Frost tolerance in winter wheat genotypes evaluated in Aral Sea cold zone in Central Asia

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Introduction

Winter wheat production is directly linked to food security in Central Asia. Frost is an important constraint to winter wheat in Aral Sea zone of Central Asia encompassing parts of Uzbekistan, Turkmenistan and Kazakhstan. Most of the commercial varieties of winter wheat in the region lack adequate level of frost tolerance, which can occur any time between mid December to early March. There is an urgent need to identify frost tolerant improved varieties to increase productivity, and bring additional area under wheat cultivation to improve food security.

Objective

To identify improved winter wheat genotypes with frost tolerance for the Aral Sea cold zone in Central Asia

Materials and methods

Three field experiments were conducted using more than 335 experimental lines and released cultivars of winter wheat in the Aral Sea Action Site (Figure 1) of the CGIAR Research Program on Dryland Systems (CRP1.1) in Nukus, Uzbekistan during 2014-2015 crop season. Three different field experiments were conducted.

Experiment 1
A set of 169 advanced breeding lines of winter wheat from International Winter Wheat Improvement Program (IWWIP) and one local cultivar were evaluated in plot size of 1 m^2 during winter. Data were recorded on plant stand in the first week of December 2013 and in the first week of March 2014 to estimate frost kill. Data were also recorded for maturity, agronomic traits and grain yield and physical quality.

Experiment 2
A set of 150 winter wheat genotypes adapted to Central Asia was planted at 2 and 4 cm depths. The farmers often don't maintain a fixed seeding depth in planting winter wheat, in particular when seeding is done in standing cotton crop. Each plot was planted with 100 seeds at 10 cm distance. Seedling counts were made after germination, and before and after winter. Snow was removed from the plots to expose wheat plants to frost damage.

Experiment 3
A set of 14 genotypes that had been selected for frost tolerance in 2013, and one local cultivar ('Krasnodar-99') were planted in 50 m^2 plots in two replicates. Visual observations on plant stand in each plot were recorded in December and in the first week of March, 2014 (example shown in Fig. 2).

Estimation of frost tolerance
Frost occurred during first two weeks of February 2014 when minimum temperatures ranged from -18ºC to -25ºC. Frost kill was estimated as percent of plants killed during winter compared to prior winter crop stand. Frost kill of at ≤10% was considered a measure of tolerance.

Results

Experiment 1

- 87 of 170 (51%) lines had ≤10% frost kill.
- Arrays of genotypic variation occurred among frost tolerant lines for maturity and grain yield (a few superior lines and checks ar shown in Table 1).

Table 1. Superior winter wheat lines and checks among 170 genotypes evaluated in the 21st FAWWON-Irrigated international winter wheat nursery, Nukus, Uzbekistan, 2014

Entry number	Variety name	Frost kill (%)	Grain yield (g/m^2)
1	Bezostaya 1 (check)	0	590
2	Seri (check)	100	
3	Sultan 95 (check)	0	296
4	Katia 1 (check)	80	
5	Konya (check)	0	652
6	Krasnodar 99 (Local Check)	0	518
98	OK07214	0	967
96	F07098G1	0	782
99	OK07218	0	715
97	F07270G2	0	675
23	Jcam/Emu//Dove/3/Jgr/4/Thk/5/Boema	0	672
18	Polovchanka/Pehlivan	0	671
109	Grom	0	666
100	OK09634	0	642

Experiment 2

- Seeding depth affected frost kill(Fig. 3)
- The number of lines showing ≤10% frost kill:
  2 cm seeding dept: 24 out of 150 (16%)
  4 cm seeding depth: 74 out of 150 (49%)
- The lines tolerant at 2 cm were also tolerant at 4 cm seeding depth.

Experiment 3

- The lines selected for frost tolerance in 2013 (Fig. 4) were also tolerant in 2014 (Table 2).
- The tolerant lines differed significantly for grain yield, plant height, and days to heading (Table 2).
- UZ10MLY-14 and Kirya were the most superior tolerant lines (Table 2, Fig. 5).

Table 2. Performance of frost tolerant winter wheat lines, Nukus, Uzbekistan, 2014

Entry name	Frost kill (%)		Grain yield (t/ha)	Days to heading	Plant height (cm)
	2013	2014			
Krasnodar-99 (check)	0	0	2.58	219	89
KR11-9809	0	0	2.27	221	91
KR11-9811	0	0	3.52	217	90
UZ10MLY-14	0	0	4.20	220	90
KR11-9816	0	0	2.91	218	93
KR11-9824	0	0	2.99	218	90
KR11-9828	0	0	1.06	224	95
UZ10MLY-20	0	0	5.22	218	94
KR11-9831	0	0	3.08	221	87
KR11-9835	0	0	2.46	219	93
KR11-9840	0	0	2.83	218	91
UZ11CW-24	0	0	2.36	219	90
Kuyalnik	0	0	3.74	218	90
Victoria	0	0	2.86	219	89
Kiriya	0	0	5.30	217	91
$LSD_{0.05}$			1.53	3	4

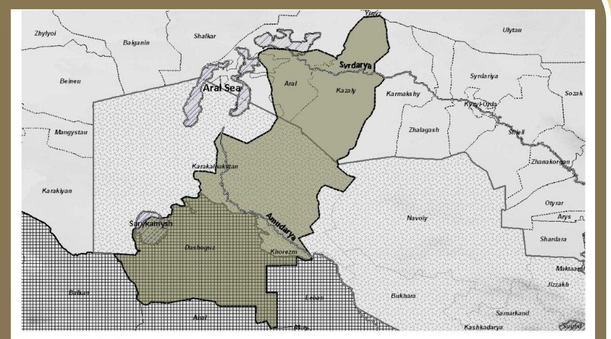

Figure 1. CGIAR Research Program on Dryland Systems (CRP1.1) Action Site: Aral Sea Region

Figure 2. Evaluation of frost damage in February, evaluated on 7 March 2014, Urgench, Uzbekistan.

Fig.3. Higher frost damage at 2 cm than 4 cm seeding depth; crop on 16 April 2014, Nukus, Uzbekistan

Figure 4. Frost damage caused in December 2012, crop on 18 April 2013, Urgench, Uzbekistan

Summary discussion

- Arrays of genotypic variation occurred among the winter wheat genotypes adapted to Central Asia and the advanced breeding lines introduced from IWWIP in Central Asia.
- Many frost tolerant genotypes also possessed superior agronomic and grain characteristics, which were advanced to further evaluations.
- Seeding depth strongly influenced frost survival.
- Planting winter wheat at 4 cm depth in frost prone environments could provide better protection than 2 cm depth.
- A number of genotypes survived well (≤10% frost damage) even under 2 cm seeding depth; this demonstrated their superior level of frost tolerance.
- Fourteen lines survived frost occurrence at -29ºC in December 2012 and -25ºC in February 2014 demonstrating their tolerance.
- UZ10MLY-20, UZ10MLY-14 and Kiriya were identified superior among the frost tolerant lines based on grain yield and agronomic traits.
- These results have open possibilities in the identification of superior frost tolerant winter wheat genotypes for many frost-prone regions.

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Fig. 5. Farmers and researchers evaluating frost tolerant wheat, 2014, Nukus, Uzbekistan

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