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Short Communication

Identification of *Fusarium* wilt resistant genotypes in lentil

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ABSTRACT

Fusarium wilt is a serious disease of lentil crop. In the present investigation, 144 pre-breeding lines derived from crosses involving accessions *of Lens curlinaris* subsp. *orientalis* and *L. curlinaris* subsp. *tomentosus* and 117 Mediterranean landraces of lentil were screened under wilt sick plot. This is resulted in the identification of a highly resistant pre-breeding line IPLPBR-1 [IPL 406 (*L. culinaris* subsp. *culinaris*) x IG 136667 (ILWL 44; *L. curlinaris* subsp. *tomentosus*)] and a Mediterranean landraces IG 54 having a resistance level of <10%. Testing of these genotypes for over four years under similar wilt sick plots showed an average wilt incidence ranging from 8.5 % to 8.8 % in resistant genotypes while it was observed from 82.0 to 86.4 % in susceptible check genotypes. The other genotypes showed moderate resistance to high susceptibility against the Kanpur isolate of the *Fusarium* wilt in the present study. These resistant genotypes are useful donors for breeding Fusarium wilt resistant cultivars in lentil.

Key words: *Fusaium* wilt, Genotypes, Lentil, Resistance

Lentil is one of the important cool season crops and it ranks second in production among Rabi pulses after chickpea in India. The major lentil-producing states in India are Madhya Pradesh (30.94%), Uttar Pradesh (28.72%), Bihar (15.24%), and West Bengal (5.81%) which together contribute 80% of the total production of lentil. Uttar Pradesh especially the Bundelkhand region is one of the major lentil-producing states after Madhya Pradesh in India. Lentil is cultivated as a rainfed crop and is affected by several biotic (fungi, viruses, nematodes, insect pests and parasitic plants) and abiotic (terminal drought, heat stress, cold, waterlogging and low soil fertility) stresses. Among the biotic stresses, Fusarium wilt (FW) is a serious disease, that affects lentil yield in India and other countries (Hamdi and Hassanein, 1996) and a loss due to fusarium wilt has been reported from up to 50% of the production to complete yield loss (100%) if severely affected. The disease appears at the seedling stage (early wilt) or during the reproductive stage (late wilt) (Khare, 1981; Stoilova and Chavdarov, 2008). FW is the major disease that seriously limits lentil production in Uttar Pradesh (Agrawal *et al.,* 1993; Chaudhary *et al.,* 2009, 2010). The development of improved high-yielding varieties having a high level of resistance to fusarium wilt is the most economical means to control this disease (Kumar *et al.,* 2010). However, due to the evolution of new races and the co-existence of more than one pathotype, it is difficult to develop resistant cultivars. Therefore, the knowledge of the inheritance and genetics of wilt resistance is important for developing resistant cultivars. The studies on the genetics of resistance to fusarium wilt will eventually help produce more resistant lentil cultivars (Eujayl *et al.,* 1998). During past years, although using the conventional breeding approach, resistant or moderately resistant lentil cultivars such as DPL 62, JL3, IPL 81 and IPL 316 have been developed that significantly helped reduce wilt incidence and increase grain yield (Chaudhary and Amarjit, 2002). However, highly resistant variety/donors for wilt resistance are still limited in lentil and very limited studies have been conducted in India to identify the highly wilt-resistant donors and their use for knowing the genetics of wilt resistance in lentil. In a recent study, a set of 20 diverse lentil genotypes comprising breeding lines and released varieties were evaluated, along with susceptible controls, for resistance to fusarium wilt under natural epiphytotic conditions for two continuous years (2010–11 and 2011–12) in six diverse lentil-growing environments in India. This study resulted in the identification of PL 101 and released cultivar L 4076 as wilt tolerant indicating their great potential for use in lentil-breeding programs (Parihar *et al.,* 2017). In another study, screening of 70 accessions of four

Table 1. Origin and source of germplasm materials of lentil screened under Fusarium wilt sick plot conditions in the present study

Sl. No.	Prebreeding line/Genotype name	Type of material	Origin	Source
1	IPLPRB-1	Prebreeding line	IPL 406 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur
2	IPLPRB-2	Prebreeding line	IPL 406 × IG136667 (ILWL 44; ; *L. tomentosus*)	ICAR-IIPR, Kanpur
3	IPLPRB-3	Prebreeding line	IPL 406 × IG136667 (ILWL 44; ; *L. tomentosus*)	ICAR-IIPR, Kanpur
4	IPLPRB-4	Prebreeding line	IPL 406 × IG136667 (ILWL 44; ; *L. tomentosus*)	ICAR-IIPR, Kanpur
5	IPLPRB-5	Prebreeding line	IPL 406 × IG136667 (ILWL 44; ; *L. tomentosus*)	ICAR-IIPR, Kanpur
6	IPLPRB-6	Prebreeding line	IPL 406 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur
7	IPLPRB-7	Prebreeding line	IPL 406 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur
8	IPLPRB-8	Prebreeding line	IPL 406 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur
9	IPLPRB-9	Prebreeding line	IPL 406 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur
10	IPLPRB-10	Prebreeding line	IPL 406 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur
11	IPLPRB-11	Prebreeding line	IPL 406 × IG136665 (ILWL 42 *L. tomentosus*)	ICAR-IIPR, Kanpur
12	IPLPRB-12	Prebreeding line	IPL 406 × IG136665 (ILWL 42 *L. tomentosus*)	ICAR-IIPR, Kanpur
13	IPLPRB-13	Prebreeding line	IPL 406 × IG136665 (ILWL 42 *L. tomentosus*)	ICAR-IIPR, Kanpur
14	IPLPRB-14	Prebreeding line	IPL 406 × IG136665 (ILWL 42 *L. tomentosus*)	ICAR-IIPR, Kanpur
15	IPLPRB-15	Prebreeding line	IPL 406 × IG136665 (ILWL 42 *L. tomentosus*)	ICAR-IIPR, Kanpur
16	IPLPRB-16	Prebreeding line	IPL 406 × IG136665 (ILWL 42 *L. tomentosus*)	ICAR-IIPR, Kanpur
17	IPLPRB-17	Prebreeding line	IPL 406 × IG136665 (ILWL 42 *L. tomentosus*)	ICAR-IIPR, Kanpur
18	IPLPRB-18	Prebreeding line	IPL 406 × IG136665 (ILWL 42 *L. tomentosus*)	ICAR-IIPR, Kanpur
19	IPLPRB-19	Prebreeding line	IPL 406 × IG136665 (ILWL 42 *L. tomentosus*)	ICAR-IIPR, Kanpur
20	IPLPRB-20	Prebreeding line	IPL 406 × IG136665 (ILWL 42 *L. tomentosus*)	ICAR-IIPR, Kanpur
21	IPLPRB-21	Prebreeding line	ILWL 135 (*L. Ervoides*) × ILWL 118 (*L. culinaris*)	ICAR-IIPR, Kanpur
22	IPLPRB-22	Prebreeding line	ILWL 135 (*L. Ervoides*) × ILWL 118 (*L. culinaris*)	ICAR-IIPR, Kanpur
23	IPLPRB-23	Prebreeding line	ILWL 135 (*L. ervoides*) × ILWL 118 (*L. culinaris*)	ICAR-IIPR, Kanpur
24	IPLPRB-24	Prebreeding line	ILWL 135 (*L. ervoides*) × ILWL 118 (*L. culinaris*)	ICAR-IIPR, Kanpur
25	IPLPRB-25	Prebreeding line	ILWL 135 (*L. ervoides*) × ILWL 118 (*L. culinaris*)	ICAR-IIPR, Kanpur
26	IPLPRB-26	Prebreeding line	ILWL 97 (*L. culinaris* subsp *orientalis*) × DPL58	ICAR-IIPR, Kanpur
27	IPLPRB-27	Prebreeding line	ILWL 97 (*L. culinaris* subsp *orientalis*) × DPL58	ICAR-IIPR, Kanpur
28	IPLPRB-28	Prebreeding line	ILWL 97 (*L. culinaris* subsp *orientalis*) × DPL58	ICAR-IIPR, Kanpur
29	IPLPRB-29	Prebreeding line	ILWL 97 (*L. culinaris* subsp *orientalis*) × DPL58	ICAR-IIPR, Kanpur
30	IPLPRB-30	Prebreeding line	ILWL 97 (*L. culinaris* subsp *orientalis*) × DPL58	ICAR-IIPR, Kanpur
31	IPLPRB-31	Prebreeding line	ILWL 97 (*L. culinaris* subsp *orientalis*) × IPL 220	ICAR-IIPR, Kanpur
32	IPLPRB-32	Prebreeding line	ILWL 97 (*L. culinaris* subsp *orientalis*) × IPL 220	ICAR-IIPR, Kanpur
33	IPLPRB-33	Prebreeding line	ILWL 97 (*L. culinaris* subsp *orientalis*) × IPL 220	ICAR-IIPR, Kanpur
34	IPLPRB-34	Prebreeding line	ILWL 97 (*L. culinaris* subsp *orientalis*) × IPL 220	ICAR-IIPR, Kanpur
35	IPLPRB-35	Prebreeding line	ILWL 97 (L. culinaris subsp orientalis) × IPL 220	ICAR-IIPR, Kanpur
36	IPLPRB-36	Prebreeding line	IPL 220 × ILWL 118 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
37	IPLPRB-37	Prebreeding line	IPL 220 × ILWL 118 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
38	IPLPRB-38	Prebreeding line	IPL 220 × ILWL 118 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
39	IPLPRB-39	Prebreeding line	IPL 220 × ILWL 118 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur

40	IPLPRB-40	Prebreeding line	IPL 220 × ILWL 118 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
41	IPLPRB-41	Prebreeding line	ILWL 97 (*L. culinaris* subsp *orientalis)* × IG136658 (*L. culinaris* subsp *orientalis)*	ICAR-IIPR, Kanpur
42	IPLPRB-42	Prebreeding line	ILWL 97 (*L. culinaris* subsp *orientalis)* × IG136658 (*L. culinaris* subsp *orientalis)*	ICAR-IIPR, Kanpur
43	IPLPRB-43	Prebreeding line	ILWL 97 (*L. culinaris* subsp *orientalis)* × IG136658 (*L. culinaris* subsp *orientalis)*	ICAR-IIPR, Kanpur
44	IPLPRB-44	Prebreeding line	K75 × ILWL 237 (*L. culinaris* subsp *orientalis)*	ICAR-IIPR, Kanpur
45	IPLPRB-45	Prebreeding line	K75 × ILWL 237 (*L. culinaris* subsp *orientalis)*	ICAR-IIPR, Kanpur
46	IPLPRB-46	Prebreeding line	K75 × ILWL 237 (*L. culinaris* subsp *orientalis)*	ICAR-IIPR, Kanpur
47	IPLPRB-47	Prebreeding line	DPL 15 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur
48	IPLPRB-48	Prebreeding line	DPL 15 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur
49	IPLPRB-49	Prebreeding line	DPL 15 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur
50	IPLPRB-50	Prebreeding line	DPL 15 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur
51	IPLPRB-51	Prebreeding line	ILWL 145 (*L. culinaris* subsp *orientalis)* × DPL 62	ICAR-IIPR, Kanpur
52	IPLPRB-52	Prebreeding line	ILWL 145 (*L. culinaris* subsp *orientalis)* × DPL 63	ICAR-IIPR, Kanpur
53	IPLPRB-53	Prebreeding line	ILWL 145 (*L. culinaris* subsp *orientalis)* × DPL 64	ICAR-IIPR, Kanpur
54	IPLPRB-54	Prebreeding line	ILWL 145 (*L. culinaris* subsp *orientalis)* × DPL 65	ICAR-IIPR, Kanpur
55	IPLPRB-55	Prebreeding line	ILWL 145 (*L. culinaris* subsp *orientalis)* × DPL 66	ICAR-IIPR, Kanpur
56	IPLPRB-61	Prebreeding line	ILWL 118 (*L. culinaris* subsp *orientalis)* × IPL 220	ICAR-IIPR, Kanpur
57	IPLPRB-62	Prebreeding line	ILWL 118 (*L. culinaris* subsp *orientalis)* × IPL 220	ICAR-IIPR, Kanpur
58	IPLPRB-63	Prebreeding line	ILWL 118 (*L. culinaris* subsp *orientalis)* × IPL 220	ICAR-IIPR, Kanpur
59	IPLPRB-64	Prebreeding line	ILWL 118 (*L. culinaris* subsp *orientalis)* × IPL 220	ICAR-IIPR, Kanpur
60	IPLPRB-65	Prebreeding line	ILWL 118 (*L. culinaris* subsp *orientalis)*) × IPL 220	ICAR-IIPR, Kanpur
61	IPLPRB-66	Prebreeding line	IPL 534 × ILWL 126 (*L ervoides*)	ICAR-IIPR, Kanpur
62	IPLPRB-67	Prebreeding line	IPL 534 × ILWL 126 (*L ervoides*)	ICAR-IIPR, Kanpur
63	IPLPRB-68	Prebreeding line	IPL 534 × ILWL 126 (*L ervoides*)	ICAR-IIPR, Kanpur
64	IPLPRB-69	Prebreeding line	IPL 534 × ILWL 126 (*L ervoides*)	ICAR-IIPR, Kanpur
65	IPLPRB-70	Prebreeding line	IPL 534 × ILWL 126 (*L ervoides*)	ICAR-IIPR, Kanpur
66	IPLPRB-71	Prebreeding line	IPL 406 × ILWL 208 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
67	IPLPRB-72	Prebreeding line	IPL 406 × ILWL 208 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
68	IPLPRB-73	Prebreeding line	IPL 406 × ILWL 208 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
69	IPLPRB-74	Prebreeding line	IPL 406 × ILWL 208 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
70	IPLPRB-75	Prebreeding line	IPL 406 × ILWL 208 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
71	IPLPRB-78	Prebreeding line	ILWL 118 (*L. culinaris* subsp *orientalis*) × DPL 58	ICAR-IIPR, Kanpur
72	IPLPRB-79	Prebreeding line	ILWL 118 (*L. culinaris* subsp *orientalis*) × DPL 58	ICAR-IIPR, Kanpur
73	IPLPRB-80	Prebreeding line	ILWL 118 (*L. culinaris* subsp *orientalis*) × DPL 58	ICAR-IIPR, Kanpur
74	IPLPRB-81	Prebreeding line	ILWL 118 (*L. culinaris* subsp *orientalis*) × DPL 58	ICAR-IIPR, Kanpur
75	IPLPRB-82	Prebreeding line	ILWL 118 (*L. culinaris* subsp *orientalis*) × DPL 58	ICAR-IIPR, Kanpur
76	IPLPRB-83	Prebreeding line	ILWL 118 (*L. culinaris* subsp *orientalis*) × DPL 58	ICAR-IIPR, Kanpur
77	IPLPRB-84	Prebreeding line	ILWL 118 (*L. culinaris* subsp *orientalis*) × DPL 58	ICAR-IIPR, Kanpur
78	IPLPRB-85	Prebreeding line	IPL 220 × ILWL 248 (*L. orientalis*)	ICAR-IIPR, Kanpur
79	IPLPRB-86	Prebreeding line	IPL 220 × ILWL 248 (*L. orientalis*)	ICAR-IIPR, Kanpur
80	IPLPRB-87	Prebreeding line	IPL 220 × ILWL 248 (*L. orientalis*)	ICAR-IIPR, Kanpur
81	IPLPRB-88	Prebreeding line	IPL 220 × ILWL 248 (*L. orientalis*)	ICAR-IIPR, Kanpur

82	IPLPRB-89	Prebreeding line	ILWL 443 (*L. orientalis*) × IPL 220	ICAR-IIPR, Kanpur
83	IPLPRB-90	Prebreeding line	ILWL 443 (*L. orientalis*) × IPL 221	ICAR-IIPR, Kanpur
84	IPLPRB-91	Prebreeding line	IPL 406 × ILWL 324 (*L. orientalis*)	ICAR-IIPR, Kanpur
85	IPLPRB-92	Prebreeding line	IPL 406 × ILWL 324 (*L. orientalis*)	ICAR-IIPR, Kanpur
86	IPLPRB-93	Prebreeding line	IPL 406 × ILWL 350 (*L. orientalis*)	ICAR-IIPR, Kanpur
87	IPLPRB-94	Prebreeding line	IPL 406 × ILWL 350 (*L. orientalis*)	ICAR-IIPR, Kanpur
88	IPLPRB-95	Prebreeding line	IPL 406 × ILWL 350 (*L. orientalis*)	ICAR-IIPR, Kanpur
89	IPLPRB-96	Prebreeding line	IPL 406 × ILWL 350 (*L. orientalis*)	ICAR-IIPR, Kanpur
90	IPLPRB-97	Prebreeding line	IPL 406 × ILWL 350 (*L. orientalis*)	ICAR-IIPR, Kanpur
91	IPLPRB-98	Prebreeding line	IG 136655 (*L. orientalis*) × DPL 62	ICAR-IIPR, Kanpur
92	IPLPRB-99	Prebreeding line	IG 136655 (*L. orientalis*) × DPL 62	ICAR-IIPR, Kanpur
93	IPLPRB-100	Prebreeding line	IPLM -08 × ILWL 118 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
94	IPLPRB-101	Prebreeding line	IPLM -08 × ILWL 118 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
95	IPLPRB-102	Prebreeding line	IPL 316 × ILWL 248(*L. orientalis*)	ICAR-IIPR, Kanpur
96	IPLPRB-105	Prebreeding line	IPL 316 × ILWL 248(*L. orientalis*)	ICAR-IIPR, Kanpur
97	IPLPRB-106	Prebreeding line	IPL 316 × IG 135385 (ILWL 66; *L. orientalis*)	ICAR-IIPR, Kanpur
98	IPLPRB-107	Prebreeding line	IPL 316 × IG 135385 (ILWL 66; *L. orientalis*)	ICAR-IIPR, Kanpur
99	IPLPRB-108	Prebreeding line	IPL 406 × ILWL 242 (*L. orientalis*)	ICAR-IIPR, Kanpur
100	IPLPRB-111	Prebreeding line	IPL 406 × ILWL 242 (*L. orientalis*)	ICAR-IIPR, Kanpur
101	IPLPRB-112	Prebreeding line	IPL 406 × ILWL 242 (*L. orientalis*)	ICAR-IIPR, Kanpur
102	IPLPRB-113	Prebreeding line	IPL 406 × ILWL 251(*L. Ervoides*)	ICAR-IIPR, Kanpur
103	IPLPRB-114	Prebreeding line	IPL 406 × ILWL 251(*L. Ervoides*)	ICAR-IIPR, Kanpur
104	IPLPRB-115	Prebreeding line	IPL 406 × ILWL 251(*L. Ervoides*)	ICAR-IIPR, Kanpur
105	IPLPRB-116	Prebreeding line	IPL 406 × ILWL 251(*L. Ervoides*)	ICAR-IIPR, Kanpur
106	IPLPRB-117	Prebreeding line	IPL 406 × ILWL 251(*L. Ervoides*)	ICAR-IIPR, Kanpur
107	IPLPRB-118	Prebreeding line	IPL 406 × ILWL 251(*L. Ervoides*)	ICAR-IIPR, Kanpur
108	IPLPRB-119	Prebreeding line	IPL 406 × ILWL 251(*L. Ervoides*)	ICAR-IIPR, Kanpur
109	IPLPRB-120	Prebreeding line	IPL 406 × ILWL 251(*L. Ervoides*)	ICAR-IIPR, Kanpur
110	IPLPRB-121	Prebreeding line	IPL 406 × ILWL 251(*L. Ervoides*)	ICAR-IIPR, Kanpur
111	IPLPRB-122	Prebreeding line	IPL 406 × ILWL 251(*L. Ervoides*)	ICAR-IIPR, Kanpur
112	IPLPRB-123	Prebreeding line	IPL 406 × ILWL 93 (*L. tomentosus*)	ICAR-IIPR, Kanpur
113	IPLPRB-124	Prebreeding line	IPL 406 × ILWL 93 (*L. tomentosus*)	ICAR-IIPR, Kanpur
114	IPLPRB-125	Prebreeding line	IPL 406 × ILWL 93 (*L. tomentosus*)	ICAR-IIPR, Kanpur
115	IPLPRB-126	Prebreeding line	IPL 406 × ILWL 93 (*L. tomentosus*)	ICAR-IIPR, Kanpur
116	IPLPRB-127	Prebreeding line	IPL 406 × ILWL 93 (*L. tomentosus*)	ICAR-IIPR, Kanpur
117	IPLPRB-128	Prebreeding line	IPL 220 × ILWL 11 (*L. orientalis*)	ICAR-IIPR, Kanpur
118	IPLPRB-129	Prebreeding line	IPL 220 × ILWL 11 (*L. orientalis*)	ICAR-IIPR, Kanpur
119	IPLPRB-130	Prebreeding line	DPL 15 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur
120	IPLPRB-131	Prebreeding line	DPL 15 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur
121	IPLPRB-132	Prebreeding line	DPL 15 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur
122	IPLPRB-133	Prebreeding line	DPL 15 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur
123	IPLPRB-134	Prebreeding line	DPL 15 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur
124	IPLPRB-135	Prebreeding line	DPL 15 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur

125	IPLPRB-136	Prebreeding line	DPL 15 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur
126	IPLPRB-137	Prebreeding line	DPL 15 × IG136667 (ILWL 44; *L. tomentosus*)	ICAR-IIPR, Kanpur
127	IPLPRB-138	Prebreeding line	IPL 406 × ILWL 208 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
128	IPLPRB-139	Prebreeding line	IPL 406 × ILWL 208 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
129	IPLPRB-140	Prebreeding line	IPL 406 × ILWL 208 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
130	IPLPRB-141	Prebreeding line	IPL 406 × ILWL 208 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
131	IPLPRB-142	Prebreeding line	IPL 406 × ILWL 208 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
132	IPLPRB-143	Prebreeding line	IPL 406 × ILWL 208 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
133	IPLPRB-144	Prebreeding line	IPL 406 × ILWL 208 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
134	IPLPRB-145	Prebreeding line	IPL 406 × ILWL 208 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
135	IPLPRB-146	Prebreeding line	IPL 406 × ILWL 208 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
136	IPLPRB-147	Prebreeding line	IPL 406 × ILWL 208 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
137	IPLPRB-148	Prebreeding line	IPL 220 × ILWL 145 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
138	IPLPRB-149	Prebreeding line	IPL 220 × ILWL 145 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
139	IPLPRB-150	Prebreeding line	*IPL 220 × ILWL 145 (L. culinaris* subsp *orientalis)*	ICAR-IIPR, Kanpur
140	IPLPRB-151	Prebreeding line	IPL 526 × ILWL 248 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
141	IPLPRB-152	Prebreeding line	IPL 526 × ILWL 248 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
142	IPLPRB-153	Prebreeding line	IPL 526 × ILWL 248 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
143	IPLPRB-154	Prebreeding line	IPL 526 × ILWL 248 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
144	IPLPRB-155	Prebreeding line	IPL 526 × ILWL 248 (*L. culinaris* subsp *orientalis*)	ICAR-IIPR, Kanpur
145	IG-129185	Land race	Egypt	ICARDA, Rabat
146	IG-129287	Land race	Egypt	ICARDA, Rabat
147	IG-129291	Land race	Egypt	ICARDA, Rabat
148	IG-129293	Land race	Egypt	ICARDA, Rabat
149	IG-129302	Land race	Egypt	ICARDA, Rabat
150	IG-129304	Land race	Egypt	ICARDA, Rabat
151	IG-129309	Land race	Egypt	ICARDA, Rabat
152	IG-129313	Land race	Egypt	ICARDA, Rabat
153	IG-129315	Land race	Egypt	ICARDA, Rabat
154	IG-129317	Land race	Egypt	ICARDA, Rabat
155	IG-129319	Land race	Egypt	ICARDA, Rabat
156	IG-129370	Land race	Egypt	ICARDA, Rabat
157	IG-129372	Land race	Egypt	ICARDA, Rabat
158	IG-2352	Land race	Egypt	ICARDA, Rabat
159	IG-70238	Land race	Egypt	ICARDA, Rabat
160	IG-71487	Land race	Egypt	ICARDA, Rabat
161	IG-129560	Land race	Ethiopia	ICARDA, Rabat
162	IG-69502	Land race	Ethiopia	ICARDA, Rabat
163	IG-69522	Land race	Ethiopia	ICARDA, Rabat
164	IG-69546	Land race	Ethiopia	ICARDA, Rabat
165	IG-69549	Land race	Ethiopia	ICARDA, Rabat
166	IG-69568	Land race	Ethiopia	ICARDA, Rabat
167	IG-70174	Land race	Ethiopia	ICARDA, Rabat

168	IG-936	Land race	Ethiopia	ICARDA, Rabat
169	IG-134327	Land race	Iran	ICARDA, Rabat
170	IG-134342	Land race	Iran	ICARDA, Rabat
171	IG-134349	Land race	Iran	ICARDA, Rabat
172	IG-134356	Land race	Iran	ICARDA, Rabat
173	IG-136607	Land race	Iran	ICARDA, Rabat
174	IG-2159	Land race	Iran	ICARDA, Rabat
175	IG-2190	Land race	Iran	ICARDA, Rabat
176	IG-223	Land race	Iran	ICARDA, Rabat
177	IG-2284	Land race	Iran	ICARDA, Rabat
178	IG-2287	Land race	Iran	ICARDA, Rabat
179	IG-2294	Land race	Iran	ICARDA, Rabat
180	IG-2334	Land race	Iran	ICARDA, Rabat
181	IG-2374	Land race	Iran	ICARDA, Rabat
182	IG-2385	Land race	Iran	ICARDA, Rabat
183	IG-2413	Land race	Iran	ICARDA, Rabat
184	IG-71352	Land race	Iran	ICARDA, Rabat
185	IG-49	Land race	Iraq	ICARDA, Rabat
186	IG-53	Land race	Iraq	ICARDA, Rabat
187	IG-54	Land race	Iraq	ICARDA, Rabat
188	IG-13	Land race	Jordan	ICARDA, Rabat
189	IG-130033	Land race	Jordan	ICARDA, Rabat
190	IG-2	Land race	Jordan	ICARDA, Rabat
191	IG-20	Land race	Jordan	ICARDA, Rabat
192	IG-21	Land race	Jordan	ICARDA, Rabat
193	IG-2148	Land race	Jordan	ICARDA, Rabat
194	IG-4365	Land race	Jordan	ICARDA, Rabat
195	IG-4913	Land race	Jordan	ICARDA, Rabat
196	IG-5069	Land race	Jordan	ICARDA, Rabat
197	IG-5187	Land race	Jordan	ICARDA, Rabat
198	IG-5190	Land race	Jordan	ICARDA, Rabat
199	IG-5305	Land race	Jordan	ICARDA, Rabat
200	IG-5320	Land race	Jordan	ICARDA, Rabat
201	IG-5360	Land race	Jordan	ICARDA, Rabat
202	IG-7	Land race	Jordan	ICARDA, Rabat
203	IG-73798	Land race	Jordan	ICARDA, Rabat
204	IG-73802	Land race	Jordan	ICARDA, Rabat
205	IG-73816	Land race	Jordan	ICARDA, Rabat
206	IG-9	Land race	Jordan	ICARDA, Rabat
207	IG-129214	Land race	Lebanon	ICARDA, Rabat
208	IG-2272	Land race	Lebanon	ICARDA, Rabat
209	IG-2276	Land race	Lebanon	ICARDA, Rabat
210	IG-2280	Land race	Lebanon	ICARDA, Rabat

211	IG-482	Land race	Lebanon	ICARDA, Rabat
212	IG-485	Land race	Lebanon	ICARDA, Rabat
213	IG-842	Land race	Lebanon	ICARDA, Rabat
214	IG-843	Land race	Lebanon	ICARDA, Rabat
215	IG-111991	Land race	Morocco	ICARDA, Rabat
216	IG-111996	Land race	Morocco	ICARDA, Rabat
217	IG-112078	Land race	Morocco	ICARDA, Rabat
218	IG-112108	Land race	Morocco	ICARDA, Rabat
219	IG-112128	Land race	Morocco	ICARDA, Rabat
220	IG-112131	Land race	Morocco	ICARDA, Rabat
221	IG-112137	Land race	Morocco	ICARDA, Rabat
222	IG-130219	Land race	Morocco	ICARDA, Rabat
223	IG-130272	Land race	Morocco	ICARDA, Rabat
224	IG-71432	Land race	Morocco	ICARDA, Rabat
225	IG-71433	Land race	Morocco	ICARDA, Rabat
226	IG-71434	Land race	Morocco	ICARDA, Rabat
227	IG-71456	Land race	Morocco	ICARDA, Rabat
228	IG-97	Land race	Morocco	ICARDA, Rabat
229	IG-26	Land race	Syria	ICARDA, Rabat
230	IG-29	Land race	Syria	ICARDA, Rabat
231	IG-41	Land race	Syria	ICARDA, Rabat
232	IG-4448	Land race	Syria	ICARDA, Rabat
233	IG-4481	Land race	Syria	ICARDA, Rabat
234	IG-4545	Land race	Syria	ICARDA, Rabat
235	IG-71519	Land race	Syria	ICARDA, Rabat
236	IG-71531	Land race	Syria	ICARDA, Rabat
237	IG-71603	Land race	Syria	ICARDA, Rabat
238	IG-71646	Land race	Syria	ICARDA, Rabat
239	IG-71650	Land race	Syria	ICARDA, Rabat
240	IG-71651	Land race	Syria	ICARDA, Rabat
241	IG-71685	Land race	Syria	ICARDA, Rabat
242	IG-71710	Land race	Syria	ICARDA, Rabat
243	IG-73717	Land race	Syria	ICARDA, Rabat
244	IG-73920	Land race	Syria	ICARDA, Rabat
245	IG-73933	Land race	Syria	ICARDA, Rabat
246	IG-109039	Land race	Turkiye	ICARDA, Rabat
247	IG-114	Land race	Turkiye	ICARDA, Rabat
248	IG-115	Land race	Turkiye	ICARDA, Rabat
249	IG-116551	Land race	Turkiye	ICARDA, Rabat
250	IG-149	Land race	Turkiye	ICARDA, Rabat
251	IG-161	Land race	Turkiye	ICARDA, Rabat
252	IG-163	Land race	Turkiye	ICARDA, Rabat
253	IG-195	Land race	Turkiye	ICARDA, Rabat

254	IG-2226	Land race	Turkiye	ICARDA, Rabat
255	IG-334	Land race	Turkiye	ICARDA, Rabat
256	IG-539	Land race	Turkiye	ICARDA, Rabat
257	IG-5431	Land race	Turkiye	ICARDA, Rabat
258	IG-70203	Land race	Turkiye	ICARDA, Rabat
259	IG-70208	Land race	Turkiye	ICARDA, Rabat
260	IG-70233	Land race	Turkiye	ICARDA, Rabat
261	IG-73945	Land race	Turkiye	ICARDA, Rabat

Table 2. Disease (wilt) incidence (%) in the lentil genotypes observed in the present study

S. No.	Genotype	Wilt incidence %				Mean wilt incidence (%)	Disease reaction*
		2018-19	2019-20	2020-21	2021-22		
1.	IPLPBR-1	7.89	8.45	8.57	9.23	8.5	R
2.	IG 54	8.19	8.89	8.3	9.90	8.8	R
3.	L9-12 (Susceptible check)	83.4	81.9	87.7	92.4	86.4	HS
4.	K 75 (Susceptible check)	84.45	82.455	82.14	79.1	82.0	HS
5.	Sehore 74-3 (Susceptible check)	80.34	76.00	80.3	77.4	79.0	HS
6.	Other lines	12.45-90.56	15.25-87.16	11.98-83.62	16.45-78.39		MR*-HS

*Disease reaction: R=resistant, MR=moderately resistant, HS=highly susceptible

wild species/sub-species for *Fusarium oxysporum* f. sp. *lentis* (Fol) resistance resulted in the identification of resistant wild accessions (Gupta and Sharma, 2006). Moreover, wild species and landraces have been reported to have alien genes that control resistance in lentil. The availability of these highly resistant donors for FW provides an opportunity to know the inheritance of wilt resistance in lentil in a biparental mapping population. Kamboj *et al.* (1990) have reported five independent genes to confer resistance to fusarium wilt in lentil. A study based on an allelism test, identified 2 genes each of duplicate genes and complementary genes imparting resistance in the variety PL 234, JL 446, and PL 286, respectively (Eujayl *et al.,* 1998). Therefore, the present study aimed to identify the Fusarium wilt resistance genotypes in lentil under natural wilt sick conditions.

In the present study, 144 pre-breeding lines derived from crosses involving accessions of *Lens curlinaris* subsp. *orientalis* and *L. curlinaris* subsp. *tomentosus* along with 117 Mediterranean landraces and three susceptible checks L9-12, K75 and Sehore 74-3 were screened under a wilt sick plot at ICAR-IIPR, Kanpur. These genotypes were evaluated under natural conditions with appropriate crop geometry, i.e. row-to-row and plant-to-plant distances of 30 and 10 cm, respectively. To maintain adequate disease pressure in trials, the highly susceptible local cultivar (L-9-12) was planted after every fifth row of testing material. High wilt incidence (>80%) in susceptible checks ensured that the epiphytotic conditions prevailed in the field used to screen the test genotypes.

Data on the incidence of wilt disease on test entries were recorded under field conditions. Wilt-infected total plant counts were made, and the proportion of affected plants of each genotype was calculated at different growth stages of the crop. For every genotype, aggregate disease-incidence data were used for analysis. Based on wilt incidence, test entries or genotypes were categorized as resistant (1–10% mortality), moderately resistant (11–20%), susceptible (21–50%), and highly susceptible (>50% mortality) as suggested by Haware and Nene (1982). The appearance of wilt symptoms, and the percentage of wilted plants was recorded following the method proposed by Bayaa and Erskine (1990).

The following formula was used to calculate wilt disease incidence

Disease incidence (%) = Total number of plants examined/ No. of plants infected × 100

The screening of 144 pre-breeding lines derived from crosses involving accessions *of Lens curlinaris* subsp. *orientalis* and *L. curlinaris* subsp. *tomentosus* and 117 Mediterranean landraces of lentil under wilt sick plot resulted in the identification of a highly resistant pre-breeding line IPLPBR-1 [IPL 406 (*L. culinaris* subsp. *culinaris*) × IG 136667 (ILWL 44; *L. curlinaris* subsp. *tomentosus*)] and a Mediterranean landraces IG 54 with a resistance level of <10% (Table 2). These genotypes were tested for over four years under similar wilt sick plots which showed an average wilt incidence ranging from 8.5% to 8.8% in resistant genotypes while it was observed from 82.0 to 86.4% in susceptible check genotypes. The other genotypes showed moderate resistance to high susceptibility against the Kanpur isolate of the *Fusarium* wilt in the present study. In a recent study, 20 lentil genotypes were evaluated for fusarium wilt across six diverse geographical locations (i.e. Durgapura Faizabad Pantnagar Ranchi Sehore Shillongani) in India where lentil is largely cultivated. A high proportion of environmental variance (54.68%) accounted for the total variation of wilt disease incidence in this study, while G × E interaction accounted for 17.32% of the variation, suggesting the need for evaluation of the genotypes at multi-locations over multiple years (Parihar *et al.*, 2017). Thus present genotypes showed consistently low disease incidence over the years and are valuable for use in any effective resistance-breeding programs (Sharma and Duveiller, 2007; Sharma *et al.*, 2012). The availability of these resistant donors for FW provides an opportunity for knowing the inheritance of wilt resistance in lentil in a biparental mapping population derived from crossing between highly resistant donors (IPLPBR-1 and IG 54) and highly susceptible genotype L 9-12 and markers associated with Fusarium wilt resistance genes can be identified in lentil as two SSR markers, PBALC203 and PBALC1409 flanking the wilt resistance gene at 8.2 cM and 9.4 cM distance, respectively were identified in an earlier study (Meena *et al.*, 2023). This knowledge can further be utilized in lentil breeding programs for developing fusarium wilt-resistant cultivars and molecular tagging of FW-resistant genes can help to introgress the wilt-resistance genes more rapidly and precisely in the background of improved cultivars through molecular markers as compared to the conventional recombination breeding approach.

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