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Horticultural characterization and *papaya ringspot virus* reaction of papaya Pune Selections

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ABSTRACT

***Papaya ringspot virus* (PRSV) is the most devastating viral disease in major papaya-growing areas of the world. To minimize the losses caused by the virus, use of a resistant/tolerant papaya variety remains the only workable solution in the present scenario, though there is no PRSV resistant/tolerant commercial papaya variety available in India. Towards that end, ICAR-Indian Agricultural Research Institute, Regional Station, Pune has developed four PRSV tolerant dioecious lines (namely, Pune Selection(PS)-1 PS-2, PS-3 and PS-5. Characterization of these lines *vis-a-vis* the popular commercial variety, Red Lady, was documented for four commercial life cycles (seasons) each one spreading over a year. On the basis of the average of all four seasons, PS-3 proved tallest (175 cm). The stem girth of all lines was lesser than that of Red Lady (39 cm). Fruiting height was the minimum in PS-5 (79 cm). The maximum length of fruiting column was observed in PS-3 (58 cm), and it was the lowest in Red Lady. All the PS lines proved superior in respect of fruit yield over Red Lady, registering the highest value in PS-2 (27 kg/plant). PRSV intensity in all Pune Selections was considerably lower than Red Lady. These lines can be used as a source of PRSV tolerance in resistant breeding programmes.**

Key words: *Carica papaya*, PRSV tolerant lines.

INTRODUCTION

Papaya (*Carica papaya* L.), one of a major tropical fruit crops, is cultivated globally in tropical and sub-tropical climate, but major share of its total production (13.05 million tonnes from 441,964 hectare) is being shared by Asia, Central America and Africa. India, Brazil, Nigeria, Indonesia and Mexico are among major papaya producing countries (FAO, 4). Commercial cultivation of papaya is unable to achieve its full potential due to widespread incidence of viral diseases. Among various viral diseases affecting papaya cultivation, *Papaya ringspot virus* (PRSV) is the most devastating worldwide (Gonsalves *et al*., 5; Tripathi *et al*., 13). The disease is so devastating that farmers have stopped growing papaya in severely affected areas. In the absence of any resistant/ tolerant commercial variety available in India, the present approaches of managing PRSV have only limited success. Therefore, developing a PRSV resistant/tolerant papaya variety remains the only stable option for sustainable papaya production. Success of such programmes depends on the identification and selection of vigorous and superior plants exhibiting PRSV resistance/tolerance (Prakash *et al*., 7). Working in that direction, Singh *et al*. (11) evaluated 21 accessions of papaya comprising Indian and exotic cultivars and promising selections to identify superior varieties having tolerance against viral diseases under north Indian climatic conditions of Lucknow. They accessed the variability with the aim of using it in future breeding programme. ICAR-Indian Agricultural Research Institute, Regional Station, Pune (IARI, Pune) has successfully developed four PRSV tolerant dioecious lines, Pune Selection-1 (PS-1), PS-2, PS-3 and PS-5. These lines were selected from a segregating population of land race of papaya, named Madhubala, in 2009. Since then, they have been developed into lines by repeated sib-mating. Two of these lines (PS-1 and PS-3) have been registered as a unique germplasm with National Germplasm Registration Committee of Indian Council of Agricultural Research, New Delhi (Datar *et al*., 2; Sharma *et al*., 10). The objective of the study was to document important horticultural characters and PRSV tolerance of these lines vis-à-vis the commercial cultivar, Red Lady.

MATERIALS AND METHODS

The experiment was conducted at Research Farm of IARI regional station, Pune (18° 31' N, 73° 51' E) during 2014-18. Fifty plants, each of the test lines (PS-1, PS-2, PS-3 and PS-5) and Red Lady (a popular commercial variety as a check), were planted during spring season of each year at a spacing of 1.8 m (plant to plant) × 2.4 m (row to row). It may be noted that under the climatic conditions of Pune, papaya is commercially cultivated as an annual crop. Data of four crop cycles each spreading over

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a year was recorded on productive plants on growth, fruiting characters, fruit yield and intensity of PRSV infection. Plant height was measured from the ground level to the growing tip of the plant, stem girth was measured at the height of 15 cm from the ground. Growth data was recorded at fruit maturity stage. Fruiting height was measured from the ground to the stalk of the first fruit. Fruit yield was measured following the procedure standardized by Sharma and Chandrashekar (9) and verified by recording actual yield. PRSV intensity was measured by modified method used by Datar *et al*. (3) at fruit setting stage**.** In the modified score card, each plant was given a score based on the symptoms appeared on leaf, petiole, stem and fruit at fruit setting stage (Table 1). Since it was not a replicated trial, population data was subjected to the calculation of range and Standard Deviation.

RESULTS AND DISCUSSION

Based on the average of four crop cycles (2014 to 2018), maximum plant height was observed in PS-3 (175 cm) and minimum in PS-5 (146 cm), while that of Red Lady was 158 cm (Table 2). Spreading over four cropping cycles, maximum plant height was observed in PS-3 (193 cm) in 2016-17 and it was minimum in PS-5 (128 cm) in 2014-15. Variability in plant height in Red Lady ranged from 137 cm (2014-15) to 185 cm (2015-16).Whereas it varied in Pune Selections from 157 cm (2017-18) to 191 cm (2015-16) in PS-1; from 148 cm (2014-15) to 186 cm (2015-16) in PS-2; from 146 cm (2014-15) to 193 cm (2016-17) in PS-3; and from 128 cm (2014-15) to 173 cm (2015-16) in PS-5 (Table 2). The stem girth in PS-2 (39 cm) was maximum, whereas it was found minimum in PS-5 (32 cm). When we compared the entire data of four crop cycles, maximum stem girth was in PS-3 and Red Lady (46 cm) in 2017-18 and minimum stem girth was observed in PS-5 (28 cm) in 2014-15. Overall the stem girth of PS lines was lower than Red Lady, except for PS-2 in 2014-15 and 2016-17. Stem girth variations in Red Lady ranged from 34 cm (2014-15) to 46 cm (2017-18). Whereas in Pune Selections, it ranged from 31 cm (2016-17) to 37 cm (2017-18) in PS-1; from 36 cm (2014-15) to 45 cm (2017-18) in PS-2; from 33 cm (2014-15, 2015-16 and 2016-17) to 46 cm (2017-18) in PS-3; and from 28 cm (2014-15) to 35 cm (2017-18) in PS-5 (Table 2).

Overall average data on fruiting height from 2014 to 2018 showed 92 cm (maximum) for PS-2 and 79 cm (minimum) for PS-5 while that of Red Lady was 89 cm. When further compared all crop cycles data, maximum fruiting height was observed in PS-2 (107 cm) in 2016-17 and minimum was observed in PS-5 (70 cm) in 2017-18 (Table 3). Fruiting height of Pune Selections was less than Red Lady except for the year 2016-17. The fruiting height was variable in different seasons in Red Lady which was ranged from 85 cm (2014-15) to 100 cm (2015-16). These variations in Pune Selections were 75 cm (2017-18) to 97 cm (2016-17) in PS-1; 82 cm (2017-18) to 107 cm (2016-17) in PS-2; 80 cm (2014-15) to 102 cm (2016-17) in PS-3; and 70 cm (2017-18) to 91 cm (2016-17) in PS-5 (Table 3). PS-3 showed maximum length of fruiting column 58 cm whereas the minimum fruiting column of 46 cm was recorded in PS-2. The lowest fruiting column was noted in Red Lady (Table 3). Individual year comparative data indicate the maximum fruiting column in PS-1 (70 cm) in 2015-16 and minimum in PS-2 (27 cm) in 2016-17. In general the length of fruiting column was more in

Table 1. PRSV score-card (Modified from Datar *et al.*, 3).

Disease score	Symptoms
00	No symptom
03	Appearance of one or two of the following symptoms: Mild mosaic / oily spot on petiole or stem / ringspot on fruits
05	Either all symptoms mentioned in score 03 or Appearance of one of the following symptoms: Blisters on leaf (A) / mild leaf reduction (B) / mild fruit deformation (C)
07	All symptoms in score 03 + A or B or C or Leaf distortion or Leaf margin burning or Shoestring formation in less than 10% foliage
09	All symptoms mentioned in score 03 + Shoestring formation in more than 10% foliage, or Stunted growth or defoliation, or A + B + C + Shoestring formation, or A + B + C + Severe fruit deformation

PRSV-P intensity was calculated by using the formula:
Disease severity = [Total Score / (Total number of plants × Maximum Score)] × 100

Table 2. Population plant growth (cm) [Average Value (Range) ± Standard Deviation].

Line/ Variety	2014-15		2015-16		2016-17		2017-18		*Average	
	Plant Height	Stem Girth	Plant Height	Stem Girth	Plant Height	Stem Girth	Plant Height	Stem Girth	Plant Height	Stem Girth
PS-1	164(115-190)±18	33(24-39)±4	191(165-210)±15	32(30-35)±2	166(145-190)±11	31(26-36)±3	157(125-195)±18	37(29-48)±4	166(115-210) ±19	34(24-48) ±4
PS-2	148(110-200)±23	36(28-44)±5	186(160-225)±20	37(36-40)±1	167(150-180)±8	37(33-42)±2	174(145-195)±11	45(36-51)±4	168(110-225) ±20	39(28-51) ±5
PS-3	146(95-175)±18	33(20-40)±4	184(160-235)±18	33(30-38)±2	193(165-235)±19	33(29-42)±3	169(120-210)±24	46(32-57)±6	175(95-235) ±27	36(20-57) ±7
PS-5	128(105-145)±10	28(24-36)±3	173(155-195)±11	32(27-36)±2	154(125-175)±13	30(22-36)±4	139(110-170)±17	35(28-42)±3	146(105-195) ±21	32(22-42) ±4
Red Lady	137(100-165)±15	34(26-41)±3	185(145-225)±18	43(37-52)±4	148(110-170)±16	35(28-43)±3	175(150-210)±14	46(40-57)±3	158(100-225)±24	39(26-57) ±6

*Based on pooled data of four seasons

Table 3. Fruiting characters of the population (cm) [Average Value (Range) ± Standard Deviation].

Line/ Variety	2014-15		2015-16		2016-17		2017-18		**Average	
	Fruiting Height	*Column Length	Fruiting Height	*Column Length	Fruiting Height	*Column Length	Fruiting Height	*Column Length	Fruiting Height	*Column Length
PS-1	80(60-120)±12	63(35-80)±14	90(70-110)±12	70(55-85)±11	97(80-120)±10	41(25-65)±9	75(55-90) ±8	54(64-66)±15	84(55-120) ±14	55(20-90)±16
PS-2	83(60-150)±12	46(20-60)±10	94(75-125)±16	49(20-70)±15	107(90-130)±9	27(15-45)±9	82(70-90)±6	64(25-80)±11	92(60-130)±15	46(15-80)±18
PS-3	80(60-110)±15	54(30-70)±12	89(70-110)±10	61(25-85)±14	102(80-155)±17	54(20-75)±16	82(65-105)±9	66(45-75)±9	89(60-155)±17	58(20-85)±14
PS-5	73(60-85)±6	47(35-60)±8	88(70-125)±13	59(45-75)±9	91(75-105)±7	35(20-55)±9	70(65-80)±5	59(35-75)±19	79(60-125)±12	50(20-75)±14
Red Lady	85(65-115)±12	36(20-55)±9	100(90-115)±9	49(30-65)±9	86(70-115)±12	31(15-55)±10	90(65-125)±10	54(25-80)±13	89(65-125)±12	43(15-80)±14

*Length of fruiting zone; **Based on pooled data of four seasons

PS lines as compared to Red Lady except for PS-2 in 2016-17. Length of fruiting column in Red Lady ranged from 31 cm (2016-17) to 54 cm (2017-18). Whereas it varied in Pune Selections from 41 cm (2016-17) to 70 cm (2015-16) in PS-1; from 27 cm (2016-17) to 64 cm (2017-18) in PS-2; from 54 cm (2014-15 and 2016-17) to 66 cm (2017-18) in PS-3; and from 35 cm (2016-17) to 59 cm (2015-16 and 2017-18) in PS-5 (Table 3). The comparative average fruit yield was estimated from 2014 to 2018 which revealed the maximum yield (27 kg/plant) in PS-2 while minimum yield (21 kg/plant) was observed in PS-1 among PS lines. In the same observation, papaya cv Red Lady yielded 18 kg/plant. Further analyses of four cropping cycles showed maximum fruit yield in PS-3 (44 kg/plant) in 2017-18 and minimum in PS-5 (12 kg/plant) in 2014-15. Fruit yield of Pune Selections was more than Red Lady except for PS-1 in 2016-17 and PS-2 in 2015-16. Fruit yield ranged from 9.46 kg/plant (2014-15) to 19.13 kg/plant (2017-18) in case of Red Lady. Whereas, yield variation in Pune Selections were recorded 15 kg/plant (2016-17) to 24 kg/plant (2015-16) in PS-1; 14 kg/plant (2014-15) to 36 kg/plant (2017-18) in PS-2; 18 kg/plant (2015-16) to 44 kg/plant (2017-18) in PS-3; and 12 kg/plant (2014-15) to 30 kg/plant (2017-18) in PS-5 (Table 4). Saran *et al*. (8) also obtained maximum fruit yield in Pune Selection-3 (62 kg/plant) among 14 papaya germplasm lines at Pusa Bihar. Singh *et al*. (12) in a study on genetic variability and correlation for vegetative, reproductive and yield attributing traits in papaya, found maximum fruiting zone in PS-3 (129.8 cm) followed by a hybrid of PS-3 (128 cm). Represented images of Pune Selections and Red Lady displaying horticultural traits (plant growth, fruiting, and fruits) are depicted in Fig. 1.

Table 4. Fruit yield (kg/plant) of the plant population [Average value (range) Standard Deviation].

Line/ Variety	2014-15	2015-16	2016-17	2017-18	*Average
PS-1	18.14(8.00-29.65)±6.37	23.76(15.40-39.60)±6.90	14.53(10.65-18.00)±2.34	23.27(8.90-50.00)±9.14	21.08(8.00-50.00)±7.90
PS-2	14.12(6.10-20.95)±5.20	14.94(9.45-20.68)±4.33	19.00(15.00-23.00)±6.25	36.44(20.90-56.20)±9.55	26.52(6.10-56.20)±13.30
PS-3	18.68(8.20-29.90)±6.04	18.44(9.07-28.37)±4.43	19.74(7.80-30.85)±4.96	44.28(23.25-70.90)±13.09	24.90(7.80-70.90)±13.25
PS-5	12.34(5.70-17.85)±3.62	21.39(9.33-30.01)±5.15	15.73(12.20-17.45)±2.50	30.01(9.10-52.00)±11.76	21.92(5.70-52.00)±10.84
Red Lady	9.46(5.40-14.40)±3.86	18.08(6.25-43.35)±7.48	15.47(12.00-19.45)±3.48	19.13(5.49-37.32)±8.34	17.79(5.40-43.35)±7.86

*Based on pooled data of four seasons

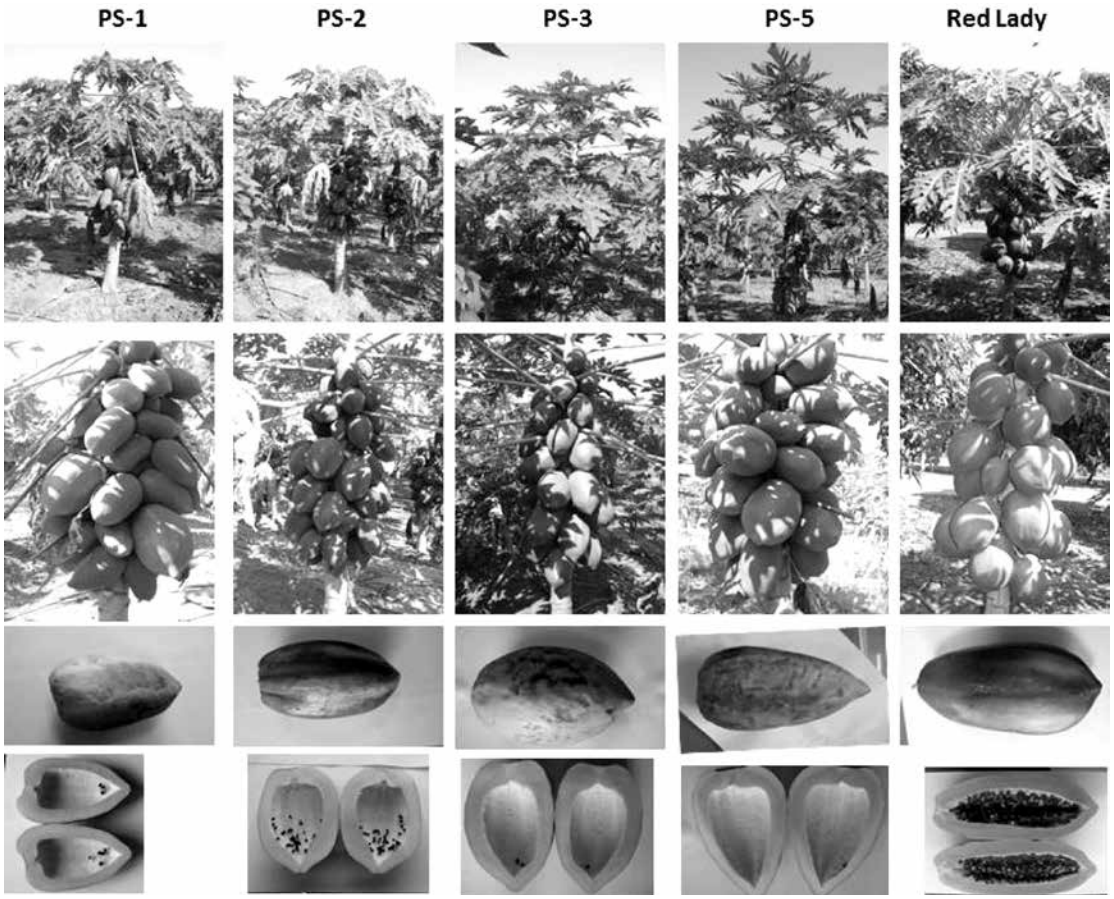

Fig. 1. Horticultural characters of Pune Selections vis-a-vis Red Lady.

The Standard deviation ranges of Pune Selections for studied horticultural characters such as plant height (8-24), stem girth (1-6), fruiting height (5-17), length of fruiting column (8-19 and fruit yield (2-13) were acceptable as these were closer to the standard deviation ranges in Red Lady (F1 hybrid) for their respective horticultural traits (Table 2, 3 and 4).

The PRSV-disease intensity (overall mean of four years) was recorded maximum (41%) in PS-2 and minimum (26%) in PS-5 among PS lines, whereas the highest PRSV intensity of 53% was recorded in commercial papaya cv Red Lady. Year wise data indicated the maximum PRSV intensity in PS-2 (79%) in 2014-15 and minimum in PS-2 and PS-5 (0%) in

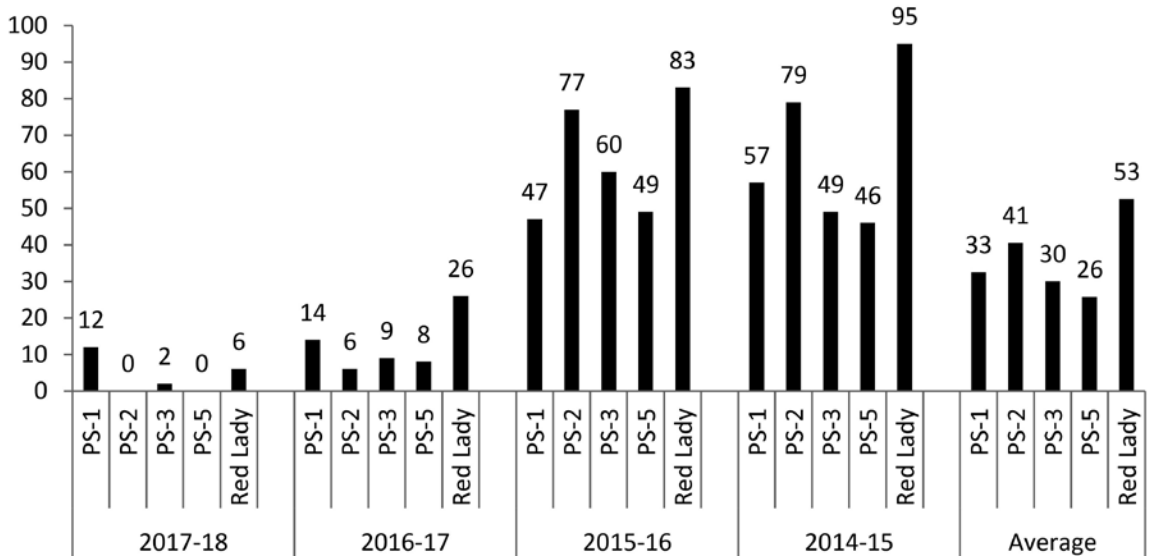

Fig. 2. Performance of PS lines vis-à-vis Red Lady against PRSV infection during experimental period of four cropping cycles (2014 to 2018).

2017-18. Overall comparative data on PRSV intensity from 2014 to 2018 showed that the PRSV intensity in all PS lines was less than Red Lady except for PS-1 in 2017-18. PRSV-disease intensity in Red Lady ranged from 6% (2017-18) to 95% (2014-15). Whereas, it ranged from 12% (2017-18) to 57% (2014-15) in PS-1; 0% (2017-18) to 79% (2014-15) in PS-2; 2% (2017-18) to 60% (2015-16) in PS-3; and 0% (2017-18) to 49% (2015-16) in PS-5. Overall PRSV-disease pressure was lower in 2017-18 and 2016-17 as compared to 2014-15 and 2015-16 (Fig. 2). The results are in conformity with Chavan, *et al*. (1) who screened eight commercial papaya cultivars under Pune climate. They observed the lowest PRSV incidence (13.2%) at full flowering stage in 'Madhubala' (parent material of Pune Selections) when compared with CO-2 (39.8%), Pusa Nanha (44.8%) and Red Lady (86.0%). Prakash and Singh (6) screened 16 papaya genotypes against the viral diseases under climatic conditions of north India (New Delhi) and concluded that PS-3 could be incorporated in the future breeding programme to develop PRSV tolerant genotypes.

On the basis of average of all four seasons, most Pune selections lines showed better plant height than Red Lady. Fruiting height was either less than or similar to the Red Lady. Length of the fruiting column in all Pune lines was more than Red Lady. Per plant fruit yield was more than Red Lady, and PRSV intensity was considerably lower than Red Lady in all the lines. Therefore, these lines can be used as a source of PRSV tolerance in future breeding programme.

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