For amendment /correction see below

dentification of purple blotch and thrips resistant lines of onion (*Allium cepa* L.)

ABSTRACT

An experiment was conducted for Identification of purple blotch and thrips resistant lines of onion (*Allium cepa* L.) . 36 elite genotypes were evaluated during winter season (*rabi*) 2022-23 at three different environments in 3 replications. RO-1, RO-59, RO-1 × RO-59, RO-1 × Pusa Madhavi, RO-59 × Pusa Madhavi, RO-59 × Kashi No. 1 genotypes had showed thrips population less than 22.90 and highly resistant to thrips infestation. Purple blotch disease, caused by *Alternaria porri*is the most common devastating disease of onion under field conditions throughout the globe. RO-1, Pusa Shobha, RO-1 × RO-59 and Bhima Kiran × Bhima Shakti were found resistant with grade scale of 1. The per cent leaf area infection ranged from 1-10 per cent. The identified resistant genotypes can further be used for commercial cultivation or may be used as parents in future onion improvement programmes.

Keywords: Onion, *Allium cepa* L., germplasm, purple blotch disease, thrips

INTRODUCTION

Onion (*Allium cepa* L.) is a prime vegetable crop of the genus *Allium* belongs to the family alliaceae with chromosome number 2n (2x) =16 and it is confounded to be originated from Central Asia centre of origin and near East and Mediterranean regions are considered as secondary centers of origin (Vavilov, 1926 and Mccollum, 1976). Onions are used as raw as salad, vegetable and spice all over the world (Katyal, 1985). The bulb and greens are rich in vitamin C, dietary fiber, mineral potassium, folic acid and it is richest source of mineral vanadium. It is also contains calcium, iron and high quality protein with low sodium without fat (Roshania and Agrawal, 1981). Onion bulb contains 86.8 per cent of moisture, 11 g of carbohydrates, 1.2 g of protein, 0.6 g of fiber, 0.08 mg of thiamine, 11 mg of vitamin- C, 180 mg of calcium, 50 mg of phosphorus, 0.7 mg of iron, 0.4 mg of nicotinic acid and 0.01 mg of riboflavin per 100 g of edible portion (Nadkarni, 1993).

Onion is susceptible to foliar diseases that reduce bulb yield and quality (Cramer 2000), among foliar diseases purple blotch disease caused by *Alternaria porri*(Ellis). Cif. major threat for onion production, purple blotch infected leaves are reddish brown septate non-sporulatingmycelium (Datar 1994), air borne spores of *A. porri*were responsible for increased disease incidence of onioncultivar Creamish-golden coloured leaves with requiredleaf wetness duration at 5 °C for 16 h and 8 h at 10-25°C. The numbers of lesions are increased with increaseof leaf wetness duration and temperature reported bySuheri and Price (2001). It was first reported by Ajrekar(1921) from Bombay state of India, and it is a majoronion disease across the world (Cramer2000) prevalent in warm humidclimate (Suheri and Price 2001). The infestation causeson leaves and flower stalks, reduces oniontops yield by 62–92 % (Suheri and Price 2001), loss ofbulb yield by 30 % and seedyield by 10 % under congenial environmental

conditions(Schwartz 2004), causing heavy yieldloss ranging from 2.5 to 87.8 % during *kharif* season(Srivastava et al. 1994).

Among several insect pest onion thrips (*Thrips tabaci*Lindeman, Thysanoptera: Thripidae) pose severe problem(Gupta et al. 1994) and major limiting factor affectingyield, larvae and adults were rasping of leaves andsucking of sap from plant parts could lead to thechlorotic spot of leaves, deformities of foliage and finally it led to reduced size and yield of bulb (Salas 1994). The highest infestation recorded from 35 to 100% thrips incidence and 3.5-30.3 nymphs per plant, both nymphs and adults of thrips by rasping of leaves, suck the exuding sap. *T. tabaci*Lindeman densities increased matured plant and low on young plants on which higher numbers of larvae gathered than adults at the base of plants as hiding place (Mo et al. 2008), as cryptic life style stay under the leaf surface and places far from reach control problematic, and consequently difficult to control by means of cultural and chemicals and cause yield losses estimated due to the incidence of thrips in onion has to the tune of 40 to50% (Gupta et al. 1994).

MATERIALS AND METHODS

The experiment was conducted at Horticulture farm, SKN College of Agriculture, Jobner (Jaipur) (Rajasthan), during rabi season of 2022-23. Eight genetically diverse parents namely, RO-1, RO-59, Bhima Kiran, Bhima Shakti, Pusa Shobha, Pusa Madhavi, Kashi No. 1 and Pusa Red were crossed in diallel fashion excluding reciprocals. All the 28 F_1s were evaluated in a randomized block design with three replications under 3 different date of sowing. The seedlings were planted in row 15 cm apart by hand dibbling method with a row to rowspacing of 10 cm. The standard cultural practices were followed to raise the crop. Number of thrips (both nymphs and adults) was recorded from 5 randomly selected plants in each plot by keeping a white paper below the plant and then shaking the plants with finger. The tested genotypes were also grouped into four categories of resistance viz., highly resistant, resistant, susceptible and highly susceptible based on number of thrips per plant. For purple blotch disease incidencewas recorded by using the disease scale given by Bhangale and Joi (1985). Disease incidence data was recorded after 75 days of transplanting on each cultivar by using following formula.

$$\text{Disease incidence \%} = \frac{\text{Total infected plants observed}}{\text{Total plants observed}} \times 100$$

The genotypes were placed in different categories of resistance and susceptibility as follows on the basis of score method.

Scale: 0 = (I) Immune
1 = (R) Resistant (1- 10%)
2 = (MR) moderately resistant (11- 20%)
3 = (MS) moderately susceptible (21- 40%)
4 = (S) Susceptible (41- 60%)
5 = (HS) highly susceptible (61% and above)

Results and Discussion

Screening of different genotypes of onion against purple blotch disease (*Alternaria porri*)

A total of 36 onion genotypes were screened in field under natural condition. The genotypes were grouped as per the scale of Bhangale and Joi (1985) and data is presented in Table 2.

The results revealed that at 75 DAP in E_1, among the genotypes none of them were found immune, while four genotypes *viz.*, RO-1, Pusa Shobha, RO-1 × RO-59 and Bhima Kiran × Bhima Shakti were found resistant with grade scale of 1. The per cent leaf area infection ranged from 1-10 per cent. Thirteen genotypes RO-59, Pusa Madhavi, RO-1 × Bhima Shakti, RO-59 × Bhima Shakti, RO-59 × Pusa Shobha, Bhima Kiran × Pusa Shobha, Bhima Shakti × Pusa Shobha, Bhima Shakti × Pusa Madhavi, Pusa Shobha × Pusa Madhavi, Pusa Shobha × Kashi No. 1, Pusa Shobha × Pusa Red, Pusa Madhavi × Pusa Red and Kashi No. 1 × Pusa Red were grouped under in moderately resistant group and the grade scale was 2 with 11-20 per cent leaf area infection. Fifteen genotypes Bhima Kiran, Bhima Shakti, Pusa Red, RO-1 × Bhima Kiran, RO-1 × Pusa Shobha, RO-1 × Pusa Madhavi, RO-1 × Pusa Red, RO-59 × Bhima Kiran, RO-59 × Pusa Madhavi, RO-59 × Pusa Red, Bhima Kiran × Pusa Madhavi, Bhima Kiran × Kashi No. 1, Bhima Shakti × Kashi No. 1, Bhima Shakti × Pusa Red and Pusa Madhavi × Kashi No. 1 were grouped under in moderately susceptible group and the grade scale was 3 with 21-40 per cent leaf area infection and three genotypes Kashi No. 1, RO-1 × Kashi No. 1 and Bhima Kiran × Pusa Red were susceptible with grade scale of 4. The per cent leaf area infection ranged from 41-60 per cent and among the genotypes none of them were found highly susceptible group. In E_2, among the genotypes none of them were found immune, while one genotype *viz.*, RO-59 were found resistant with grade scale of 1. The per cent leaf area infection ranged from 1-10 per cent. Twelve genotypes RO-1, Pusa Shobha, RO-1 × RO-59, RO-1 × Bhima Shakti, RO-59 × Bhima Shakti, RO-59 × Pusa Madhavi, RO-59 × Pusa Red, Bhima Shakti × Pusa Madhavi, Pusa Shobha × Pusa Madhavi, Pusa Shobha × Kashi No. 1, Pusa Madhavi × Pusa Red and Kashi No. 1 × Pusa Red were grouped under in moderately resistant group and the grade scale was 2 with 11-20 per

cent leaf area infection. Fifteen genotypes Bhima Shakti, Pusa Red, RO-1 × Bhima Kiran, RO-1 × Pusa Shobha, RO-1 × Pusa Madhavi, RO-59 × Bhima Kiran, RO-59 × Pusa Shobha, RO-59 × Kashi No. 1, Bhima Kiran × Bhima Shakti, Bhima Kiran × Pusa Shobha, Bhima Kiran × Pusa Madhavi, Bhima Shakti × Pusa Shobha, Bhima Shakti × Kashi No. 1, Pusa Shobha × Pusa Red and Pusa Madhavi × Kashi No. 1 were grouped under in moderately susceptible group and the grade scale was 3 with 21-40 per cent leaf area infection and six genotypes Bhima Kiran, Pusa Madhavi, Kashi No. 1, RO-1 × Kashi No. 1, RO-1 × Pusa Red, Bhima Kiran × Kashi No. 1 and Bhima Shakti × Pusa Red were susceptible with grade scale of 4. The per cent leaf area infection ranged from 41-60 per cent and among the genotypes none of them were found highly susceptible group. In E_3, among the genotypes none of them were found immune and resistant, while five genotypes RO-59, RO-1 × RO-59, Bhima Kiran × Pusa Shobha, Bhima Kiran × Pusa Madhavi, and Bhima Shakti × Pusa Shobha were grouped under in moderately resistant group and the grade scale was 2 with 11-20 per cent leaf area infection. Twenty four genotypes RO-1, Bhima Shakti, Pusa Shobha, Pusa Madhavi, Pusa Red, RO-1 × Bhima Shakti, RO-1 × Pusa Shobha, RO-59 × Bhima Kiran, RO-59 × Pusa Madhavi, RO-59 × Bhima Shakti, RO-59 × Pusa Shobha, RO-59 × Pusa Red, Bhima Kiran × Bhima Shakti, Bhima Kiran × Kashi No. 1, Bhima Kiran × Pusa Red, Bhima Shakti × Pusa Madhavi, Bhima Shakti × Kashi No. 1, Bhima Shakti × Pusa Red, Pusa Shobha × Pusa Madhavi, Pusa Shobha × Kashi No. 1, Pusa Shobha × Pusa Red, Pusa Madhavi × Kashi No. 1, Pusa Madhavi × Pusa Red and Kashi No. 1 × Pusa Red were grouped under in moderately susceptible group and the grade scale was 3 with 21-40 per cent leaf area infection and four genotypes RO-1 × Bhima Kiran, RO-1 × Pusa Madhavi, RO-1 × Pusa Red and RO-59 × Kashi No. 1 were susceptible with grade scale of 4. The per cent leaf area infection ranged from 41-60 per cent and three genotypes Bhima Kiran, Kashi No. 1 and RO-1 × Kashi No. 1 were found highly susceptible group and the grade scale was 4 with 61 per cent and more leaf area infection.Similar result were reported byAlimousavi et al. (2007), Kumari et al. (2011),Tripathy et al. (2013), Suhas et al. (2016) andLakshmipathi (2016).

Screening of different genotypes of onion against thrips (*Thrips tabaci*)

The different genotypes of onion were also grouped into four different categories of resistance viz., highly resistant, resistant, moderately resistant and susceptible are presented in Table 1.

At 75 DAP in E_1, RO-1, RO-59, RO-1 × RO-59, RO-1 × Pusa Madhavi, RO-59 × Pusa Madhavi, RO-59 × Kashi No. 1 genotypes had showed thrips population less than 22.90 and highly resistant to thrips infestation. However, genotypes RO-1 × Bhima Kiran, RO-59 × Pusa Red. Bhima Shakti × Kashi No. 1, Pusa Shobha × Pusa Madhavi and Pusa Madhavi × Pusa Red showed thrips population more than 22.90 but less than 23.83 per plant were grouped into resistant. While, genotypes, Bhima Kiran, Bhima Shakti, Pusa Shobha, Pusa Madhavi, Pusa Red, RO-1 × Bhima Shakti, RO-1 × Pusa Shobha, RO-1 × Kashi No. 1, RO-1 × Pusa Red, RO-59 × Bhima Kiran, RO-59 × bhima Shakti, RO-59 × Pusa Shobha, Bhima Kiran × Bhima Shakti, Bhima Kiran × Pusa Shobha, Bhima Kiran × Pusa Madhavi, Bhima Kiran × Kashi No. 1, Bhima Kiran × Pusa Red, Bhima Shakti × Pusa Shobha, Bhima Shakti × Pusa Madhavi, Bhima Shakti × Pusa Red, Pusa Shobha × Kashi No. 1, Pusa Shobha × Pusa Red, Pusa Madhavi × Kashi No. 1, Pusa Madhavi × Pusa Red, Kashi No. 1 × Pusa Red were found moderately resistant by recording thrips population more than 23.83 but less than 27.10 per plant. Whereas, none of the genotypes found susceptible by recording thrips population more than 27.10 per plants, In E_2, RO-1, RO-59, RO-1 × RO-59, RO-1 × Bhima Kiran, RO-1 × Bhima Shakti, RO-59 × bhima Shakti, RO-59 × Pusa Madhavi, RO-59 × Pusa Red, Bhima Shakti × Pusa Madhavi and Pusa Madhavi × Kashi No. 1 genotypes had showed thrips population less than 24.69 and highly resistant to thrips infestation. However, genotypes RO-59 × Bhima Kiran, RO-59 × Kashi No. 1, Bhima Shakti × Pusa Shobha, Bhima Shakti × Pusa Red and Pusa Shobha × Pusa Red showed thrips population more than 24.69 but less than 25.61 per plant were grouped into resistant. While, genotypes, Bhima Kiran, Bhima Shakti, Pusa Shobha, Pusa Madhavi, Kashi No. 1, Pusa Red, RO-1 × Pusa Madhavi, RO-1 × Kashi No. 1, RO-1 × Pusa Red, RO-59 × Pusa Shobha, Bhima Kiran × Bhima Shakti, Bhima Kiran × Pusa Shobha, Bhima Kiran × Pusa Madhavi, Bhima Kiran × Pusa Red, Pusa Shobha × Pusa Madhavi, Pusa Madhavi × Pusa Red and Kashi No. 1 × Pusa Red were found moderately resistant by recording thrips population more than 25.61 but less than 29.31 per plant. Whereas, Bhima Kiran × Kashi No. 1, Bhima Shakti × Kashi No. 1 and Pusa Shobha × Kashi No. 1 genotypes found susceptible by recording thrips population more than 29.31 per plants. In E_3, RO-1 × RO-59 genotype had showed thrips population less than 23.76 and highly resistant to thrips infestation. However, RO-1, RO-59, Bhima Kiran, Bhima Shakti, Kashi No. 1, RO-1 × RO-59, RO-1 × Bhima Kiran, RO-1 × Pusa Red, RO-59 × Bhima Kiran, RO-59 × bhima Shakti, RO-59 × Pusa Shobha, RO-59 × Pusa Madhavi, RO-59 × Kashi No. 1, RO-59 × Pusa Red, Bhima Kiran × Pusa Madhavi, Bhima Shakti × Pusa Shobha, Bhima Shakti × Pusa Madhavi, Bhima Shakti × Kashi No. 1, Pusa Shobha × Pusa Madhavi, Pusa Madhavi × Kashi No. 1, Pusa Madhavi × Pusa Red and Kashi No. 1 × Pusa Red genotypes showed thrips population more than 23.76 but less than 27.08 per plant were grouped into resistant. While, genotypes, RO-1 × Bhima Shakti, RO-1 × Kashi No. 1 and Bhima Kiran × Pusa Red were found moderately resistant by recording thrips population more than 27.08 but less than 28.24 per plant. Whereas, Pusa Shobha, Pusa Madhavi, Pusa Red, RO-1 × Pusa Shobha, RO-1 × Pusa Madhavi, Bhima Kiran × Bhima Shakti, Bhima Kiran × Pusa Shobha, Bhima Kiran × Kashi No. 1, Bhima Shakti × Pusa Red, Pusa Shobha × Kashi No. 1 andPusa

Shobha × Pusa Red genotypes found susceptible by recording thrips population more than 27.10 per plants.Similar result were reported byAlimousavi et al. (2007), Kumari et al. (2011),Tripathy et al. (2013), Suhas et al. (2016) andLakshmipathi (2016).

CONCLUSION

RO-1, RO-59, RO-1 × RO-59, RO-1 × Pusa Madhavi, RO-59 × Pusa Madhavi, RO-59 × Kashi No. 1 genotypes had showed thrips population less than 22.90 and highly resistant to thrips infestation. Purple blotch disease, caused by *Alternaria porri*is the most common devastating disease of onion under field conditions throughout the globe. RO-1, Pusa Shobha, RO-1 × RO-59 and Bhima Kiran × Bhima Shakti were found resistant with grade scale of 1. The per cent leaf area infection ranged from 1-10 per cent. The identified resistant genotypes can further be used for commercial cultivation or may be used as parents in future onion improvement programmes.

Reference

Abubakar, L. and Ado, S. G., 2010. Heterosis of purple blotch [Alternaria porri (Ellis) Cif.] resistance, yield and earliness in tropical onions (*Allium cepa* L.). *Euphytica*, 164: 63–74.

Alimousavi SA, Hassandokht MR and Moharramipour S (2007) Evaluation of Iranian onion germplasm for resistance to thrips. *Inter J Agri Bio* 9(6): 897–900.

Ambresh and Gowda, V., 2013. Studies on heterosis for purple blotch disease and bulb yield using male sterile lines in onion (*Allium cepa* L.). *Asian J. Hort*., 8(1): 68-70.

Anonymous, 2021-22. Estimate of Area and Production of Horticulture Crops. *Ministry of Agriculture*, Government of India 85, Institutional Area, Sector-18, Gurgaon, Haryana.pp.230,260

Cramer CS (2000) Breeding and genetics of fusarium basal rot resistance in onion. Euphytica 115: 159–166

Datar VV (1994) Investigation on purple blotch of onion in India. Acta Hort 358: 259–263.

Gowda, V. and Ambresh, 2014. Heterosis for yield and quality traits and resistance to purple blotch in onion. *Indian J. Hort*., **71**(4): 511-515.

Gupta RP, Srivastava KJ and Pandey UB (1994) Diseases and insect pests of onion in India. Acta Hort 358: 265–269.

Katyal, S. L., 1985, Vegetable growing in India, Oxford and IBH pub Co. New Delhi.

Kumari S.M.V., Pramodh HP, Gowda RV, Balol BG, Divya BL and Narendrappa T (2011) Evaluation of onion genotypes for disease resistance to purple blotch under field conditions. Res J Agri Sci 2(4): 88–91.

Lakshmipathi N (2016) Studies on collection and evaluation of onion landraces *(Allium cepa* .L) Dissertation: M. Sc. (Hort) Vegetable Science, UHS, Bagalkot.

Mccollum, G. D., 1976, Evaluation of crop plants, ed. N.W. Simmonds, Longman, London and New York, p. 186-190

Mo J, Munro S, Boulton A and Stevens M (2008) With in plant distribution of onion thrips (Thysanoptera: Thripidae) inonions. J Econ Entomol 101: 1331–1336.

Nadkarni, K. M., 1993, Indian Material Media. Nadkarni and Co., Bombay.

Roshania, B. D. andAgrawal, Y. K., 1981, Chemical Analysis, (Warsaw)., **26**: 191.

Salas J (1994) Biology and life habits of the onion thrips (*Thrips tabaci*Lindeman). Acta Hort 358: 383–387.

Suhas YH (2016) Studies on performance of varieties, F1 hybrids and synthetics of onion in eastern dry zone of Karnataka, Dissertation: M Sc (Hort) Vegetable Science, UHS,Bagalkot.

Suheri H and Price TV (2001) Purple leaf blotch disease of *Allium* spp. In Australia. Acta Hort 555: 171–173.

Tripathy P, Priyadarshini SK, Das BB, Sahoo and Dash DK (2013) Evaluation of onion (*Allium cepa* L.) genotypes fortolerance to thrips and purple blotch. Inter J Biores Stress Mang 4(4): 561–564.

Vavilov, N. I., 1926, Centres of the origin of cultivated plants, *Trudy Prikl. Bot. Genet.*, **1**: 20.

Genotypes	Plant Disease Index		
	E_1	E_2	E_3
RO-1 (P_1)	10	20	25
RO-59 (P_2)	15	10	20
Bhima Kiran (P_3)	35	45	65
Bhima Shakti (P_4)	30	40	40

Pusa Shobha (P_5)	10	20	25
Pusa Madhavi (P_6)	20	30	25
Kashi No. 1 (P_7)	45	55	65
Pusa Red (P_8)	30	40	35
P_1 x P_2	10	15	20
P_1 x P_3	25	35	50
P_1 x P_4	15	15	25
P_1 x P_5	30	25	35
P_1 x P_6	30	40	60
P_1 x P_7	45	55	65
P_1 x P_8	40	45	50
P_2 x P_3	25	30	35
P_2 x P_4	15	20	25
P_2 x P_5	20	25	30
P_2 x P_6	25	15	30
P_2 x P_7	45	40	50
P_2 x P_8	25	20	30
P_3 x P_4	10	25	30
P_3 x P_5	15	25	20
P_3 x P_6	30	35	20
P_3 x P_7	40	45	30
P_3 x P_8	45	50	35
P_4 x P_5	15	25	20
P_4 x P_6	20	15	25
P_4 x P_7	25	35	40
P_4 x P_8	30	45	40
P_5 x P_6	15	20	25
P_5 x P_7	20	15	25
P_5 x P_8	20	25	30
P_6 x P_7	35	40	30
P_6 x P_8	20	15	25
P_7 x P_8	10	15	20

Table 1: Screening of different genotypes of onion against Purple blotchdisease

Scale: 0 = (I) Immune
1 = (R) Resistant (1-10%)
2 = (MR) Moderately resistant (11-20%)
3 = (MS) Moderately susceptible (21-40%)
4 = (S) Susceptible (41-60%)
5 = (HS) Highly susceptible (61% and above)

Table 2: Screening of different genotypes of onion against thrips

Category of resistance	Scale (Thrips population)	Screening of different genotypes of onion against thrips
Highly resistant in E_1	< 22.90	RO-1, RO-59, RO-1 x RO-59, RO-1 x Pusa Madhavi, RO-59 x Pusa Madhavi and RO-59 x Kashi No. 1

Resistant in E_1	> 22.90 <23.83	RO-1 x Bhima Kiran, RO-59 x Pusa Red. Bhima Shakti x Kashi No. 1, Pusa Shobha x Pusa Madhavi and Pusa Madhavi x Pusa Red
Moderatey resistant in E_1	>23.83<27.10	Bhima Kiran, Bhima Shakti, Pusa Shobha, Pusa Madhavi, Pusa Red, RO-1 x Bhima Shakti, RO-1 x Pusa Shobha, RO-1 x Kashi No. 1, RO-1 x Pusa Red, RO-59 x Bhima Kiran, RO-59 x bhima Shakti, RO-59 x Pusa Shobha, Bhima Kiran x Bhima Shakti, Bhima Kiran x Pusa Shobha, Bhima Kiran x Pusa Madhavi, Bhima Kiran x Kashi No. 1, Bhima Kiran x Pusa Red, Bhima Shakti x Pusa Shobha, Bhima Shakti x Pusa Madhavi, Bhima Shakti x Pusa Red, Pusa Shobha x Kashi No. 1, Pusa Shobha x Pusa Red, Pusa Madhavi x Kashi No. 1, Pusa Madhavi x Pusa Red and Kashi No. 1 x Pusa Red
Susceptible in E_1	>27.10	-
Highly resistant in E_2	< 24.69	RO-1, RO-59, RO-1 x RO-59, RO-1 x Bhima Kiran, RO-1 x Bhima Shakti, RO-59 x bhima Shakti, RO-59 x Pusa Madhavi, RO-59 x Pusa Red, Bhima Shakti x Pusa Madhavi and Pusa Madhavi x Kashi No. 1
Resistant in E_2	> 24.69 <25.61	RO-59 x Bhima Kiran, RO-59 x Kashi No. 1, Bhima Shakti x Pusa Shobha, Bhima Shakti x Pusa Red and Pusa Shobha x Pusa Red
Moderatey resistant in E_2	>25.61 <29.31	Bhima Kiran, Bhima Shakti, Pusa Shobha, Pusa Madhavi, Kashi No. 1, Pusa Red, RO-1 x Pusa Madhavi, RO-1 x Kashi No. 1, RO-1 x Pusa Red, RO-59 x Pusa Shobha, Bhima Kiran x Bhima Shakti, Bhima Kiran x Pusa Shobha, Bhima Kiran x Pusa Madhavi, Bhima Kiran x Pusa Red, Pusa Shobha x Pusa Madhavi, Pusa Madhavi x Pusa Red and Kashi No. 1 x Pusa Red
Susceptible in E_2	>29.31	Bhima Kiran x Kashi No. 1, Bhima Shakti x Kashi No. 1 and Pusa Shobha x Kashi No. 1
Highly resistant in E_3	< 23.76	RO-1 x RO-59
Resistant in E_3	> 23.76 <27.08	RO-1, RO-59, Bhima Kiran, Bhima Shakti, Kashi No. 1, RO-1 x RO-59, RO-1 x Bhima Kiran, RO-1 x Pusa Red, RO-59 x Bhima Kiran, RO-59 x bhima Shakti, RO-59 x Pusa Shobha, RO-59 x Pusa Madhavi, RO-59 x Kashi No. 1, RO-59 x Pusa Red, Bhima Kiran x Pusa Madhavi, Bhima Shakti x Pusa Shobha, Bhima Shakti x Pusa Madhavi, Bhima Shakti x Kashi No. 1, Pusa Shobha x Pusa Madhavi, Pusa Madhavi x Kashi No. 1, Pusa Madhavi x Pusa Red and Kashi No. 1 x Pusa Red
Moderatey resistant in E_3	>27.08< 28.24	RO-1 x Bhima Shakti, RO-1 x Kashi No. 1 and Bhima Kiran x Pusa Red
Susceptible in E_3	>28.24	Pusa Shobha, Pusa Madhavi, Pusa Red, RO-1 x Pusa Shobha, RO-1 x Pusa Madhavi, Bhima Kiran x Bhima Shakti, Bhima Kiran x Pusa Shobha, Bhima Kiran x Kashi No. 1, Bhima Shakti x Pusa Red, Pusa Shobha x Kashi No. 1 andPusa Shobha x Pusa Red

This is for amendment

Identification of purple blotch and thrips resistant lines of onion (*Allium cepa* L.)

ABSTRACT

An experiment was conducted for the identification of purple blotch and thrips resistant lines of onion (*Allium cepa* L.) . Thirty six elite genotypes were evaluated during the winter season (*rabi*) 2022-23 at three different environments in 3 replications. RO-1, RO-59, RO-1 × RO-59, RO-1 × Pusa Madhavi, RO-59 × Pusa Madhavi, RO-59 × Kashi No. 1 genotypes had showed a thrips population less than 22.90 and highly resistant to thrips infestation. Purple blotch disease, caused by *Alternaria porri*is the most common devastating disease of onion under field conditions throughout the globe. RO-1, Pusa Shobha, RO-1 × RO-59 and Bhima Kiran × Bhima Shakti were found resistant with a grade scale of 1. The percent leaf area infection ranged from 1-10 per cent. (The identified resistant genotypes can further be used for commercial cultivation or may be used as parents in future onion improvement programmes.This sentence may be included in recommendation section, not here)

Keywords: Onion, *Allium cepa* L., germplasm, purple blotch disease, thrips

INTRODUCTION

Onion (*Allium cepa* L.) is a prime vegetable crop of the genus *Allium* belongs to the family alliaceae with chromosome number 2n (2x) =16 and it is confounded to be originated from Central Asia centre of origin and near East and Mediterranean regions are considered as secondary centers of origin (Vavilov, 1926 and Mccollum, 1976). Onions are used as raw as salad, vegetable and spice all over the world (Katyal, 1985). The bulb and greens are rich in vitamin C, dietary fiber, mineral potassium, folic acid and it is richest source of mineral vanadium. It is also contains calcium, iron and high quality protein with low sodium without fat (Roshania and Agrawal, 1981). Onion bulb contains 86.8 per cent of moisture, 11 g of carbohydrates, 1.2 g of protein, 0.6 g of fiber, 0.08 mg of thiamine, 11 mg of vitamin- C, 180 mg of calcium, 50 mg of phosphorus, 0.7 mg of iron, 0.4 mg of nicotinic acid and 0.01 mg of riboflavin per 100 g of edible portion (Nadkarni, 1993).

Onion is susceptible to foliar diseases that reduce bulb yield and quality (Cramer 2000), among foliar diseases purple blotch disease caused by *Alternaria porri*(Ellis). Cif. major threat for onion production, purple blotch infected leaves are reddish brown septate non-sporulatingmycelium (Datar 1994), air borne spores of *A. porri*were responsible for increased disease incidence of onioncultivar Creamish-golden coloured leaves with requiredleaf wetness duration at 5 °C for 16 h and 8 h at 10-25°C. The numbers of lesions are increased with increaseof leaf wetness duration and temperature reported bySuheri and Price (2001). It was first reported by Ajrekar(1921) from Bombay state of India, and it is a majoronion disease across the world (Cramer2000) prevalent in warm humidclimate (Suheri and Price 2001). The infestation causeson leaves and flower stalks, reduces oniontops yield by 62–92 % (Suheri and Price 2001), loss ofbulb yield by 30 % and seedyield by 10 % under congenial environmental

conditions(Schwartz 2004), causing heavy yieldloss ranging from 2.5 to 87.8 % during *kharif* season(Srivastava et al. 1994).

Among several insect pest onion thrips (*Thrips tabaci*Lindeman, Thysanoptera: Thripidae) pose severe problem(Gupta et al. 1994) and major limiting factor affectingyield, larvae and adults were rasping of leaves andsucking of sap from plant parts could lead to thechlorotic spot of leaves, deformities of foliage and finally it led to reduced size and yield of bulb (Salas 1994). The highest infestation recorded from 35 to 100% thrips incidence and 3.5-30.3 nymphs per plant, both nymphs and adults of thrips by rasping of leaves, suck the exuding sap. *T. tabaci*Lindeman densities increased matured plant and low on young plants on which higher numbers of larvae gathered than adults at the base of plants as hiding place (Mo et al. 2008), as cryptic life style stay under the leaf surface and places far from reach control problematic, and consequently difficult to control by means of cultural and chemicals and cause yield losses estimated due to the incidence of thrips in onion has to the tune of 40 to50% (Gupta et al. 1994).

*Highlighted references by red color are not found in the reference list .

MATERIALS AND METHODS

The experiment was conducted at Horticulture farm, SKN College of Agriculture, Jobner (Jaipur) (Rajasthan), during rabi season of 2022-23. Eight genetically diverse parents namely, RO-1, RO-59, Bhima Kiran, Bhima Shakti, Pusa Shobha, Pusa Madhavi, Kashi No. 1 and Pusa Red were crossed in diallel fashion excluding reciprocals. All the 28 F_1s were evaluated in a randomized block design with three replications under 3 different date of sowing. The seedlings were planted in row 15 cm apart by hand dibbling method with a row to rowspacing of 10 cm. The standard cultural practices were followed to raise the crop. Number of thrips (both nymphs and adults) was recorded from 5 randomly selected plants in each plot by keeping a white paper below the plant and then shaking the plants with finger. The tested genotypes were also grouped into four categories of resistance viz., highly resistant, resistant, susceptible and highly susceptible based on number of thrips per plant. For purple blotch disease incidencewas recorded by using the disease scale given by Bhangale and Joi (1985). Disease incidence data was recorded after 75 days of transplanting on each cultivar by using following formula.

Disease incidence % = Total infected plants observed X 100

Total plants observed

The genotypes were placed in different categories of resistance and susceptibility as follows on the basis of score method.

Scale: 0 = (I) Immune
1 = (R) Resistant (1- 10%)
2 = (MR) moderately resistant (11- 20%)
3 = (MS) moderately susceptible (21- 40%)
4 = (S) Susceptible (41- 60%)
5 = (HS) highly susceptible (61% and above)

RESULTS AND DISCUSSION

Screening of different genotypes of onion against purple blotch disease (*Alternaria porri*)

A total of 36 onion genotypes were screened in field under natural condition. The genotypes were grouped as per the scale of Bhangale and Joi (1985) and data is presented in Table 2.

The results revealed that at 75 DAP in E_1, among the genotypes none of them were found immune, while four genotypes *viz.*, RO-1, Pusa Shobha, RO-1 × RO-59 and Bhima Kiran × Bhima Shakti were found resistant with grade scale of 1. The per cent leaf area infection ranged from 1-10 per cent. Thirteen genotypes RO-59, Pusa Madhavi, RO-1 × Bhima Shakti, RO-59 × Bhima Shakti, RO-59 × Pusa Shobha, Bhima Kiran × Pusa Shobha, Bhima Shakti × Pusa Shobha, Bhima Shakti × Pusa Madhavi, Pusa Shobha × Pusa Madhavi, Pusa Shobha × Kashi No. 1, Pusa Shobha × Pusa Red, Pusa Madhavi × Pusa Red and Kashi No. 1 × Pusa Red were grouped under in moderately resistant group and the grade scale was 2 with 11-20 per cent leaf area infection. Fifteen genotypes Bhima Kiran, Bhima Shakti, Pusa Red, RO-1 × Bhima Kiran, RO-1 × Pusa Shobha, RO-1 × Pusa Madhavi, RO-1 × Pusa Red, RO-59 × Bhima Kiran, RO-59 × Pusa Madhavi, RO-59 × Pusa Red, Bhima Kiran × Pusa Madhavi, Bhima Kiran × Kashi No. 1, Bhima Shakti × Kashi No. 1, Bhima Shakti × Pusa Red and Pusa Madhavi × Kashi No. 1 were grouped under in moderately susceptible group and the grade scale was 3 with 21-40 per cent leaf area infection and three genotypes Kashi No. 1, RO-1 × Kashi No. 1 and Bhima Kiran × Pusa Red were susceptible with grade scale of 4. The per cent leaf area infection ranged from 41-60 per cent and among the genotypes none of them were found highly susceptible group. In E_2, among the genotypes none of them were found immune, while one genotype *viz.*, RO-59 were found resistant with grade scale of 1. The per cent leaf area infection ranged from 1-10 per cent. Twelve genotypes RO-1, Pusa Shobha, RO-1 × RO-59, RO-1 × Bhima Shakti, RO-59 × Bhima

Shakti, RO-59 × Pusa Madhavi, RO-59 × Pusa Red, Bhima Shakti × Pusa Madhavi, Pusa Shobha × Pusa Madhavi, Pusa Shobha × Kashi No. 1, Pusa Madhavi × Pusa Red and Kashi No. 1 × Pusa Red were grouped under in moderately resistant group and the grade scale was 2 with 11-20 per cent leaf area infection. Fifteen genotypes Bhima Shakti, Pusa Red, RO-1 × Bhima Kiran, RO-1 × Pusa Shobha, RO-1 × Pusa Madhavi, RO-59 × Bhima Kiran, RO-59 × Pusa Shobha, RO-59 × Kashi No. 1, Bhima Kiran × Bhima Shakti, Bhima Kiran × Pusa Shobha, Bhima Kiran × Pusa Madhavi, Bhima Shakti × Pusa Shobha, Bhima Shakti × Kashi No. 1, Pusa Shobha × Pusa Red and Pusa Madhavi × Kashi No. 1 were grouped under in moderately susceptible group and the grade scale was 3 with 21-40 per cent leaf area infection and six genotypes Bhima Kiran, Pusa Madhavi, Kashi No. 1, RO-1 × Kashi No. 1, RO-1 × Pusa Red, Bhima Kiran × Kashi No. 1 and Bhima Shakti × Pusa Red were susceptible with grade scale of 4. The per cent leaf area infection ranged from 41-60 per cent and among the genotypes none of them were found highly susceptible group. In E_3, among the genotypes none of them were found immune and resistant, while five genotypes RO-59, RO-1 × RO-59, Bhima Kiran × Pusa Shobha, Bhima Kiran × Pusa Madhavi, and Bhima Shakti × Pusa Shobha were grouped under in moderately resistant group and the grade scale was 2 with 11-20 per cent leaf area infection. Twenty four genotypes RO-1, Bhima Shakti, Pusa Shobha, Pusa Madhavi, Pusa Red, RO-1 × Bhima Shakti, RO-1 × Pusa Shobha, RO-59 × Bhima Kiran, RO-59 × Pusa Madhavi, RO-59 × Bhima Shakti, RO-59 × Pusa Shobha, RO-59 × Pusa Red, Bhima Kiran × Bhima Shakti, Bhima Kiran × Kashi No. 1, Bhima Kiran × Pusa Red, Bhima Shakti × Pusa Madhavi, Bhima Shakti × Kashi No. 1, Bhima Shakti × Pusa Red, Pusa Shobha × Pusa Madhavi, Pusa Shobha × Kashi No. 1, Pusa Shobha × Pusa Red, Pusa Madhavi × Kashi No. 1, Pusa Madhavi × Pusa Red and Kashi No. 1 × Pusa Red were grouped under in moderately susceptible group and the grade scale was 3 with 21-40 per cent leaf area infection and four genotypes RO-1 × Bhima Kiran, RO-1 × Pusa Madhavi, RO-1 × Pusa Red and RO-59 × Kashi No. 1 were susceptible with grade scale of 4. The per cent leaf area infection ranged from 41-60 per cent and three genotypes Bhima Kiran, Kashi No. 1 and RO-1 × Kashi No. 1 were found highly susceptible group and the grade scale was 4 with 61 per cent and more leaf area infection.Similar result were reported byAlimousavi et al. (2007), Kumari et al. (2011),Tripathy et al. (2013), Suhas et al. (2016) andLakshmipathi (2016).

Screening of different genotypes of onion against thrips (*Thrips tabaci*)

The different genotypes of onion were also grouped into four different categories of resistance viz., highly resistant, resistant, moderately resistant and susceptible are presented in Table 1.

At 75 DAP in E_1, RO-1, RO-59, RO-1 × RO-59, RO-1 × Pusa Madhavi, RO-59 × Pusa Madhavi, RO-59 × Kashi No. 1 genotypes had showed thrips population less than 22.90 and highly resistant to thrips infestation. However, genotypes RO-1 × Bhima Kiran, RO-59 × Pusa Red. Bhima Shakti × Kashi No. 1, Pusa Shobha × Pusa Madhavi and Pusa Madhavi × Pusa Red showed thrips population more than 22.90 but less than 23.83 per plant were grouped into resistant. While, genotypes, Bhima Kiran, Bhima Shakti, Pusa Shobha, Pusa Madhavi, Pusa Red, RO-1 × Bhima Shakti, RO-1 × Pusa Shobha, RO-1 × Kashi No. 1, RO-1 × Pusa Red, RO-59 × Bhima Kiran, RO-59 × bhima Shakti, RO-59 × Pusa Shobha, Bhima Kiran × Bhima Shakti, Bhima Kiran × Pusa Shobha, Bhima Kiran × Pusa Madhavi, Bhima Kiran × Kashi No. 1, Bhima Kiran × Pusa Red, Bhima Shakti × Pusa Shobha, Bhima Shakti × Pusa Madhavi, Bhima Shakti × Pusa Red, Pusa Shobha × Kashi No. 1, Pusa Shobha × Pusa Red, Pusa Madhavi × Kashi No. 1, Pusa Madhavi × Pusa Red, Kashi No. 1 × Pusa Red were found moderately resistant by recording thrips population more than 23.83 but less than 27.10 per plant. Whereas, none of the genotypes found susceptible by recording thrips population more than 27.10 per plants, In E_2, RO-1, RO-59, RO-1 × RO-59, RO-1 × Bhima Kiran, RO-1 × Bhima Shakti, RO-59 × bhima Shakti, RO-59 × Pusa Madhavi, RO-59 × Pusa Red, Bhima Shakti × Pusa Madhavi and Pusa Madhavi × Kashi No. 1 genotypes had showed thrips population less than 24.69 and highly resistant to thrips infestation. However, genotypes RO-59 × Bhima Kiran, RO-59 × Kashi No. 1, Bhima Shakti × Pusa Shobha, Bhima Shakti × Pusa Red and Pusa Shobha × Pusa Red showed thrips population more than 24.69 but less than 25.61 per plant were grouped into resistant. While, genotypes, Bhima Kiran, Bhima Shakti, Pusa Shobha, Pusa Madhavi, Kashi No. 1, Pusa Red, RO-1 × Pusa Madhavi, RO-1 × Kashi No. 1, RO-1 × Pusa Red, RO-59 × Pusa Shobha, Bhima Kiran × Bhima Shakti, Bhima Kiran × Pusa Shobha, Bhima Kiran × Pusa Madhavi, Bhima Kiran × Pusa Red, Pusa Shobha × Pusa Madhavi, Pusa Madhavi × Pusa Red and Kashi No. 1 × Pusa Red were found moderately resistant by recording thrips population more than 25.61 but less than 29.31 per plant. Whereas, Bhima Kiran × Kashi No. 1, Bhima Shakti × Kashi No. 1 and Pusa Shobha × Kashi No. 1 genotypes found susceptible by recording thrips population more than 29.31 per plants. In E_3, RO-1 × RO-59 genotype had showed thrips population less than 23.76 and highly resistant to thrips infestation. However, RO-1, RO-59, Bhima Kiran, Bhima Shakti, Kashi No. 1, RO-1 × RO-59, RO-1 × Bhima Kiran, RO-1 × Pusa Red, RO-59 × Bhima Kiran, RO-59 × bhima Shakti, RO-59 × Pusa Shobha, RO-59 × Pusa Madhavi, RO-59 × Kashi No. 1, RO-59 × Pusa Red, Bhima Kiran × Pusa Madhavi, Bhima Shakti × Pusa Shobha, Bhima Shakti × Pusa Madhavi, Bhima Shakti × Kashi No. 1, Pusa Shobha × Pusa Madhavi, Pusa Madhavi × Kashi No. 1, Pusa Madhavi × Pusa Red and Kashi No. 1 × Pusa Red genotypes showed thrips population more than 23.76 but less than 27.08 per plant were grouped into resistant. While, genotypes, RO-1 × Bhima Shakti, RO-1 × Kashi No. 1 and Bhima

Kiran × Pusa Red were found moderately resistant by recording thrips population more than 27.08 but less than 28.24 per plant. Whereas, Pusa Shobha, Pusa Madhavi, Pusa Red, RO-1 × Pusa Shobha, RO-1 × Pusa Madhavi, Bhima Kiran × Bhima Shakti, Bhima Kiran × Pusa Shobha, Bhima Kiran × Kashi No. 1, Bhima Shakti × Pusa Red, Pusa Shobha × Kashi No. 1 andPusa Shobha × Pusa Red genotypes found susceptible by recording thrips population more than 27.10 per plants.Similar result were reported byAlimousavi et al. (2007), Kumari et al. (2011),Tripathy et al. (2013), Suhas et al. (2016) andLakshmipathi (2016).

CONCLUSION

RO-1, RO-59, RO-1 × RO-59, RO-1 × Pusa Madhavi, RO-59 × Pusa Madhavi, RO-59 × Kashi No. 1 genotypes had showed thrips population less than 22.90 and highly resistant to thrips infestation. Purple blotch disease, caused by *Alternaria porri*is the most common devastating disease of onion under field conditions throughout the globe. RO-1, Pusa Shobha, RO-1 × RO-59 and Bhima Kiran × Bhima Shakti were found resistant with grade scale of 1. The per cent leaf area infection ranged from 1-10 per cent. The identified resistant genotypes can further be used for commercial cultivation or may be used as parents in future onion improvement programmes.

(The sentences of this concluding section are very much similar with the sentences of abstract. So it should be omitted. A recommendation may be written instead of conclusion).

REFERENCES

Abubakar, L. and Ado, S. G., 2010. Heterosis of purple blotch [Alternaria porri (Ellis) Cif.] resistance, yield and earliness in tropical onions (*Allium cepa* L.). *Euphytica*, 164: 63–74.

Alimousavi SA, Hassandokht MR and Moharramipour S (2007) Evaluation of Iranian onion germplasm for resistance to thrips. *Inter J Agri Bio* 9(6): 897–900.

Ambresh and Gowda, V., 2013. Studies on heterosis for purple blotch disease and bulb yield using male sterile lines in onion (*Allium cepa* L.). *Asian J. Hort*., 8(1): 68-70.

Anonymous, 2021-22. Estimate of Area and Production of Horticulture Crops. *Ministry of Agriculture*, Government of India 85, Institutional Area, Sector-18, Gurgaon, Haryana.pp.230,260

Cramer CS (2000) Breeding and genetics of fusarium basal rot resistance in onion. Euphytica 115: 159–166

Datar VV (1994) Investigation on purple blotch of onion in India. Acta Hort 358: 259–263.

Gowda, V. and Ambresh, 2014. Heterosis for yield and quality traits and resistance to purple blotch in onion. *Indian J. Hort*., **71**(4): 511-515.

Gupta RP, Srivastava KJ and Pandey UB (1994) Diseases and insect pests of onion in India. Acta Hort 358: 265–269.

Katyal, S. L., 1985, Vegetable growing in India, Oxford and IBH pub Co. New Delhi.

Kumari S.M.V., Pramodh HP, Gowda RV, Balol BG, Divya BL and Narendrappa T (2011) Evaluation of onion genotypes for disease resistance to purple blotch under field conditions. Res J Agri Sci 2(4): 88–91.

Lakshmipathi N (2016) Studies on collection and evaluation of onion landraces *(Allium cepa* .L) Dissertation: M. Sc. (Hort) Vegetable Science, UHS, Bagalkot.

Mccollum, G. D., 1976, Evaluation of crop plants, ed. N.W. Simmonds, Longman, London and New York, p. 186-190

Mo J, Munro S, Boulton A and Stevens M (2008) With in plant distribution of onion thrips (Thysanoptera: Thripidae) inonions. J Econ Entomol 101: 1331–1336.

Nadkarni, K. M., 1993, Indian Material Media. Nadkarni and Co., Bombay.

Roshania, B. D. andAgrawal, Y. K., 1981, Chemical Analysis, (Warsaw)., **26**: 191.

Salas J (1994) Biology and life habits of the onion thrips (*Thrips tabaci*Lindeman). Acta Hort 358: 383–387.

Suhas YH (2016) Studies on performance of varieties, F1 hybrids and synthetics of onion in eastern dry zone of Karnataka, Dissertation: M Sc (Hort) Vegetable Science, UHS,Bagalkot.

Suheri H and Price TV (2001) Purple leaf blotch disease of *Allium* spp. In Australia. Acta Hort 555: 171–173.

Tripathy P, Priyadarshini SK, Das BB, Sahoo and Dash DK (2013) Evaluation of onion (*Allium cepa* L.) genotypes fortolerance to thrips and purple blotch. Inter J Biores Stress Mang 4(4): 561–564.

Vavilov, N. I., 1926, Centres of the origin of cultivated plants, *Trudy Prikl. Bot. Genet*., **1**: 20.

*Highlighted references by red color are not found in the text .

Genotypes	Plant Disease Index		
	E_1	E_2	E_3
RO-1 (P_1)	10	20	25
RO-59 (P_2)	15	10	20
Bhima Kiran (P_3)	35	45	65
Bhima Shakti (P_4)	30	40	40
Pusa Shobha (P_5)	10	20	25
Pusa Madhavi (P_6)	20	30	25
Kashi No. 1 (P_7)	45	55	65
Pusa Red (P_8)	30	40	35
P_1 x P_2	10	15	20
P_1 x P_3	25	35	50
P_1 x P_4	15	15	25
P_1 x P_5	30	25	35
P_1 x P_6	30	40	60
P_1 x P_7	45	55	65
P_1 x P_8	40	45	50
P_2 x P_3	25	30	35
P_2 x P_4	15	20	25
P_2 x P_5	20	25	30
P_2 x P_6	25	15	30
P_2 x P_7	45	40	50
P_2 x P_8	25	20	30
P_3 x P_4	10	25	30
P_3 x P_5	15	25	20
P_3 x P_6	30	35	20
P_3 x P_7	40	45	30
P_3 x P_8	45	50	35
P_4 x P_5	15	25	20
P_4 x P_6	20	15	25
P_4 x P_7	25	35	40
P_4 x P_8	30	45	40
P_5 x P_6	15	20	25
P_5 x P_7	20	15	25
P_5 x P_8	20	25	30
P_6 x P_7	35	40	30
P_6 x P_8	20	15	25
P_7 x P_8	10	15	20

Table 1: Screening of different genotypes of onion against Purple blotchdisease

Scale: 0 = (I) Immune
1 = (R) Resistant (1-10%)
2 = (MR) Moderately resistant (11-20%)
3 = (MS) Moderately susceptible (21-40%)
4 = (S) Susceptible (41-60%)

5 = (HS) Highly susceptible (61% and above)

Table 2: Screening of different genotypes of onion against thrips

Category of resistance	Scale (Thrips population)	Screening of different genotypes of onion against thrips
Highly resistant in E_1	< 22.90	RO-1, RO-59, RO-1 x RO-59, RO-1 x Pusa Madhavi, RO-59 x Pusa Madhavi and RO-59 x Kashi No. 1
Resistant in E_1	> 22.90 <23.83	RO-1 x Bhima Kiran, RO-59 x Pusa Red. Bhima Shakti x Kashi No. 1, Pusa Shobha x Pusa Madhavi and Pusa Madhavi x Pusa Red
Moderatey resistant in E_1	>23.83<27.10	Bhima Kiran, Bhima Shakti, Pusa Shobha, Pusa Madhavi, Pusa Red, RO-1 x Bhima Shakti, RO-1 x Pusa Shobha, RO-1 x Kashi No. 1, RO-1 x Pusa Red, RO-59 x Bhima Kiran, RO-59 x bhima Shakti, RO-59 x Pusa Shobha, Bhima Kiran x Bhima Shakti, Bhima Kiran x Pusa Shobha, Bhima Kiran x Pusa Madhavi, Bhima Kiran x Kashi No. 1, Bhima Kiran x Pusa Red, Bhima Shakti x Pusa Shobha, Bhima Shakti x Pusa Madhavi, Bhima Shakti x Pusa Red, Pusa Shobha x Kashi No. 1, Pusa Shobha x Pusa Red, Pusa Madhavi x Kashi No. 1, Pusa Madhavi x Pusa Red and Kashi No. 1 x Pusa Red
Susceptible in E_1	>27.10	-
Highly resistant in E_2	< 24.69	RO-1, RO-59, RO-1 x RO-59, RO-1 x Bhima Kiran, RO-1 x Bhima Shakti, RO-59 x bhima Shakti, RO-59 x Pusa Madhavi, RO-59 x Pusa Red, Bhima Shakti x Pusa Madhavi and Pusa Madhavi x Kashi No. 1
Resistant in E_2	> 24.69 <25.61	RO-59 x Bhima Kiran, RO-59 x Kashi No. 1, Bhima Shakti x Pusa Shobha, Bhima Shakti x Pusa Red and Pusa Shobha x Pusa Red
Moderatey resistant in E_2	>25.61 <29.31	Bhima Kiran, Bhima Shakti, Pusa Shobha, Pusa Madhavi, Kashi No. 1, Pusa Red, RO-1 x Pusa Madhavi, RO-1 x Kashi No. 1, RO-1 x Pusa Red, RO-59 x Pusa Shobha, Bhima Kiran x Bhima Shakti, Bhima Kiran x Pusa Shobha, Bhima Kiran x Pusa Madhavi, Bhima Kiran x Pusa Red, Pusa Shobha x Pusa Madhavi, Pusa Madhavi x Pusa Red and Kashi No. 1 x Pusa Red
Susceptible in E_2	>29.31	Bhima Kiran x Kashi No. 1, Bhima Shakti x Kashi No. 1 and Pusa Shobha x Kashi No. 1
Highly resistant in E_3	< 23.76	RO-1 x RO-59
Resistant in E_3	> 23.76 <27.08	RO-1, RO-59, Bhima Kiran, Bhima Shakti, Kashi No. 1, RO-1 x RO-59, RO-1 x Bhima Kiran, RO-1 x Pusa Red, RO-59 x Bhima Kiran, RO-59 x bhima Shakti, RO-59 x Pusa Shobha, RO-59 x Pusa Madhavi, RO-59 x Kashi No. 1, RO-59 x Pusa Red, Bhima Kiran x Pusa Madhavi, Bhima Shakti x Pusa Shobha, Bhima Shakti x Pusa Madhavi, Bhima Shakti x Kashi No. 1, Pusa Shobha x Pusa Madhavi, Pusa Madhavi x Kashi No. 1, Pusa Madhavi x Pusa Red and Kashi No. 1 x Pusa Red
Moderatey resistant in E_3	>27.08< 28.24	RO-1 x Bhima Shakti, RO-1 x Kashi No. 1 and Bhima Kiran x Pusa Red
Susceptible in E_3	>28.24	Pusa Shobha, Pusa Madhavi, Pusa Red, RO-1 x Pusa Shobha, RO-1 x Pusa Madhavi, Bhima Kiran x Bhima Shakti, Bhima Kiran

x Pusa Shobha, Bhima Kiran x Kashi No. 1, Bhima Shakti x Pusa Red, Pusa Shobha x Kashi No. 1 andPusa Shobha x Pusa Red