Science MATTERS

ICARDA
Science for Better Livelihoods in Dry Areas

Research Brief 3

New winter wheat varieties for improving productivity on saline fields in Central Asia

The Challenge

Wheat productivity is being adversely impacted by rising soil salinity in the fields of Central Asia, as a consequence of climate change and many other factors. Salinity reduces grain yield and negatively influences many plant traits.

'Davlatle' is among the superior winter wheat varieties identified by wheat researchers in Central Asia in collaboration with International Center for Agricultural Research in the Dry Areas (ICARDA), International Maize and Wheat Improvement Center (CIMMYT), International Winter Wheat Improvement Program (IWWIP) and Bonn University with the potential to improve food security by producing more wheat on saline fields.

New winter wheat varieties for improving productivity on saline fields in Central Asia

Of the 7.8 million hectares of irrigated land in Central Asia, about 50% is saline, 29% of which has a strong to moderate degree of salinity. Increasing salinity of the irrigated soils is one of the main reasons for the current decrease in agricultural productivity in Central Asia. It limits the productivity of wheat, the most significant crop in this highly agrarian region. The problem of soil salinity, a serious abiotic stress, is likely to be exacerbated by predicted climate change impacts in the region.

Salinity adversely affects wheat plant growth. The negative effects of salinity can be observed in the early growth stage and they continue throughout the life cycle of the plant till maturity. Several agronomic traits are negatively affected by salinity causing substantial reductions in grain yield, as seen in Figure 1.

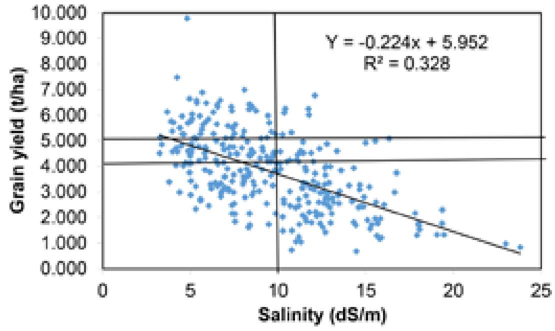


Figure 1: Effect of soil salinity on wheat grain yield recorded on 154 genotypes in Karshi, Uzbekistan, 2012

Impacts of salinity on wheat productivity

Through the collaborative efforts of national wheat improvement programs and international agricultural research centers like International Center for Agricultural Research in the Dry Areas (ICARDA), International Maize and Wheat Improvement Center (CIMMYT), International Winter Wheat Improvement Program (IWWIP) and Bonn University, wheat researchers in Central Asia have identified winter wheat varieties tolerant to soil salinity that could help increase wheat productivity. This was made possible through funding support from the German Federal Ministry for Economic Cooperation and Development BMZ/GIZ.

The negative effect of salinity can be observed in the early growth stage (Photo 1) which continues throughout the life cycle of the plant till maturity (Photo 2). Field experiments conducted at two sites in Uzbekistan (Karshi and Urgench) in 2012 showed grain yield reductions by 21% and 24%, respectively. These reductions in grain yield were due to the negative influence of salinity on a number of plant traits, as shown in Table 1.

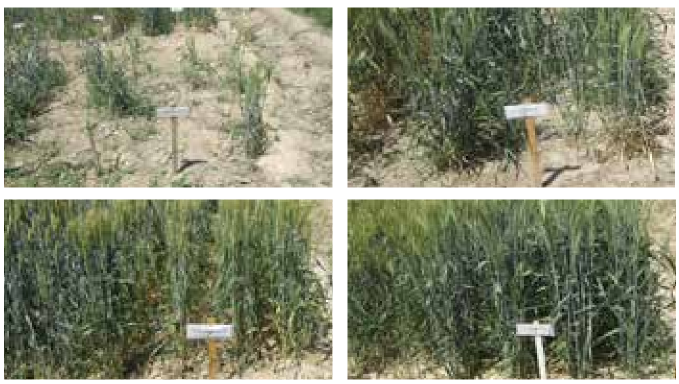
Photo 1: Effect of salinity during early growth stage

Experiments were carried out to field test diverse wheat germplasm for determining genetic variation for salinity tolerance reflected through grain yield under different levels of salinity. Effects of salinity level on grain yield were studied on a set of 154 wheat germplasm.

Table 1: Effects of salinity on different plant traits recorded on saline fields in Uzbekistan

Wheat plant trait	Reduction (%) under saline condition compared to normal soil	
	Karshi	**Urgench**
Grain yield	21.2 **	23.7 **
1000-kernel weight	6.9 *	0.1 ns
Plant height	18.3 **	9.6 **
Peduncle length	17.4 **	6.9 **
Spike length	4.7 **	6.4 **
Spike number	51.0 **	8.6 **
Tiller number per plant		24.7 **

** Reduction significant at 5% probability level*
*** Reduction significant at 1% probability level*
ns Difference non-significant at 5% probability level



Highly sensitive **Moderately sensitive**

Photo 2: Effect of salinity during advanced growth stage

New winter wheat varieties for improving productivity on saline fields in Central Asia

There was an estimated linear reduction of 224 kg/ha in grain yield per unit increase in soil salinity. These results also demonstrated the level of tolerance in wheat germplasm. Depending upon the yield target and field salinity level, the number of tolerant genotypes differed. For example, for a grain yield target of 5 t/ha at soil salinity level of 10 dS/m, seven genotypes were tolerant. However, reducing yield target to 4 t/ha for the same salinity level showed that 20 genotypes were tolerant. Such tolerant genotypes have the open possibility for further evaluation to identify new cultivars and for use as parents in crossing programs.

Salinity tolerant winter wheat varieties

One of the salinity tolerant improved varieties is synthetic derived bread wheat. Synthetic hexaploid wheats (SHWs) are produced from crosses between durum wheat and *Aegilops* (goatgrass). SHWs have contributed to broaden the genetic base of cultivated bread wheat, and the derived lines have proven to be valuable donors of improved tolerance to a range of abiotic and biotic stresses including salt tolerance. The process of developing a SHW genes from wheat and its related progenitor species found in the environment is shown in Figure 2.

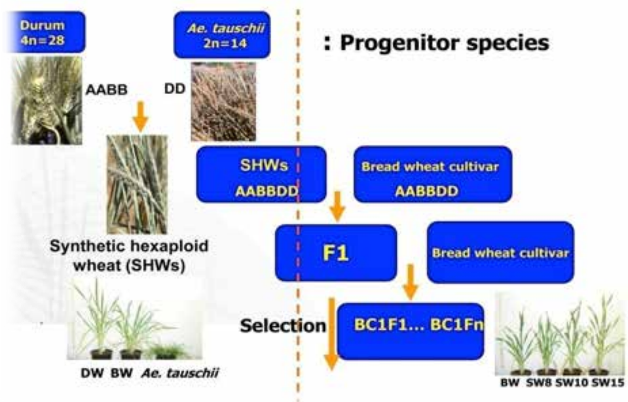


Figure 2: The development of synthetic hexaploid wheat

Davlatle – a salinity tolerant superior winter wheat variety

Davlatle is a salinity tolerant new synthetic derived winter bread wheat variety that displays tolerance to frost, drought and heat stress. It also gives a significantly higher grain yield than the local cultivar (Table 2) in the presence of medium salinity and harsh climate of Dashoguz in Turkmenistan, characterized by low rainfall, limited irrigation and extreme heat during grain development of wheat. Besides significantly higher grain yield, Davlatle matures 3 to 6 days earlier than local cultivars. It has been submitted to the State Varietal Testing Commission (SVTC) in Turkmenistan.

Davlatle is a product of international collaborations in wheat breeding. The original crossing was made at CIMMYT in Mexico and early generations selections were made in IWWIP in Turkey. It was field tested for salinity tolerance in Karshi and Urgench in Uzbekistan, Krasnovodapad in Kazakhstan and Dasoguz in Turkmenistan in 2011 under BMZ/GIZ funded project of ICARDA in Central Asia.

Researchers of Grain Institute in Dasoguz, together with the researchers from ICARDA-Tashkent selected candidate '10AYT-IR59' among the highest yielding varieties in the experiment. Further evaluations for performance of '10AYT-IR59' were done in 2012 and

Table 2. Comparative performance of Davlatle and improved and old local commercial cultivars in Dashoguz, Turkmenistan, 2012

Name	Grain yield (t/ha)	1000-kernel weight (g)	Plant height (cm)	Days to heading
Davlatle (10 AYT-IR-59)	3.00	45	66	206
Krasnodar-99 (Improved Local Check)	2.00	47	56	212
SAHRAÝY (Old Local Check)	1.15	50	53	209
$LSD_{0.05}$	0.59	4	9	2
CV (%)	12.1	4.2	7	0.5

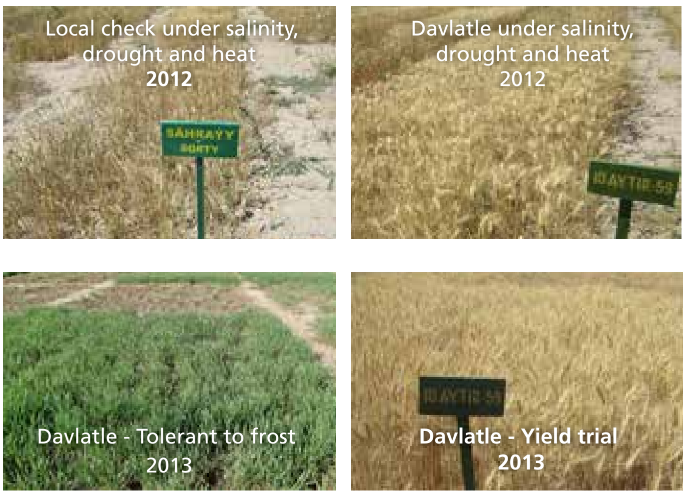


Photo 3: Performance of Davlatle (10AYTIR-59) under salinity, drought and heat stress in 2012, frost stress in 2013, and advanced yield trial in 2013

2013 (Photo 3); in both years '10AYT-IR59' had higher yield compared to several locally grown best commercial cultivars in Dasoguz. Seed multiplication was done in 2014, and '10AYT-IR59' was submitted as a new variety 'Davlatle' to the State Variety Testing Commission in Turkmenistan.

This rare combination of tolerance to multiple abiotic stresses makes Davlatle especially suitable for dryland conditions. It carries its multiple stress tolerance genes from *Aegilops squarrosa*. Davaltle was successfully field tested in Kazakhstan, Turkmenistan and Uzbekistan. The whole of Central Asia region could benefit by utilizing this improved germplasm in wheat improvement programs.

Two salt tolerant candidate varieties Aral and Amudarya (Photo 4) were identified for submission to the SVTC in Uzbekistan. Fifteen additional lines of winter wheat tolerant to salinity were identified and shared with wheat research programs in Tajikistan and Azerbaijan, and the IWWIP. The three new varieties and the advanced breeding lines reported here have satisfactory to superior quality traits compared to the local checks.

These saline tolerant improved wheat varieties hold the promise of enhanced productivity for wheat farmers in the Aral Sea Region of Uzbekistan, Turkmenistan and Kazakhstan who grow wheat on saline fields. Wheat breeders in national and international winter wheat improvement programs could also utilize these varieties and lines to develop salinity tolerant additional varieties of winter wheat.

Photo 4: Salt tolerant candidate varieties Aral (left) and Amudarya (right)

ICARDA's Crop Improvement Program

ICARDA has a global mandate for the improvement of barley, lentil, grasspea and faba bean, and a shared mandate for chickpea, bread wheat and durum wheat. With partners in more than 40 countries, ICARDA produces science-based solutions for new crop varieties (barley, wheat, durum wheat, lentil, faba bean, kabuli chickpea, grasspea, pasture and forage legumes). The Marchouch research station near Rabat in Morocco is host to a model crop improvement program that develops crop production technologies for both high and low potential agroecosystems. This research station, with cutting edge biotechnology labs, over 100 hectares of experimental fields, seed system infrastructure and a pool of world class scientists, builds on ICARDA's longstanding partnership with Institut National de la Recherche Agronomique (INRA). ICARDA has decentralized its genetic resources activities in Tel Hadya, Syria, and continues to strengthen its genebank holdings in Morocco, Lebanon and Tunisia while safely duplicating them in Svalbard in the Arctic. The crop improvement activities are well supported by facilities created at different platforms including Terbol in Lebanon, Amlaha in India and Cairo in Egypt.

A partnership of:

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