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LENTIL GERMPLASM: EVALUATION AND UTILIZATION—A REVIEW

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ABSTRACT

Lentil germplasm has been evaluated against a number of diseases and insect pests, and also for morphological and yield traits. Donors have been identified against all the major diseases and some of these are resistant to two to three diseases. There is a need to screen still larger number of germplasm accessions against insect pests and abiotic stresses. Exotic lines may be used to transfer the bold seed character to the indigenous cultivars.

Key words: *Lens culinaris*, germplasm, stress resistance.

Lentil is considered to be the oldest and a widely adapted pulse crop the world over. It is grown in India, Pakistan, Bangladesh, Nepal, Egypt, Greece, Italy, countries in the Mediterranean basin, Switzerland, Latin American countries, Canada and U.S.A. In India, it is grown in 1.188 million ha area and produces 0.851 million tonnes of dry grain [1].

So far, 25 varieties of lentil have been released in India. Of these, 17, 5 and 3 varieties have been developed by selection from landraces, hybridization, and induced mutations, respectively. Most of the released varieties are small seeded, with 1000-seed weight ranging from 15 to 20 g. Many of these are susceptible to one or more diseases. To increase yield and seed size further, combined with resistance to biotic and abiotic factors, the agronomically superior cultivars and other suitable donors may be selected as parents for hybridization. In this article, an attempt is made to review the current status of genetic resources available and to suggest the possible ways of using them in an ongoing breeding programme.

VARIATION FOR RESISTANCE TO STRESSES

Resistance to diseases. The most serious and ubiquitous diseases of lentil crop are root rot, collar rot, blight and powdery mildew [2–4]. The wilt and rust diseases also cause considerable losses in yield in certain areas. Yield losses of up to 60–69% due to rust disease have been reported in India [5]. *Fusarium* wilt may cause losses upto 50% in some cases [6]. Screening for resistance against important diseases has been carried out by different workers and sources of resistance are reported (Table 1).

In India, Sandhu and Malhotra [7] screened germplasm against wilt, blight and rust [7, 8], and the resistant lines reported by them to these diseases are listed in Table 1. During preliminary screening of 138 lentil cultivars at two locations in Punjab under field conditions, the strains LG-13, LG-41, LG-103, LG-112, LG-120, Pant L-406, Pant L-639, LL-19, LL-30, LL-56, LL-72 and LL-78 were found resistant to rust at both locations [9]. Three hundred six advanced breeding lines and 1147 germplasm accessions were also tested at two locations for two years in Punjab for blight (*Ascochyta lentis*). Two varieties, HPL-5 and

Table 1. Sources of resistance to diseases in lentil

Disease	Line(s)/Cultivar(s)	Reference
Wilt (*Fusarium oxysporum* f. sp. *lentis* (Snyder & Hensen)	LG-8, JL-33, LP-145, -199, Pusa-6-9, Pant L-209, -220, P-43, UPL-1	[4, 7]
	Pant L-234, -639	[14]
Wilt (*Ozononium Texanum* var. *parasiticum*)	BR-75, Pusa-1, LP-350	[15]
Collar rot (*Sclerotium rolfsii* (Sacc.) Curzi)	Pusa-1, LP-18, Pant L-639	[15]
Blight (*Ascochyta lentis* Bond & Vassil)	LG-169, -170, -172, -173, -174, -186, -191, -204, -209, -210, Precoz	[16]
	Precoz	[11]
	HPL-5, LG-171, L-442, -448	[9]
Blight (*Ascochyta fabae*)	SS-159, L-3328, Precoz x 830-2, Precoz x L-830,	[10]
	Precoz x 74TA 9, ILL-5562 x ILL-936, LL-858, Lenka, 78S26018, 78S26052, FLTP-84-43, L-84-85L,-84-55L,-84-27L-86-12L-86-49L	[12]
	LL-26, -27, -56, -57	[7]
Rust (*Uromyces fabae* Pers. de Bary)	LG-169, -170, -171, -172, -173, -174 -175, -176	[17]
	Pant L-234, -639	[7]
	C-31, HY 1-1, NP-47, T-36, No. 10511, -10526, -10465, -10475, -10495, -10502, -10506, -10507	[18]
	LG-13, -41, -60, -103, -108, -112, -120	[6]
	Pant L-406, -639, LL-56, -72, -78	
	Pant L-406, -639, LG-120, UPL-175	[19]
	E 153, -258	
		D. P. Singh (unpublished)

LG-171, and two lines, L-442 and L-448, recorded a disease score of 1.0 for two subsequent years and were considered to be highly resistant [10]. Under natural epiphytotic conditions, 105 genotypes were evaluated for resistance against blight (*A. fabae* sp. *lentis*) in Himachal Pradesh. At podding stage, none of the lines showed resistance. Of these, only two genotypes, SS-159 and L-3328, were moderately resistant [11].

Out of 152 genotypes tested for blight (*A. lentis*) in Pakistan, 15 cultivars were reported to be highly resistant (Table 1) and 40 resistant. Precoz was found highly resistant to blight. The genotypes derived from the crosses with Precoz as a parent showed the same reaction [12].

Twenty nine exotic accessions/cultivars were screened for resistance to pea enation mosaic virus (PEMV). All the 29 lines were susceptible and showed significant reduction in plant height and biological yield when inoculated mechanically. PI-47547 and PI-472609 were identified as tolerant based on the lower disease scores obtained when the lines were inoculated by aphids. Also, these two lines showed significantly less reduction in plant height and biological yield attributable to virus infection than the other 27 lines. The tolerant lines identified may provide germplasm for breeding improved cultivars [13].

Some of the lines presented in Table 1 are resistant to two or three diseases. Pant L-234 and Pant L-639 are resistant to rust and wilt diseases. Pant L-639 is also resistant to collar rot. LG-169, LG-170, LG-172, LG-173 and LG-174 are resistant to blight and rust diseases. These lines can be used to develop varieties with multiple disease resistance.

Resistance to insect pests. The most important insect pests of lentil are pod borer (*Etiella zinckenella*), cowpea aphid (*Aphis craccivora* Koch.), pea aphid (*Acyrthosiphon pisum* Harris), weevils (*Stona lineatus* L.) and bruchids. However, very limited work on the screening for resistance to insect pests has been conducted.

The late flowering cultivars were more resistant than the early flowering cultivars to bruchids. The varietal order of resistance was LL-56 > Pant L-406 > 19-12 > Pant L-639 > a local large seeded cultivar [20]. P-942 and P-202 were resistant to pod borer [7].

Eight varieties were studied for the incidence of aphid (*Aphis craccivora* Koch.). Of these, K-333 had the lowest pest infestation (8.6–9.8 aphids/plant), whereas variety Pant L-639 proved to be highly susceptible to the pest (33.3–40.0 aphids/plant) [21].

Resistance to abiotic stress. Abiotic stresses are a major obstacle to lentil production in arid and semiarid regions of the world. Of these, soil temperature and water stresses are important.

In the field trials with six cultivars on a zinc-deficient sandy loam calcareous soil applied with 0, 5 or 10 kg Zn/ha, DL 77-2 was found to be the most tolerant variety to Zn deficiency as it gave similar seed yields of 2.02–2.08 tonnes/ha with and without applied Zn [22].

Salt tolerance to 133 accessions was assessed at germination and seedling stages [23]. Differences among the genotypes were significant for both parameters. In the, NaCl treatment, five accessions, namely, ILL-5845, ILL-6451, ILL-6788, ILL-6793 and ILL-6796, were found to be better than others. High estimates of broad sense heritability suggest that improvement for salt tolerance is possible in lentil.

The genotypes LL-147, LL-56, LL-265, LG-224, LG-186 were tolerant to terminal heat stress under normal planting. Genotypes L 9-12, LG-128 and LG-178 showed moderate tolerance [24]. The tolerant genotypes had a high percentage of inflorescences and with two pods set whereas the moderately tolerant lines had a higher percentage of inflorescences with one pod set per peduncle.

VARIATION FOR YIELD COMPONENTS AND YIELD

Natural variation. Erskine [25] evaluated 4500 accessions at the International Centre for Agricultural Research in the Dry Areas for morphological and agronomical characters. A wide range of variation was recorded for yield and yield components. In addition to the characters presented in Table 2, he reported a wide range for grain yield (10–3257 kg/ha) and biological yield (78–10382 kg/ha).

Two hundred early maturing lines from seven countries (India, Ethiopia, Egypt, Pakistan, Yemen, Turkey and USSR) were evaluated in Bangladesh [26]. A wide range of variation was found for yield/plant, 100-seed weight, plant height, days to flower and maturity, and the range and coefficient of variation were 0.10–1.93, 48.7%; 1.3–3.8, 2.9%, 34.2–54.2, 10.9%, 103–140, 31.9%; and 53–85, 97%, respectively. Zaman et al. [27] evaluated variability in 190 collections from Bangladesh (Table 2).

In India, several workers [28–36] have evaluated indigenous germplasm collections for yield, yield components and also for seed impermeability of water (hard seed), and germinability [29]. A wide range of variation was observed for all the characters except seed weight (Table 2). Some of the desirable lines, based on these studies, are listed in Table 3. The bolder seed size to these lines can be transferred from exotic lines [25, 35]. Important bold seeded lines are given in Table 4 [33, 37]. The 1000-seed weight of these lines is 26–73 g and maturity ranges from 116 to 146 days.

Induced variation. Induced mutations could supplement the natural variation available in lentil. Three thousand lines developed through induced mutations were studied [38] for seed size, seed colour, and flowering time. Their 1000-seed weight ranged from 11.5–74.5 g. A number of seed colours were also reported. The flowering time ranged from 60 to 160

Table 2. Variation for yield and important yield components in lentil reported by different workers

Character	Eraskine [25]	Zaman et al. [27]	Singh and Singh [35]	Pandey et al. [34]
Days to flower	—	50–60 (13.5)	56–97 (2.32)	41–117 (5.38)
Days to 50% flowering	118–162	—	60–104 (2.26)	—
Days to maturity	154–197	98–120 (5)	—	—
Plant height (cm)	10–45	33.5–50.2 (14.7)	10–38 (9.43)	18.3–58.7 (11.94)
Pods/plant	—	50.3–190.4 (58.1)	10–255 (7.26)	19.0–617.2 (30.88)
Pods/peduncle	1.01–1.7	—	—	—
Primary branches/plant	—	1.6–3.2 (1.6)	—	2.2–6.0 (3.74)
Seeds/pod	1.0–2.0	1.2–2.0 (10.3)	—	1.0–2.0 (10.39)
Hundred seed weight (g)	1.07–8.55	1.4–2.8 (21.9)	1.3–6.2 (8.80)	1.1–4.2 (7.72)
Yield/plant (g)	—	1.7–4.1 (64.0)	0.32–13.52 (20.97)	0.75–14.89 (32.61)

Note. Figures in parentheses are the coefficients of variation.

days. However, 75% of all the lines flowered in 80–120 days after sowing. Tyagi and Gupta [39] studied the spectrum and frequency of macromutations in M_2 and M_3 populations of gamma rays and ethyl methane sulphonate (EMS) treated Pant L-639. The spectrum of macromutations was found to be wider in EMS than in the gamma-ray treatments.

Desirable lines for yield and yield components. An array of superior lines for different morphological and yield characters have been reported (Table 3). Some of these are exotic types. The crosses of indigenous and exotic types will throw higher number of transgressive segregants, combining resistance to stresses and bolder seed size. The lines with early seedling vigour could be used for developing cultivar(s) suitable for late planting situations, particularly after the harvest of rice.

Conclusions and suggestions. From the evaluation/screening studies conducted so far, the following conclusions can be made.

(i) Sufficient genetic variation is available for resistance to diseases. Some of the lines are also resistant to two to three diseases. They may be used in the hybridization programme.

(ii) More studies may be taken up on screening for resistance to insect-pests and to the abiotic stresses.

(iii) Wide range of variation to yield components and morphological characters is reported.

Table 3. Desirable lines of lines as donors for yield and yield components

Character	Lines	Reference
Seedling viguor	SD 1-55, -118, -180, -231, -243A EC-267706,-267669	[36]
Earliness	Ranjan SL-143 E-153	[33] [33] [35]
Higher number of primary branches/plant	KL-154	[33]
Podding from lower internode	LL 77-12	[33]
Multipodded (4 pods/peduncle)	P307, P-419	[4, 7]
Seeds/pod	MRP-83, EC-267589, L 266	[36]
Higher number of pods/plant	SD 1-316, -2-90, -156, -202, D 2-84, U 22-35, -30, EC-241474, -267584, -255486, -267608, -267613, -267646, -267661, -267664, -225490	[36]
Higher yield/plant	LL-278, L-4078, EC-157015	[33]
Seed weight	E 258 P-435, -424-, -36, -30, -28 ILL-4354, -4349, -254, -19, -752, -112, -20, -8, -9, 80S 41139, ILL-4820, -6813, -6464, -6465, -6466, -6210, -6037, -6036, -6007, -6008, -6004, -6000	[35] [7] [37]
Stable performance	LL-19, L 9-12, Pant L-406	[4, 7]
Good general combiner for yield	B-18, T-36, L 9-12, LL-3, -5, PS-43, P-927, Pant L-202	[4, 7]

The germplasm accessions from India, are generally small seeded type. The exotic lines in general are late. Some of these, however, are bold seeded and are also resistant to disease(s). Precoz, a line, from Argentina is being used by many breeders in India. It is resistant to rust and blight diseases.

E-153 was found to be resistant to rust at Faizabad as well as Pantnagar. E-258, a line from Turkey, is bold seeded (42.5 g/1000 seeds) and is also tolerant to lentil rust. The hybridization involving such exotic lines and indigenous ones may be attempted, to recover segregants with disease resistance, bold seed size and high yielding ability.

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