



Research Article

Field Assessment of Onion Genotypes for Resistance against Purple Blotch Complex (*Alternaria porri* and *Stemphylium vesicarium*) under Artificial Epiphytotic Conditions in Indian Punjab

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Abstract

Forty-one genotypes of onion were evaluated for their relative response to purple blotch complex caused by *Alternaria porri* and *Stemphylium vesicarium* under artificial epiphytotic condition in field during Rabi 2014-2015 and 2015-2016. Significant variation in disease severity among the onion genotypes was found over two years but the pooled analysis revealed that most of the variations were due to genotype x year interaction. None of the genotypes exhibited resistance to the disease complex. Of the test genotypes, eighteen were found moderately susceptible while twenty one were found susceptible to the disease complex. Two genotypes viz., Punjab Naroya and OSR-1364 exhibited highly susceptible reaction. However, six genotypes viz., P-96, P-30, P-121, OSR-1359, P-98 and OSR-1370 showed superior yield performance. Purple blotch complex exhibited highly significant negative correlation of 0.71 and 0.67 with fresh bulb yield and bulb size, respectively. Cluster analysis of onion genotypes was performed based on disease and yield variables and the genotypes were further grouped into five clusters based on average values of disease and yield variables.

Keywords: Genotypes; onion; purple blotch complex; resistance; yield

Introduction

Onion (*Allium cepa* L.), also known as “queen of kitchen” is one of the oldest known and important high value spice cum bulbous vegetable crop cultivated throughout India.. Onion is highly susceptible to many foliar, bulb and root pathogens, which reduce its yield and quality (Cramer, 2000). Among the diseases, purple leaf blotch (PLB) caused by *Alternaria porri* (Ellis) Cif. and *Stemphylium* leaf blight (SLB) caused by *Stemphylium vesicarium* (Wallr.)

Simmons, are the major diseases of onion world-wide affecting the foliage severely resulting in crop loss ranging from 30 to 100 per cent both in seed and bulb crop from year to year (Awad *et al.*, 1978; Everts and Lacy, 1990a, b; Brar *et al.*, 1990; Aveling *et al.*, 1993, 1994; Chaput, 1995; Cramer, 2000) and are more prevalent in warm and humid environment (Suheri and Price 2000a, b). The typical oval to elliptical lesions are colonised by either *Alternaria porri*, *Stemphylium vesicarium* or mixtures of both pathogens and

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thus, the symptoms are generally impossible to be distinguished (Suheri and Price, 2001). The PLB as well as SLB occur synchronously on the same umbel bearing stalk. The weather preferences for both being similar, the loss is additive. Since PLB + SLB are progressing together on the same host, it is considered to be a complex problem (Suheri and Price 2000 a, b). Uddin *et al.* (2006) also reported that the SLB pathogen (*S. vesicarium*) is first to initiate infection, which is followed by subsequent infection by the pathogen of PLB (*A. porri*) and hence, the disease is designated as purple blotch complex (PBC).

Resistant cultivars, if available, are the most effective, practical, eco-friendly and economical choice. However, at present, no such resistant varieties are available in India (Shashikanth *et al.*, 2007). Although management of disease using fungicides is an efficient option, indiscriminate use of fungicides lead to development of resistance in pathogen population besides being costly. In addition, the chemical control is debatable on account of health, ecological and economic reasons. The present investigation was thus, carried out to determine the source of resistance among onion genotypes against PBC under artificial epiphytotic conditions in the field.

Materials and Methods

Study Materials and Experimental Design

The experiment for screening of the onion genotypes against PBC was conducted in Plant Pathology Farm, Punjab Agricultural University, Ludhiana during *Rabi* season in 2014-2015 and 2015-2016. Forty-one genotypes of onion *viz.*, P-30, P- 21, P-96, P-98, P-305, Punjab White, Punjab Naroya, PRO-6, POH-1, POH-2, ON-06, ON-11, ON-27, OSR-1323, OSR-1344, OSR-1347, OSR-1349, OSR-1352, OSR-1354, OSR-1357, OSR-1359, OSR-1362, OSR-1364, OSR-1367, OSR-1370, OSR-1372, OSR-1374, OSR-1377, OSR-1379, OSR-1381, CT-1241, CT-1243, CT-1206, CT-1402, CT-1403, CT-1404, CT-1405, CT-1407, CT-1410, CT-1412 and CT-1414 were grown in randomized block design with three replications for evaluating their relative response to disease under artificial epiphytotic conditions. The artificial epiphytotic conditions were created in the field by spraying mixture of conidial suspension of *A. porri* (1×10^4 propagules/ml) and *S. vesicarium* (1×10^4 propagules/ml) during evening hours in the first and last week of February during both the years. The propagules in the pathogen inoculums had conidia along with some mycelial bits. The net plot size of 2 x 2 m² and plant to plant spacing of 15 cm x 10 cm was followed. Required fertilizers and other operations were performed during the entire cropping season as per Package of Practices for Vegetable Crops, Punjab Agricultural University, Ludhiana (Anonymous, 2013). Twenty five plants from each plot were randomly tagged for disease assessment on the 0 to 5 rating scale given by Sharma (1986). The observations on disease severity were recorded

after 120 days of transplanting and percent disease index (PDI) was computed by the following formula given by Wheeler (1969).

$$PDI = 100 [\sum SNR] [(N) (MDR)]^{-1}$$

Where,

$\sum SNR$ is the sum of numerical ratings

N is the number of observations

MDR is the maximum disease rating based on 0-5 scale

On the basis of method given by Pathak *et al.* (1986), the genotypes were categorized as Immune I (PDI= < 5%), Resistant R (PDI= 5-10%), Moderately Resistant MR (PDI= 11-20%), Moderately Susceptible MS (PDI= 21-40%), Susceptible S (PDI= 41-60%) and Highly Susceptible HS (PDI= > 61%).

Observation on bulb size (diameter in cm) was recorded on 25 randomly selected plants for all replications with the help of digital Vernier caliper and fresh bulb yield per plot was recorded after harvesting during both the years. The plot yield was recorded in kilogram for all the genotypes per replication and fresh bulb yield per hectare was extrapolated in t/ha.

Statistical Analysis

The two years data on disease severity and yield parameters (fresh bulb yield and size) were subjected to combined analysis of variance under randomized block design (RBD) using Statistical software SPSS 22.0 (SPSS Inc., USA) and the significance of differences between the means were compared using Least Significant Difference (LSD) at 5 percent level of significance. Prior to that, Levene's test for homogeneity of variances was performed. In all cases, the *P*-value was greater than 0.05, indicating that the variation in the two years of the study was not significantly different. The linear correlation between the pooled diseased severity and yield parameters were computed. Further, cluster analysis of the onion genotypes was done on the basis of Euclidean distance using agglomerative method (complete linkage) in statistical software, Statistical Tool for Agricultural Research (STAR version 2.0.1) developed by International Rice Research Institute (IRRI) .

Results and Discussion

The data presented in Table 1 revealed significant variation in the PDI among different onion genotypes. The mean PDI over two crop seasons varied from 24.97 to 63.83 per cent. The genotypes showed variable disease reaction ranging from moderately susceptible (MS) to highly susceptible (HS). None of 41 genotypes was found to exhibit either resistant (R) or moderately resistant (MR) reaction. Of the test genotypes, 18 onion genotypes *viz.*, P-30, P-121, P-96, P-98, POH-1, POH-2, ON-27, OSR-1323, OSR-1349, OSR-1359, OSR-1374, OSR-1377, OSR-1381, CT-1241, CT-1206, CT-1403, CT-1404 and CT-1407 were found to

exhibit MS reaction with mean PDI over two seasons ranging from 24.97 to 40.02 per cent while 21 onion genotypes viz., P-305, Punjab White, PRO-6, ON-06, ON-11, OSR-1344, OSR-1347, OSR-1352, OSR-1354, OSR-1357, OSR-1362, OSR-1367, OSR-1370, OSR-1372, OSR-1379, CT-1243, CT-1402, CT-1405, CT-1410, CT-1412 and CT-1414 were found to exhibit susceptible (S) reaction

in registering the mean PDI over two seasons ranging from 41.16 to 58.55 per cent. Two onion genotypes viz., Punjab Naroya and OSR-1364 exhibited HS reaction by recording mean PDI over two seasons of 63.69 and 63.83 per cent, respectively. The forty one onion genotypes were further grouped into various reaction categories against purple blotch complex in Table 2.

Table 1: Severity of purple blotch complex caused by *Alternaria porri* and *Stemphylium vesicarium* on onion genotypes under artificial epiphytotic conditions in the field during Rabi 2014-2015 and 2015-2016

S.N.	Genotypes	Per cent Disease Index			Reaction
		2014-15	2015-16	Pooled mean	
1	P-30	25.50	29.62	27.56	MS
2	P-121	23.17	26.76	24.97	MS
3	P-96	24.84	30.58	27.71	MS
4	P-98	34.17	40.14	37.16	MS
5	P-305	50.17	59.86	55.02	S
6	Punjab White	45.50	53.52	49.51	S
7	Punjab Naroya	61.17	66.21	63.69	HS
8	PRO-6	55.00	59.73	57.37	S
9	POH-1	26.67	34.40	30.54	MS
10	POH-2	30.17	46.76	38.47	MS
11	ON-06	47.01	56.64	51.83	S
12	ON-11	49.84	57.99	53.92	S
13	ON-27	37.51	40.22	38.87	MS
14	OSR-1323	30.51	38.35	34.43	MS
15	OSR-1344	40.67	48.64	44.66	S
16	OSR-1347	43.63	46.94	45.29	S
17	OSR-1349	32.50	36.74	34.62	MS
18	OSR-1352	40.50	43.11	41.81	S
19	OSR-1354	44.50	49.57	47.04	S
20	OSR-1357	35.84	46.48	41.16	S
21	OSR-1359	24.51	34.68	29.60	MS
22	OSR-1362	55.84	61.25	58.55	S
23	OSR-1364	60.00	67.65	63.83	HS
24	OSR-1367	39.84	45.76	42.80	S
25	OSR-1370	36.17	57.13	46.65	S
26	OSR-1372	39.51	46.76	43.14	S
27	OSR-1374	32.50	38.83	35.67	MS
28	OSR-1377	35.34	41.16	38.25	MS
29	OSR-1379	53.50	61.31	57.41	S
30	OSR-1381	33.84	46.19	40.02	MS
31	CT-1241	32.74	41.19	36.97	MS
32	CT-1243	41.17	42.26	41.72	S
33	CT-1206	33.50	37.67	35.59	MS
34	CT-1402	55.51	61.31	58.41	S
35	CT-1403	34.34	37.96	36.15	MS
36	CT-1404	34.50	38.49	36.50	MS
37	CT-1405	39.84	44.07	41.96	S
38	CT-1407	31.84	40.24	36.04	MS
39	CT-1410	43.50	56.52	50.01	S
40	CT-1412	54.17	62.27	58.22	S
41	CT-1414	54.01	58.61	56.31	S
	Mean	40.12	47.16	43.64	-

Source of variance	S.Em±	LSD (P<0.05)
Year (Y)	0.33	0.65
Genotype (G)	1.50	2.96
G x Y	2.13	4.21

Table 2: Reaction(s) of onion genotypes against purple blotch complex caused by *Alternaria porri* and *Stemphylium vesicarium* under artificial epiphytotic conditions in the field

Disease	Genotypes
MS	P-30, P-121, P-96, P-98, POH-1, POH-2, ON-27, OSR-1323, OSR-1349, OSR-1359,
S	P-305, Punjab White, PRO-6, ON-06, ON-11, OSR-1344, OSR-1347, OSR-1352,
HS	Punjab Naroya, OSR-1364

The data presented in Table 3 revealed significant variation in total fresh bulb yield and bulb size among different onion genotypes. The mean fresh bulb yield and bulb size of onion genotypes over two seasons varied from 8.86 to 24.62 t/ha and 3.53 to 5.79 cm, respectively. The genetic differences are known to govern the fresh bulb yield and bulb size of different genotypes. The highest mean fresh bulb yield over two seasons was recorded by the genotype P-96 (24.62 t/ha) followed by P-30 (23.87 t/ha), P-121 (23.35 t/ha), OSR-1359 (23.08 t/ha), P-98 (22.51 t/ha) and OSR-1370 (22.21 t/ha) while the lowest mean fresh bulb yield was recorded by the genotype OSR-1364 (8.86 t/ha) followed by CT-1414 (10.81 t/ha), OSR-1362 (11.14 t/ha) and OSR-1354 (12.18 t/ha). Similarly, maximum mean fresh bulb size over two seasons was registered by the genotype P-96 (5.79 cm) followed by P-30 (5.59 cm), OSR-1370 (5.56 cm), OSR-1359 (5.53 cm) and P-121 (5.51 cm) while the minimum mean fresh bulb size over two seasons was recorded by OSR-1364 (3.53 cm), OSR-1352 (3.57 cm), OSR-1354 (3.59 cm) and CT-1414 (3.60 cm).

The perusal of Table 4 revealed that PBC exhibited highly significant negative correlation with fresh bulb yield and bulb size in both the seasons. The pooled analysis over two crop seasons revealed that that PBC exhibited highly significant negative correlation of 0.71 and 0.67 with fresh bulb yield and bulb size, respectively.

Further, the onion genotypes were grouped into five clusters (Fig. 1 and Table 5) based on Euclidean distance using complete agglomerative clustering method. The cluster III recorded the highest mean disease severity of 61.05 per cent followed by cluster V (59.56%) cluster II (52.21%) and cluster V (39.83%) while cluster I recorded the lowest mean disease severity of 35.51 per cent. The highest mean fresh yield (21.53 t/ha) and bulb size (5.28 cm) was recorded in cluster I followed by cluster III (19.18 t/ha and 4.76 cm) and cluster IV (16.70 t/ha and 4.44 cm) while the lowest mean fresh yield (10.27 t/ha) and bulb size (3.60 cm) was recorded in cluster V. The genotypes in cluster III viz., Punjab Naroya and CT-1402 were found to exhibit tolerant reaction to PBC as it recorded superior yield performance despite the higher disease severity.

Table 3: Comparative yield performance of onion genotypes screened under artificial epiphytotic conditions in the field against purple blotch complex during Rabi 2014-2015 and 2015-2016

S.N.	Genotypes	Total fresh bulb yield (t/ha)			Fresh bulb size (cm)		
		2014-15	2015-16	Pooled mean	2014-15	2015-16	Pooled mean
1	P-30	24.16	23.57	23.87	5.66	5.52	5.59
2	P-121	24.30	22.40	23.35	5.72	5.31	5.51
3	P-96	25.95	23.30	24.62	5.91	5.67	5.79
4	P-98	23.50	21.53	22.51	5.38	5.22	5.30
5	P-305	17.03	16.81	16.92	4.58	4.38	4.48
6	Punjab White	14.12	13.65	13.88	4.16	4.08	4.12
7	Punjab Naroya	18.32	17.32	17.82	4.50	4.37	4.44
8	PRO-6	13.74	12.85	13.29	4.31	4.19	4.25
9	POH-1	23.9	20.19	22.04	5.38	5.08	5.23
10	POH-2	15.65	13.61	14.63	4.44	4.23	4.34
11	ON-06	15.00	13.74	14.37	4.13	4.02	4.08
12	ON-11	17.46	13.35	15.41	4.73	4.07	4.40
13	ON-27	17.94	16.50	17.22	4.48	4.29	4.39
14	OSR-1323	17.56	16.96	17.26	4.38	4.31	4.35
15	OSR-1344	15.49	14.09	14.79	4.22	4.13	4.18
16	OSR-1347	14.45	13.86	14.16	4.31	4.27	4.29
17	OSR-1349	18.06	17.51	17.79	4.57	4.52	4.55
18	OSR-1352	12.98	11.86	12.42	3.60	3.53	3.57
19	OSR-1354	12.57	11.79	12.18	3.66	3.51	3.59
20	OSR-1357	19.85	16.69	18.27	4.86	4.48	4.67
21	OSR-1359	24.05	22.11	23.08	5.62	5.44	5.53
22	OSR-1362	11.42	10.86	11.14	3.70	3.62	3.66
23	OSR-1364	9.16	8.55	8.86	3.57	3.48	3.53
24	OSR-1367	22.14	20.17	21.16	5.29	5.03	5.16
25	OSR-1370	24.81	19.60	22.21	5.85	5.27	5.56
26	OSR-1372	19.47	17.61	18.54	4.88	4.67	4.78
27	OSR-1374	18.94	17.91	18.42	4.70	4.63	4.67

S.N.	Genotypes	Total fresh bulb yield (t/ha)			Fresh bulb size (cm)		
		2014-15	2015-16	Pooled mean	2014-15	2015-16	Pooled mean
28	OSR-1377	22.24	19.23	20.74	5.28	5.06	5.17
29	OSR-1379	15.85	13.78	14.82	4.23	4.07	4.15
30	OSR-1381	20.23	18.77	19.50	5.08	4.92	5.00
31	CT-1241	22.90	19.22	21.06	5.41	4.93	5.17
32	CT-1243	20.35	19.91	20.13	5.11	5.07	5.09
33	CT-1206	20.07	19.24	19.66	5.20	5.01	5.11
34	CT-1402	21.66	19.39	20.53	5.19	4.96	5.08
35	CT-1403	21.23	19.16	20.19	5.10	5.03	5.07
36	CT-1404	20.61	19.00	19.81	5.19	5.11	5.15
37	CT-1405	16.41	15.39	15.90	4.22	4.13	4.18
38	CT-1407	22.66	18.50	20.58	5.31	4.73	5.02
39	CT-1410	17.18	14.78	15.98	4.38	4.17	4.28
40	CT-1412	14.89	13.64	14.27	4.11	3.87	3.99
41	CT-1414	11.45	10.17	10.81	3.67	3.53	3.60
	Mean	18.53	16.79	17.66	4.73	4.53	4.63

Source of variance	Total fresh bulb yield (t/ha)		Fresh bulb size (cm)	
	S.Em±	LSD ($p \leq 0.05$)	S.Em±	LSD ($p \leq 0.05$)
Year (Y)	0.08	0.16	0.009	0.02
Genotype (G)	0.37	0.74	0.04	0.08
G x Y	0.52	1.03	0.06	0.12

Table 4: Correlation matrix for purple blotch complex and yield parameters of onion

Crop season	Yield variables	Purple blotch complex
2014-15	Bulb yield	-0.71**
	Bulb size	-0.68**
2015-16	Bulb yield	-0.70**
	Bulb size	-0.66**
Pooled analysis	Bulb yield	-0.71**
	Bulb size	-0.67**

**The correlation coefficient is significant at 1 per cent level of significance

Table 5: Average values \pm standard deviation of disease and yield variables of different clusters of onion genotypes screened against onion purple blotch complex under artificial epiphytotic condition in field

Cluster	Size	Genotypes	PDI	Fresh bulb yield (t/ha)	Fresh bulb size (cm)
I	16	P-30, P-121, P-96, P-98, POH-1, OSR-1359, OSR-1367, OSR-1370, OSR-1377, OSR-1381, CT-1241, CT-1243, CT-1206, CT-1403, CT-1404, CT-1407	35.51 \pm 6.03 (24.97-46.65)*	21.53 \pm 1.60 (19.50-24.62)*	5.28 \pm 0.24 (5.00-5.79)*
II	10	P-305, Punjab White, PRO-6, ON-06, ON-11, OSR-1352, OSR-1354, OSR-1379, CT-1410, CT-1412	52.21 \pm 5.25 (41.81-58.22)	14.35 \pm 1.51 (12.18-16.92)*	4.09 \pm 0.31 (3.57-4.48)*
III	2	Punjab Naroya, CT-1402	61.05 \pm 3.73 (58.41-63.69)*	19.18 \pm 1.92 (17.82-20.53)*	4.76 \pm 0.45 (4.44-5.08)*
IV	10	POH-2, ON-27, OSR-1323, OSR-1344, OSR-1347, OSR-1349, OSR-1357, OSR-1372, OSR-1374, CT-1405	39.83 \pm 4.04 (34.43-45.29)*	16.70 \pm 1.69 (14.16-18.54)*	4.44 \pm 0.21 (4.18-4.78)*
V	3	OSR-1362, OSR-1364, CT-1414	59.56 \pm 3.86 (56.31-63.83)*	10.27 \pm 1.23 (8.86-11.14)*	3.60 \pm 0.07 (3.53-3.66)*

* Range of variables within each cluster; Cophenetic correlation coefficient= 0.67

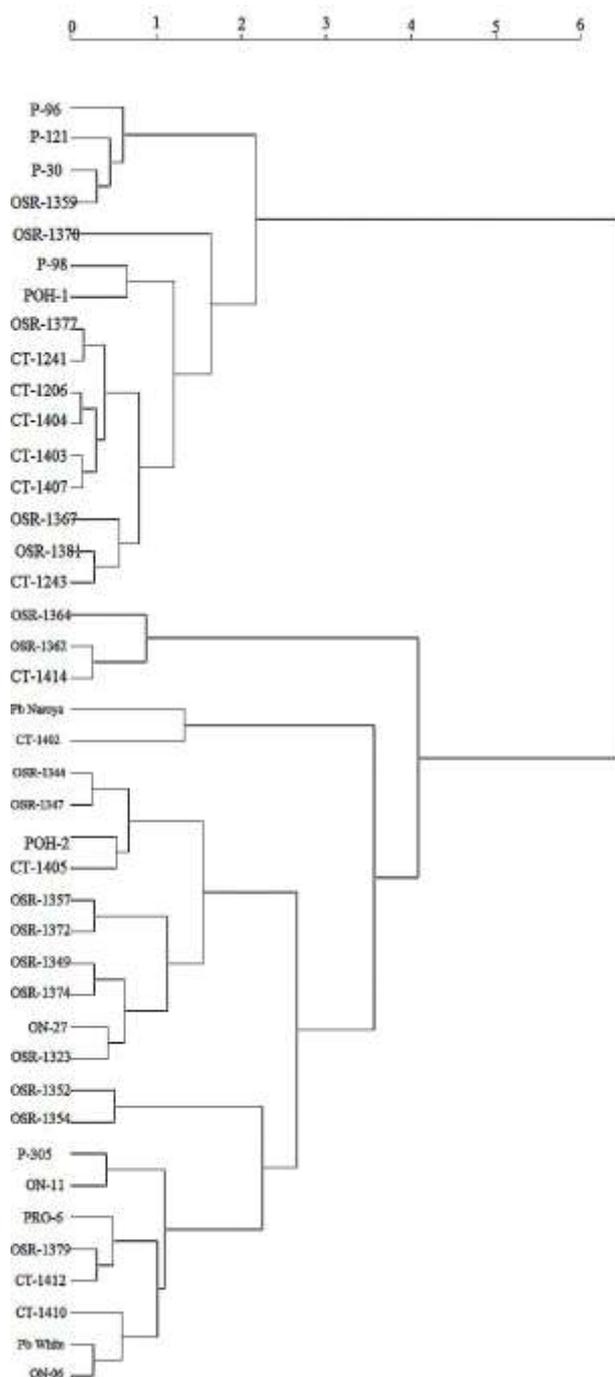


Fig. 1: Cluster analysis using agglomerative method (complete linkage) of onion genotypes based on disease severity and yield variables

Behera *et al.* (2013) reported that among 22 onion varieties screened against PLB and SLB of onion, only one variety VG-18 performed best by exhibiting R and MR reaction to PLB and SLB, respectively. Chethana *et al.* (2011) screened 18 onion genotypes to evaluate resistance against PLB and reported none of the genotypes as resistant. The genotype Arka Kalyan was found MR while the genotypes *viz.*, Rampur Rose, Agrifound Rose, Arka Pragati, Arka Niketan, Arka Pitamber and Arka Bindu were found MS. Dhiman *et al.* (1986) reported that none of the 18 genotypes raised for bulb crop were resistant against PLB. Pathak *et al.* (1986) found only one genotype IR-56-1 as resistant and five

genotypes (*viz.*, IHR-25, IHR-44, IHR-499, IHR-500 and Arka Kalyan) as MR. Sugha *et al.* (1992) screened 94 onion genotypes against PLB under natural epiphytotic conditions out of which only two genotypes *viz.*, IC39178 and IC49371 were found resistant. Sharma (1997) reported that out of 86 onion genotypes, five genotypes *viz.*, IC48059, IC48179, IC39887, IC48025 and ALR exhibited R reaction to PLB.

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