The Pharma Innovation Journal 2022; 11(10): 1883-1886

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(10): 1883-1886

www.thepharmajournal.com
Received: 18-07-2022
Accepted: 20-08-2022

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Evaluation of *Brassica juncea* germplasm for white rust resistance

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Abstract
White rust, caused by *Albugo candida* (Pers. ex Lev.) Kuntze, is the most prevalent and extremely destructive disease of *B. juncea*. The present study was carried out to evaluate *Brassica juncea* genotypes for resistance to white rust. Experimental material comprised of ninety genotypes of Indian and East European gene pool. White rust resistant genotypes *viz.* Heera and Donskaja and and susceptible genotypes RSPR 01 and Varuna were used as check genotypes. Out of ninety genotypes, three genotypes namely Donskaja IV, Domo and Cutlass showed no infection and they were considered as immune against white rust. Fifteen genotypes showed highly resistant response, twenty nine genotypes were found resistant, twenty four genotypes were observed as moderately resistant, nineteen genotypes were susceptible and none of the genotypes was found in highly susceptible category. Genotypes with immune and highly resistant genotypes can be further utilised for future breeding programmes for the improvement of this trait.

Keywords: *Brassica juncea*, white rust, *Albugo candida*, East European gene pool and Indian gene pool

Introduction
Brassica species, including vegetables and oilseed crops, are of major importance in agricultural production around the globe. Among these, *Brassica juncea* (L.) Czern & Coss. Also called as Indian mustard, is an amphidiploid with chromosome number 2n = 36 (AABB) that contains genomes of two diploid species, *Brassica Rapa* L. (AA), 2n = 20 and *Brassica nigra* L. (BB), 2n = 16.*Brassica juncea* is an important oilseed species in India, China and Pakistan (Adhikari *et al*., 2021) [1]. Both biotic and abiotic stresses adversely affect yield of this crop resulting in low productivity. Among various biotic stresses limiting production and productivity, white rust, a fungal disease caused by *Albugo candida* (Pers. ex Lev.) Kuntze, is most prevalent and extremely destructive to *B. juncea*. It is an obligate bio trophic parasite based on its scientific and economic importance and considered as top ten oomycete pathogen (Kamoun *et al*., 2015) [6]. Both the vegetative and reproductive phases of the plants are affected by this fungal pathogen. White rust disease causes zoo sporangial pustules of white to cream in colour on the aerial portions of plants, including cotyledons, leaves, stems, and inflorescences (Saharan *et al*., 2014) [12] resulting in stag head formation that produces little or no seed (Meena *et al*., 2014) [12]. The Indian cultivars are highly susceptible to white rust (Li *et al*., 2008) [7] and loss to the extent of 50 percent in seed yield has been reported, under late sown conditions.

Disease resistance plays a major role in crop production, quality assurance, environmental safety and ultimately crop yield. Disease resistance can be controlled by a single gene, *viz*., R-gene, or by many genes with small effects. A wide range of genotypic variability exists among *Brassica* species for white rust resistance. *Brassica juncea* germplasm belonging to the Indian gene pool is highly susceptible to white rust, whereas the east European germplasm is highly to moderately resistant (Chand *et al*., 2022) [4]. To achieve stability in performance, development of varieties with inbuilt resistance/tolerance to diseases including white rust is economically viable, environmentally safe and sustainable strategy for meeting the projected demands. Heera and Donskaja IV have been identified as resistant sources for white rust and are extensively utilised for breeding *Brassica juncea* varieties. Heera with resistant locus *AcB1-A4*.1 has shown moderate to strong resistance against prevalent races of *Albugo candida*. However, the locus AcB1-A5.1. From Donskaja IV imparts complete resistance to *Albugo candida* infection (Punjabi *et al*., 2010; Singh *et al*., 2015) [15, 13]. In the present study, Indian and European gene pool of *Brassica juncea* was evaluated against white rust infection to genotypes showing resistance to disease under Jammu conditions.

Materials and Methods

The field trail was carried out at Experimental Farm, School of Bio technology during the *Rabi* seasons of 2019-20, 2020-21, 2021-22. The experiment was conducted in augmented block design for evaluating ninety genotypes of Indian and East European gene pool. White rust resistant genotypes (Heera and Donskaja IV) and susceptible genotypes (RSPR-01 and Varuna) were used as check genotypes and repeated in all the four blocks of 86 genotypes. The screening against white rust was done as per scale given by Conn *et al*. (1990) [5] and three years data has been pooled to work out average response of genotypes towards white rust infection (Fig. 1). Fresh zoosporangia of *Albugo candida* from naturally infected Varuna leaves were used to make the white rust spore suspension. A blade or needle was used to scrape the single white rust pustules. Test tubes containing sterilised, double-distilled water and sporangial powder were mixed, thoroughly shaken, and held at 4 degrees Celsius for four hours to allow sporangia to germinate and release zoospores**.** Genotypes were artificially inoculated twice i.e. initiation of flowering stage (60-65 days after sowing) and pod formation stage in the field. Spraying of white rust inoculum was done with the help of atomizer/small sprayer in the afternoon after 3:00 PM. Moisture was maintained by regular watering. Disease scoring based on severity of infection was done as per the scale given by Conn *et al.* (1990) [5]. Observations for disease severity were recorded 15 days after inoculation (DAI) on leaves in six grades namely 0, 1, 3, 5, 7 and 9 representing 0, 5, 10, 25, 50 and more than 50 percent leaf area covered with white rust pustules, respectively. Final observations for disease reaction were recorded 25 days before maturity (at pod formation stage).

Results and Discussion

White rust scores based on reaction response of genotypes (Conn *et al*., 1990) [5] are presented in Table 1. Out of 90 genotypes, three genotypes (Donskaja IV, Domo and Cutlass) showed no infection and they were considered as immune against white rust. Donskaja IV is reported to be the highly resistant genotype and is donor parent for white rust resistance locus AcB1-A5.1. Domo and Cutlass are also the genotypes belonging to East European gene pool and characterized for resistance to major diseases including white rust, as well as superior agronomical and quality traits. Fifteen genotypes *viz*. Skorospelka, VN11MK 351, Zeltosemiannaja 230,AC Vulcan, Yanagawa Shirokuki, Miike Akachirimen, Sendai Bashouna, J807/1/6, J/807/1/6, J/824/6, 1-49-24, M.Br.4, Kafiav N Zagora, German accession No. 114, Zem 1 and Heera were considered as highly resistant based on average score of three seasons. They belonged to East European gene pool. Another set of twenty nine genotypes *viz*. Neosypajuscajasia 2, Volgogradskaja1891, VNIIMK 405, Zaria, PGR 3330, PGR 3383, Commercial Brown Mustard, Lethbridge 22A, Blaze, Ekla, Primus, Stoke, Jubilejnaja, Skorospelka 2, PGR 12573, PGR 12574, Stepniacka, J/807/12/1, J/817/2, J/824, PGR 12586,Scimitar, SRS 319, 63-0134-68, Bass, R 871, Skorospieka II, EC 699038 –I and EC 699038-IIfrom East European gene pool were resistant. Twenty four genotypes *viz*. (Ooba Takana, Burgonde, PGR 12568, 74/5, 64-1398-69, EC 287711, EC 491584, EC 206712, EC 699059, PAK 85387, PAK 85483, Desi Saram, Sharsham, SB-12-P4, RLM-240, Vardan, IB 1479, IB 1436, Urvashi, Pusa Karishma, Kranti, RSPR-69, DMR-J-31and RSPR-03) were considered as moderately resistant. Nineteen accessions (B. Juncea from Turkey, PGR 12585, PAK 85506, PAK 85590, PAK 85667, Toria Mitha, PAK 85393, Raya (L.23), RLC 1021, Krishna, Rohini, Pusa Tarak, RSPR-01, DRMR-2017, Pusa Mehak, Varuna, Pusa Bold, RH-749 and RB-55) from Indian gene pool were considered as susceptible. None of the genotypes was found in highly susceptible category. Genotypes such as Heera, Kafiav N Zagora and Zem1are are considered as elite genotypes in Esat European gene pool. Li *et al*. (2007) [8] screened 44 genotypes of *Brassica juncea* against white rust and it was observed that most of the genotypes of Indian gene pool showed moderate to susceptible reaction to the disease. Meena *et al*. (2011) [9] identified PBC 9221 and EC 414299 as resistant sources for white rust. Awasthi *et al*. (2012) [2], Bisht *et al*. (2016) [3], Yadav *et al*. (2018) [14] also screened *Brassica juncea* against white rust and identified various resistant genotypes.

Table 1: Response of genotypes for white rust resistance (Conn *et al*., 1990) [5]

S. No.	Genotypes	WR score 2019-20	WR score 2020-21	WR score 2021-22	Average score	Response to WR
1	Neosypajuscajasia 2	1	3	3	3.00	Resistant
2	Volgogradskaja1891	3	3	1	2.34	Resistant
3	Skorospelka	1	1	1	1.00	Highly Resistant
4	VNIIMK 351	3	1	1	1.00	Highly Resistant
5	VNIIMK 405	3	3	3	3.00	Resistant
6	Zeltosemiannaja 230	1	1	3	1.67	Highly Resistant
7	Zaria	1	3	3	2.34	Resistant
8	Donskaja 4	0	0	0	0.00	Immune
9	PGR 3330	3	3	1	2.34	Resistant
10	PGR 3383	1	3	3	2.34	Resistant
11	Commercial Brown Mustard	3	3	3	3.00	Resistant
12	Lethbridge 22A	1	3	3	2.34	Resistant
13	Blaze	3	3	1	2.34	Resistant
14	Domo	0	0	0	0.00	Immune
15	AC Vulcan	3	1	1	1.67	Highly Resistant
16	YanagawaShirokuki	1	1	1	1.00	Highly Resistant
17	MiikeAkachirimen	3	1	1	1.67	Highly Resistant
18	Sendai Bashouna	1	1	1	1.00	Highly Resistant
19	Ooba Takana	5	5	5	5.00	Moderately Resistant
20	Burgonde	3	5	5	5.00	Moderately Resistant
21	Ekla	1	3	3	2.34	Resistant

22	Primus	3	3	3	3.00	Resistant
23	Stoke	3	3	1	2.34	Resistant
24	Jubilejnaja	1	3	3	2.34	Resistant
25	Skorospelka 2	3	3	3	3.00	Resistant
26	PGR 12568	3	5	5	4.33	Moderately Resistant
27	74/5	3	5	5	4.33	Moderately Resistant
28	PGR 12573	1	3	3	2.34	Resistant
29	PGR 12574	3	3	3	3.00	Resistant
30	Stepniacka	3	3	1	2.34	Resistant
31	J807/1/6	1	1	1	1.00	Highly Resistant
32	J/807/12/1	3	3	1	2.34	Resistant
33	J/817/2	1	3	3	2.34	Resistant
34	J/824	3	3	3	3.00	Resistant
35	J/824/60	1	1	1	1.00	Highly Resistant
36	PGR 12586	3	3	1	2.34	Resistant
37	Cutlass	0	0	0	0.00	Immune
38	Scimitar	3	3	3	3.00	Resistant
39	SRS 319	3	3	1	2.34	Resistant
40	I-49-24	1	1	1	1.00	Highly Resistant
41	M.Br.4	1	1	3	1.67	Highly Resistant
42	63-0134-68	3	3	3	3.00	Resistant
43	64-1398-69	3	5	5	4.34	Moderately Resistant
44	Bass	3	3	3	3.00	Resistant
45	R 871	1	3	3	2.34	Resistant
46	Kafiav N Zagora	1	1	1	1.00	Highly Resistant
47	German accession No. 114	1	1	1	1.00	Highly Resistant
48	Zem 1	1	1	1	1.00	Highly Resistant
49	Skorospieka II	3	3	1	2.34	Resistant
50	EC 287711	5	5	3	4.34	Moderately Resistant
51	EC 491584	5	5	3	4.34	Moderately Resistant
52	EC 206712	5	5	3	4.34	Moderately Resistant
53	EC 699059	3	5	5	4.34	Moderately Resistant
54	EC 699038 –I	3	3	3	3.00	Resistant
55	EC 699038-II	3	3	3	3.00	Resistant
56	*B. juncea* from Turkey	7	7	5	6.33	Susceptible
57	PGR 12585	5	7	7	6.33	Susceptible
58	PAK 85387	5	5	7	5.67	Moderately Resistant
59	PAK 85483	5	5	5	5.00	Moderately Resistant
60	PAK 85506	7	7	5	6.33	Susceptible
61	PAK 85590	5	7	7	6.33	Susceptible
62	PAK 85667	7	7	7	7.00	Susceptible
63	ToriaMitha	7	7	5	6.33	Susceptible
64	DesiSaram	5	5	5	5.00	Moderately Resistant
65	Sharsham	5	5	5	5.00	Moderately Resistant
66	PAK 85393	7	7	7	7.00	Susceptible
67	Raya (L.23)	5	7	7	6.33	Susceptible
68	SB-12-P4	5	5	5	5.00	Moderately Resistant
69	RLM-240	7	5	5	5.67	Moderately Resistant
70	RLC 1021	7	7	7	7.00	Susceptible
71	Krishna	7	7	7	7.00	Susceptible
72	Rohini	7	7	7	7.00	Susceptible
73	Vardan	5	5	5	5.00	Moderately Resistant
74	IB 1479	7	5	5	5.67	Moderately Resistant
75	IB 1436	7	5	5	5.67	Moderately Resistant
76	PusaTarak	7	7	7	7.00	Susceptible
77	RSPR-01	7	7	7	7.00	Susceptible
78	Urvashi	7	5	5	5.67	Moderately Resistant
79	DRMR-2017	7	7	7	7.00	Susceptible
80	PusaMehak	7	7	5	6.33	Susceptible
81	PusaKarishma	5	5	5	5.00	Moderately Resistant
82	Varuna	7	7	7	7.00	Susceptible
83	Kranti	5	5	5	5.00	Moderately Resistant
84	RSPR-69	5	5	7	5.67	Moderately Resistant
85	Pusa Bold	7	7	7	7.00	Susceptible
86	Heera	1	1	1	1.00	Highly Resistant
87	DMR-J-31	5	5	5	5.00	Moderately Resistant
88	RSPR-03	5	5	5	5.00	Moderately Resistant

89	RH-749	7	7	7	7.00	Susceptible
90	RB-55	7	7	7	7.00	Susceptible

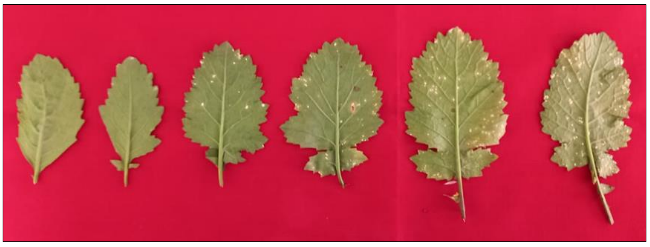

Fig 1: White rust symptoms depicting severity of disease used for standardization of score as per (Conn *et al*., 1990) [5]

Conclusion

In this study, ninety germplasm of *Brassica juncea* were screened against white rust disease. Among these, Out of ninety genotypes, three genotypes (Donskaja IV, Domo and Cutlass) showed no infection and they were considered as immune against white rust. These can be exploited as resistant source in future breeding programmes for the development of resistant varieties against white rust disease.

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