Rajapuri × Kesar	0.03^{f}	38.00^{j}	2.00^{h}
Sindhu	0.02^{fg}	112.00^{e}	75.00^{b}
Desi	0.32^{ab}	180.00^{b}	6.30^{gh}
Seedling	0.26^{b}	90.00^{g}	100.00^{a}
Neelam	0.15^{c}	150.00^{cd}	28.57^{e}
Badami modal	0.03^{f}	150.33^{cd}	100.00^{a}
Mahuda golkeri	0.09^{cde}	210.00^{a}	50.00^{c}
Mankhurad	0.01^{g}	150.00^{cd}	100.00^{a}
Joshipura Junagadh	0.13^{cd}	65.00^{i}	100.00^{a}
Elite Ditla	0.09^{cde}	90.00^{g}	100.00^{a}
Banganpalli ×Alphonso	0.13^{cd}	110.00^{e}	100.00^{a}
Sardar	0.03^{f}	146.00^{d}	40.00^{d}

Means with the same letter (superscript) in the columns do not showing significantly different (P=0.05) – (Duncan Multiple Range Test).

Table 2 Relationship between burl incidence, burl size, fruit yield loss with meteorological parameters in cv. Langra under Gujarat conditions

Location	Incidence (%)	Average burl size (m^2)	Fruit yield loss (%)	Temperature (°C)		RH (%)	Rainfall (mm)
				Max.	Min.		
Dantiwada	87.34^{b}	0.05^{c}	21.03^{c}	33.39^{ab}	19.65^{bc}	65.27^{b}	100.93^{b}
Pariya	91.98^{a}	0.87^{a}	24.58^{a}	33.26^{bc}	18.89^{c}	69.91^{a}	153.26^{a}
Anand	88.36^{b}	0.29^{b}	22.74^{b}	33.19^{bc}	20.51^{a}	66.82^{b}	72.88^{d}
Junagadh	55.49^{c}	0.04^{c}	17.25^{d}	33.82^{a}	20.39^{ab}	60.99^{c}	91.5^{c}

Means with the same letter (superscript) in the columns do not showing significantly different (P=0.05) – (Duncan Multiple Range Test).

and host plants for survival and are thus likely to be highly susceptible to changes in environmental conditions (Hance *et al.* 2007, Saran *et al.* 2020).

The age of Langra mango trees had positive relationship with burl size, incidence and fruit yield loss (Fig 1). As the age of trees increased, the burl size, incidence and fruit yield loss significantly increased (Table 3). Maximum burl size (0.87 m^2), incidence (97.07%) and fruit yield loss (33.57%) were observed at age group 41–80 years, while minimum size of burl, incidence percent and fruit yield loss were observed at age group 10–20 years (0.03 m^2, 49.25% and 15.61%, respectively). The burl originates in single cell and enlarges with increasing age of tree for many years (Sinclair *et al.* 1993, Saran *et al.* 2011).

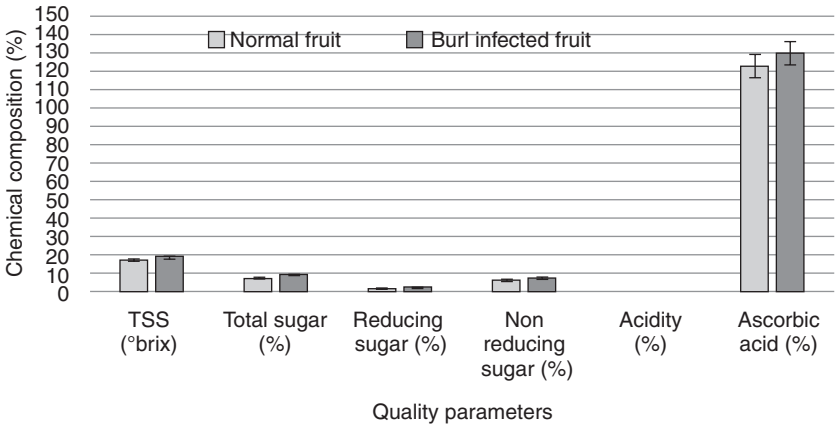

Fig 2 Quality parameters in normal and burl infected fruits of Langra mango.

Chemical composition of Langra fruit: The consumption quality of a fruit is a function of its sweetness and sourness at fruit ripening stage. Total soluble solids, sugars, acidity and ascorbic acid content in fruits play a major role in fruit quality and test (Fig 2). The burl infected tree fruits had maximum content of TSS, total sugar, reducing sugar, non-reducing sugar and ascorbic acid content (18.8 °brix, 9.59%, 2.11%, 7.49% and 129.39%, respectively). The acidity of fruit pulp was found minimum (0.15%) in burl infected samples and maximum (0.33%) in normal fruit samples. Root application of Plant Growth Promoting Rhizobacteria strains significantly increased total soluble solids, total sugar and reduced sugar, but decreased titratable acidity (Pirlak and Kose 2009). This could be due to change in sugar metabolism and hydrolytic enzymes, therefore, shelf life of burl infected fruits is reduced. The quick decline disease affects the production and distribution of sugars metabolism in leaf and bark of Langra (Shade *et al.* 2002, Saleem *et al.* 2017). The pathogens help to contribute destructive sugar metabolism in diseased mango tree and change in sugar content may be result of plant defense mechanism (Shaheen *et al.* 2015).

In conclusion, the mango germplasm, viz. Arka Aruna, Mehmud Vikarabad, Seedling, Badami Modal, Mankurad, Joshipura Junagadh, Elite Ditla, Seedling, Banganpalli × Alphonso, were most susceptible to burl disease. Highest incidence, burl size and yield loss were found in Pariya location might be due to the maximum relative humidity, temperature flux and rainfall which favours burl development. The burl size, incidence and fruit yield loss were significantly increased with advancement of the tree age under Western part of India in Langra mangoes. Therefore, only disease free varieties/germplasm must be selected for healthy mango cultivation.

Table 3 Relationship between age of tree and burl development in cv. Langra under Gujarat conditions

Age group	Burl size (m^2)	Incidence (%)	Fruit yield loss (%)
10-20	0.03^d	49.25^d	10.1^d
21-30	0.12^c	82.37^c	16.57^c
31-40	0.29^b	93.92^b	26.48^b
41-80	0.87^a	97.07^a	33.27^a

Means with the same letter (superscript) in the columns do not showing significantly different (P=0.05) – (Duncan Multiple Range Test).

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