Sources of winter hardiness in wild lentil

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Summary

In high altitude areas (> c. 850 m elevation) in west Asia and north Africa, lentil (Lens culinaris) is grown as a spring crop to avoid severe winter cold. But late fall-sown lentil with winter hardiness has higher yield potential in these areas. In this study a total of 245 accessions of wild lentil, 10 of cultivated lentil and three accessions of Vicia montbretii (syn. L. montbretii) were evaluated for winter hardiness in Syria and Turkey during the 1991/92 season. The absolute minimum temperatures were –16 °C in Syria and –18.9 °C in Turkey and the susceptible indicators were killed at both locations showing that the cold was sufficient for screening. Although winter hardiness was assessed as percentage of survived plants in Syria and as a visual damage rating on a 1–9 scale in Turkey, there was agreement between the winter hardiness ratings with a correlation of r = –0.56, P < 0.001. Accessions of L. culinaris ssp. orientalis exhibited the highest level of winter hardiness, on average; whereas accessions of L. nigricans ssp. ervoides were the most susceptible. Correlations revealed that winter hardiness was concentrated among accessions originating from high elevation areas.

Introduction

In west Asia and north Africa lentil (Lens culinaris Medikus) is grown as a spring crop at elevations above c. 850 m above sea level due to the severe winter cold (ICARDA, 1989). Experiments in Turkey have shown that autumn-sown lentil can yield 50–100% more than the traditional spring sowing using cultivars with winter hardiness (Sakar et al., 1988). Clearly, winter-hardiness is a key objective in breeding highland lentils (ICARDA, 1991). Sources of cold resistance have been identified in the world collection of cultivated lentil (Erskine et al., 1981), and winter hardy lentils have been released in Turkey (Sakar et al., 1988) and in the U.S.A. (Spaeth & Muehlbauer, 1991).

Alternative sources of winter hardiness have not been sought among wild lentils. At ICARDA, as part of the systematic evaluation of wild lentil genetic resources for key stresses, this study was conducted to evaluate the wild species of the genus Lens Miller for winter hardiness for potential use to further improve the trait.

Materials and methods

A total of 255 accessions representative of the subspecies of the genus Lens, in addition to three accessions of Vicia montbretii Fisch. et Mey. (syn. L. montbretii (Fisch. et Mey.) Davis et Plitm; Ladizinsky & Sakar, 1982) were selected from the germplasm collection at ICARDA, primarily on the basis of diversity of origin (Table 1). For the cultivated lentil, selection also covered the known spectrum of winter hardiness. The Lens subspecies were L. culinaris Medik ssp. cultinaris (the cultigen), ssp. orientalis (Boiss.) Ponert and ssp. odemensis Lad. and L. nigricans (M.B.) Godr. ssp. nigricans and ssp. ervoides (Brign.) Lad. (Ladizinsky et al., 1984). The coordinates of collection locations were traced on topographic maps to find the approximate altitudes of the origins for the wild accessions studied. The origins of the accessions ranged from sea level to an elevation of approximately 2000 m.

An experiment was grown at two locations during the winter of 1991/92. The locations were Maader, Syria (33° 42’N, 36° 08’E; 1400 m above sea level)
Table 1. Number of accessions studied of different subspecies of the genus *Lens* and the mean altitude (m above sea level) of their collection locations, together with a listing of the countries represented.

<table>
<thead>
<tr>
<th>Species/subspecies</th>
<th>Acc. no.</th>
<th>Average altitude</th>
<th>Countries represented</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>L. culinaris</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ssp. <em>culinaris</em></td>
<td>10</td>
<td></td>
<td>ARG, CSK, EGY, ETH, IND, JOR, SDN</td>
</tr>
<tr>
<td>ssp. <em>orientalis</em></td>
<td>85</td>
<td>810</td>
<td>CYP, JOR, SYR, SUN, TUR</td>
</tr>
<tr>
<td>ssp. <em>odemensis</em></td>
<td>37</td>
<td>810</td>
<td>SYR, TUR, UN</td>
</tr>
<tr>
<td><em>L. nigricans</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ssp. <em>nigricans</em></td>
<td>34</td>
<td>420</td>
<td>ESP, FRA, ITA, SUN, TUR, YUG</td>
</tr>
<tr>
<td>ssp. <em>ervoides</em></td>
<td>89</td>
<td>480</td>
<td>SYR, TUR, SUN, YUG</td>
</tr>
</tbody>
</table>


and Haymana, Turkey (39° 50'N, 32° 40'E; 1050 m above sea level). Fertilizer at 50 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and 30 kg N ha<sup>-1</sup> was soil-incorporated prior to sowing. Wild lentil seeds were scarified. The experiment was in a randomized complete block design with two replications. Twenty seeds of each accession were sown in single-row plots 1 m long with an inter-row spacing of 30 cm on 20 October 1991 at Maader and 15 October 1991 at Haymana. Rows of susceptible indicators to cold of cv. Precoz (ILL 4605) in Maader and cv. Malazgirt '89 (ILL 1384) in Haymana were sown every tenth plot. In addition, the cold-tolerant lentil check (ILL 4400) was also repeated every ten plots at Maader. Plots were weeded by hand and no diseases or insects were observed. *Rhizobium* inoculation was not made, but nodulation was adequate throughout.

Winter hardiness was measured by two methods. At Maader, emerged plants were counted in each plot before the onset of severe winter cold (20 November 1991); then the number of survived plants were counted after winter (13 April 1992). The percentage of survived to emerged plants was calculated and accessions classified according to percentage survival using a 1–5 scale (Singh et al., 1984), where 1 = 100% survival (highly tolerant); 2 = 67–99% (tolerant); 3 = 34–66% (medium tolerant); 4 = 1–33% (susceptible); 5 = 0% (highly susceptible).

At Haymana, winter-hardiness was assessed by a visual rating of plant damage on a scale of 1 to 9, as used by Singh et al. (1989) in chickpea, scored after the susceptible check was killed. In this scale, 1 = no visible symptoms of damage; 2 = highly tolerant (<10% of leaflets show withering and drying; no plants killed); 3 = tolerant (11–20% of leaflets show withering; <20% of branches show withering and drying; no plants killed); 4 = moderately tolerant (21–40% of leaflets and <20% of branches show withering and drying; no plants killed); 5 = intermediate (41–60% of leaflets and 21–40% of branches show withering and drying; <5% plants killed); 6 = moderately susceptible (61–80% of leaflets and 41–60% of branches show withering and drying; 6–25% plants killed); 7 = susceptible (81–99% of leaflets and 61–80% of branches show withering and drying; 26–50% plants killed); 8 = highly susceptible (81–99% of leaflets and 81–99% of branches show withering and drying; 51–99% plants killed); and 9 = 100% plants killed.

Data were analyzed by analysis of variance and sub-species means were compared by Tukey's honestly significant difference test (Petersen, 1985).

Results

There was severe cold during the growing season at both locations with the mean minimum monthly temperatures sub-zero from December through March. At Maader, 95 frost days occurred between the early vegetative growth stage in December and flowering in April, and there was an absolute minimum temperature of −16 °C. Haymana was even colder than Maader with more frosty days (109 days) and a lower absolute minimum temperature of −18.9 °C. There was snow cover during the coldest period at both sites.

All plants of the susceptible checks were killed at both locations, indicating that the winter cold was suf-