Whealbi

Wheat and barley Legacy for Breeding Improvement

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Collaborative Project
SEVENTH FRAMEWORK PROGRAMME

Deliverable D3.1

Report on phenotypic evaluation of the basic adaptive traits involved in adaptation to climatic conditions for the whole WHEALBI germplasm

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Workpackage concerned: 3

Concerned workpackage leader: CREA

Dissemination level: PU

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Foreword:

The short delay in the submission is due to the decision taken by the WP leader in response to the inputs of the project advisory board of scoring some more traits in addition to those indicated in the DoW. The score of these traits, mainly measured on harvested plants, has slowed down the whole phenotyping process, but it has increased the scientific value of the work.

Glossary and Definitions

Garden Experiment: a network of nursery field trials carried out in different locations with small plots for the evaluation of basic adaptive traits (e.g. plant height, flowering time).

Description of the deliverable

The WP3 explores different phenotyping strategies to complement the sequence data generated in WP2. The first phenotyping step has been dedicated to the evaluation of the basic adaptive traits of the whole germplasm collection to identify loci controlling local adaptation in wheat and barley.

1.1. Objective

The objective of D3.1 is to provide a phenotypic evaluation of basic adaptive traits involved in wheat and barley adaptation to different climatic conditions.

1.2. Rationale and teams involved

This activity has been accomplished through the organization of a network of field trials (common garden experiments) across different latitudes (from Scotland to Turkey) and climatic conditions (from wet to extreme dry, from sea level to 1200 meters), where all the WHEALBI accessions have been tested. Overall, 10 common garden experiments have been successfully carried out for barley and 8 for wheat.
The seeds were distributed from IPK and all trials were sown according to a common augmented p-rep design prepared by DLO. According to the experimental design, in each location a subset of the accessions (about 20%) was replicated twice. Two elite cultivars were used to control for spatial effects. The garden experiments for wheat were carried out in winter sowing in Hungary (MTA-ATK), France (INRA), UK (KWS), Turkey (Univ. of Curkurova as subcontractor of IPK) and in spring sowing in Hungary and Turkey. An additional wheat garden experiment was sown in UK during spring, but germination and plant establishment failed due to an exceptionally dry season. The wheat spring sowing in France (INRA) has been converted in the measure of the carbon isotope discrimination (done on winter wheat same location) in response to a specific request of the project advisory board. Furthermore, a wheat trial was carried out also in Israel (HU) to test for adaptation to local conditions and for seed multiplication in view of the activity of Task 3.2, nevertheless this trial did not follow the general experimental design due to rules and limitations imposed by the quarantine requested to import the seeds into Israel as described in details in the first annual report. The garden experiments for barley were carried out using both winter and spring sowing in Hungary (MTA-ATK), Italy (CREA), UK (JHI) and Turkey (Univ. of Curkurova as subcontractor of IPK). In Turkey all trials were duplicated and carried out in both irrigated and rainfed conditions. Meteo data have been collected in all the environments hosting the common garden experiments.

1.3. Main results

In all experiments the plants were scored following common protocols for plant establishment, winter survival, flowering time, plant height, awn length, row-type (barley). Furthermore, some “additional traits” (carbon isotope discrimination, seed size, seed weight, diseases, leaf size, peduncle length, fruiting efficiency, etc.) were

scored in a limited number of trials. Notably, the additional traits have been included in the WP3 activity in response to specific inputs of the project advisory board and these scores exceed the list of the characters indicated in the DoW.
All data have been collected using a standard file format (Ephesys, prepared by INRA-URGI) that will facilitate the storage of the data in the WHEALBI website and their analysis. A list of the traits successfully collected in each garden experiment is reported in the following table; for each trait the average value and the range of variation is indicated. Some of the additional traits deriving from the analysis of the plants and seeds harvested from the garden experiments will be completed during the next months (indicated as “in progress” in the table). Although the phenotyping of some of these traits is still in progress, the data collected so far are sufficient to fulfill the deliverable 3.1 as indicated in the DoW and to complete all the next project activities that relay on the output of the garden experiments.

Garden experiment summary. For each crop specie (barley, wheat), sowing time (winter, spring) and location the table reports the traits successfully scored with mean value and range of variation.

			Barley Winter				
			BW1	BW2	BW3	BW4	BW5
	Variable Name	Description	CRA-ITA	JHI-UK	MTA-HUN	TUR	TUR
mandatory traits	Plant Establishment	Visual score (0-3)	Min=0; Max=3; Mean=1.3	Min=0; Max=2; Mean=1.0	Min=1; Max=3; Mean=2.8	Min=1; Max=3; Mean=1.8	Min=1; Max=3; Mean=1.9
	Winter survival	Visual score (0-9)	Min=0; Max=4; Mean=1.3	Min=1; Max=6; Mean=2.9	Min=0; Max=9; Mean=3.1	-	-
	Heading date	Nr. Of days - from sowing to Zadoks DGS 53	Min=156; Max=207; Mean=186.7	Min=201; Max=240; Mean=221.2	Min=180; Max=207; Mean=194.6	Min=169; Max=188; Mean=179.6	Min=169; Max=185; Mean=178.8
	Plant height	cm - from soil to the insertion of the spike	Min=27; Max=130; Mean=75.0	Min=32; Max=111; Mean=69.9	Min=42; Max=111; Mean=75.2	Min=60; Max=131.5; Mean=95.1	Min=38.5; Max=128; Mean=89.3
	Row type	2-rows/6-rows/other	Available	Available	Available	Available	Available
	Awn length	cm - from the tip of the spike to the end of the awn	Min=0; Max=25.0; Mean=12.1	Min=0; Max=18.5; Mean=10.9	-	In progress	In progress
	Awn roughness	1: Smooth; 2: smooth base/rough tip; 3: rough	Available	-	-	In progress	In progress
	(1000)Grain weight	g - average weight of 3 reps of 100 kernels	Min=30.3 *(no H. Spont)*; Max=69.6; Mean=49.1	Min=23.5; Max=81.3; Mean=52.9	Min=16.5; Max=75.5; Mean=49.5	In progress	In progress
additional traits	Flag leaf length	cm - from auricles to the tip	Min=3.0; Max=32.0; Mean=13.0	-	-	-	-
	Flag leaf width	cm - at the widest point	Min=0.2; Max=1.9; Mean=0.7	-	-	-	-
	Peduncle length	cm - from the last node to the base of the spike	Min=5.0; Max=65.0; Mean=28.3	-	-	Min=6.0; Max=53.0; Mean=26.1	Min=8.0; Max=69.0; Mean=25.0
	Peduncle extrusion	cm - from the auricle of the flag leaf to the base of the spike	Min=-1.0; Max=40.0; Mean=5.5	Min=-4.5; Max=37.3; Mean=9.4	-	-	-
	Spike length	cm - from base to tip of the spike	Min=3.0; Max=18.0; Mean=9.9	Min=3.0; Max=15.5; Mean=8.0	-	In progress	In progress
	Fruiting efficiency	Grain/spike weight ratio	Min=0.28; Max=0.93; Mean=0.68	-	-	In progress	In progress
	Seed Width	mm - Marvin at JHI, WinSeed at CRA	In progress	Min=2.3; Max=4.4; Mean=3.6	-	-	-
	Seed Length	mm - Marvin at JHI, WinSeed at CRA	In progress	Min=6.3; Max=16.4; Mean=9.9	-	-	-
	Seed Area	mm2 - Marvin at JHI, WinSeed at CRA	In progress	Min=16.3; Max=39.7; Mean=26.2	-	-	-
	Meteo data		Available	Available	Available	Available	Available
	Sowing date		27/10/2014	29/10/2014	20/10/2014	12/11/2014	12/11/2014
	Notes		Bad establ. + insect damage	Severe lodging, not harvested	-	Irrigated	Rainfed
	Seeds		Stored	10 ears harvested	Stored + sent to CREA	Stored	Stored

			Barley Spring				
			BS1	BS2	BS3	BS4	BS5
	Variable Name	Description	CRA-ITA	JHI-UK	MTA-HUN	TUR	TUR
mandatory traits	Plant Establishment	Visual score (0-3)	Min=0; Max=3; Mean=1.5	Min=0; Max=3; Mean=2.1	Min=1; Max=3; Mean=2.9	Min=0; Max=2; Mean=1.0	Min=0; Max=2; Mean=1.0
	Heading date	Nr. Of days - from sowing to Zadoks DGS 53	Available	Min=67; Max=106; Mean=82.8	Min=60; Max=93; Mean=72.5	-	-
	Plant height	cm - from soil to the insertion of the spike	-	Min=47; Max=131; Mean=91.5	Min=34; Max=99; Mean=67.9	Min=20; Max=93; Mean=52.6	Min=20; Max=113; Mean=66.1
	Row type	2-rows/6-rows/other	Available	Available	Available	In progress	In progress
	Awn length	cm - from the tip of the spike to the end of the awn	-	Min=0; Max=17.0; Mean=9.8	-	In progress	In progress
	(1000)Grain weight	g - average weight of 3 reps of 100 kernels	-	Min=22.5; Max=73.0; Mean=51.1	-	In progress	In progress
additional traits	Peduncle length	cm - from the last node to the base of the spike				Min=-5; Max=44; Mean=19.8	Min=-6; Max=45; Mean=25.0
	Peduncle extrusion	cm - from the auricle of the flag leaf to the base of the spike	-	Min=-2.8; Max=34.5; Mean=13.4	-	-	-
	Spike length	cm - from base to tip of the spike	-	Min=3.3; Max=14.3; Mean=8.3	-	In progress	In progress
	Fruiting efficiency	Grain/spike weight ratio	-	-	-	In progress	In progress
	Seed Width	mm - Marvin at JHI, WinSeed at CRA	-	Min=2.2; Max=4.3; Mean=3.6	-	-	-
	Seed Length	mm - Marvin at JHI, WinSeed at CRA	-	Min=6.6; Max=18.9; Mean=9.9	-	-	-
	Seed Area	mm2 - Marvin at JHI, WinSeed at CRA	-	Min=14.6; Max=42.5; Mean=26.0	-	-	-
	Meteo data		Available	Available	Available	Available	Available
	Sowing date		31/03/2015	30/04/2015	11/03/2015	26/03/2015	26/03/2015
	Notes		Very late sowing, uneven heading	Severe lodging, not possible to harvest	-	Irrigated	Rainfed
	Seeds		Not harvested	10 ears harvested	Not harvested	Stored	Stored

			Wheat Winter				
			WW1	WW2	WW3	WW4	WW5
	Variable Name	Description	INRA-FRA	KWS-UK	MTA-HUN	TUR	TUR
mandatory traits	Plant Establishment	Visual score (0-3)	Min=0; Max=2; Mean=1.3	-	Min=0; Max=3; Mean=2.7	Min=1; Max=3; Mean=1.9	Min=0; Max=2; Mean=1.3
	Winter survival	Visual score (0-9)	Min=0; Max=4; Mean=1.3	-	Min=0; Max=9; Mean=0.6	-	-
	Heading date	Nr. Of days - from sowing to Zadoks DGS 53	Min=142; Max=186; Mean=159.0	Min=195; Max=236; Mean=215.5	Min=197; Max=237; Mean=212.7	Min=187; Max=210; Mean=197.1	Min=177; Max=200; Mean=193.5
	Plant height	cm - from soil to the tip of the spike	Min=48; Max=174; Mean=103.3	Min=40; Max=185; Mean=108.3	Min=41; Max=149; Mean=95.8	Min=22; Max=144.5; Mean=90.8	Min=25.5; Max=130; Mean=86.4
	Awn length	cm - from the tip of the spike to the end of the awn	Min=0; Max=13.7; Mean=3.8	Presence *vs.* Absence of awns	Min=0; Max=12.5; Mean=3.1	In progress	In progress
	Awn roughness	1: Smooth; 2: smooth base/rough tip; 3: rough	Min=1; Max=3; Mean=2.96	-	-	In progress	In progress
	(1000)Grain weight	g - average weight of 3 reps of 100 kernels	Min=22.4; Max=73.6; Mean=43.8	-	Min=15.1; Max=69.1; Mean=39.8	In progress	In progress
additional traits	Peduncle length	cm - from the last node to the base of the spike	-	-	-	Min=5.0; Max=50.0; Mean=26.4	Min=7.0; Max=60.0; Mean=28.3
	Lodging intensity	Visual score (1-9)	Min=1; Max=9; Mean=1.8	-	-	-	-
	Spike length	cm - from base to tip of the spike	-	-	Min=3.9; Max=18.0; Mean=10.7	-	-
	Fruiting efficiency	Grain/spike weight ratio	-	-	Min=0.51; Max=0.97; Mean=0.71	-	-
	Yellow rust	Visual score (0-100%)	-	Min=0; Max=100; Mean=59.0	-	-	-
	Carbon isotope discrimination		Min=-31.2; Max=-25.9; Mean=-29.6	-	-	-	-
	Carbon content	Percentage (%)	Min=30.7; Max=55.5; Mean=43.9				
	Leaf rust	Visual score (1-9)	Min=1; Max=3; Mean=1.0	-	-	-	-
	Stripe rust	Visual score (1-9)	Min=1; Max=9; Mean=1.5	-	-	-	-
	Powdery mildew	Visual score (1-9)	Min=1; Max=5; Mean=1.04	-	-	-	-
	Meteo data		Available, along with soil information	Only temperature	Available	Available	Available
	Sowing date		5-10/12/2014	27/10/2014	20/10/2014	12/11/2014	12/11/2014
	Notes		-	Different sowing plan	-	Irrigated	Rainfed
	Seeds		Stored + sent to INRA	Not harvested	Stored + sent to UZH and DLO	Stored	Stored

			Wheat Spring		
			WS2	WS3	WS4
	Variable Name	Description	MTA-HUN	TUR	TUR
mandatory traits	Plant Establishment	Visual score (0-3)	Min=0; Max=3; Mean=2.5	Min=0; Max=1; Mean=0.9	Min=0; Max=1; Mean=0.9
	Heading date	Nr. Of days - from sowing to Zadoks DGS 53	Min=74; Max=112; Mean=88.4; 40% of plots did not flower	-	-
	Plant height	cm - from soil to the tip of the spike, awn excluded	Min=35; Max=118; Mean=81.7	Min=20; Max=124; Mean=57.4	Min=24; Max=120; Mean=69.5
	Awn length	cm - from the tip of the spike to the end of the awn	-	In progress	In progress
	(1000)Grain weight	g - average weight of 3 reps of 100 kernels	-	In progress	In progress
	Peduncle length	cm - from the last node to the base of the spike	-	Min=3; Max=64; Mean=23.2	Min=5; Max=56; Mean=27.5
	Meteo data		Available	Available	Available
	Sowing date		11/03/2015	26/03/2015	26/03/2015
	Notes		-	Irrigated	Rainfed
	Seeds		Not harvested	Stored	Stored

1.4. Conclusions

The phenotypic data acquired highlight the wide genetic diversity present in the WHEALBI germplasm, suggesting that different genetic factors are responsible for the adaptation of each genotype to specific environmental conditions. These data will be analyzed together with the molecular data generated by exome capture and resequencing in WP2 to identify the genes responsible of specific adaptive traits.
The garden experiments have also served as multiplication of all accessions in order to produce enough seeds for the phenotyping activities organized in the next three years of the project.