

IDEOTYPE SUD

wheat varieties adapted to the climate



It is essential to prepare for global warming by developing varieties that are able to cope with water and heat stress.

Arvalis's collaboration with Portuguese teams including farmers, researchers and field advisors, as well as the implementation of the CHN model, are helping to further characterise wheat varieties that tolerate water and heat stress better.

Adapting to climate change is the main focus of the work carried out by the Gréoux-les-Bains experimental station in Provence (south-eastern France). Of all the Arvalis sites, this one is the most significantly affected by this issue for wheat, and it gives an insight into the conditions that producers in other parts of Europe, even the most northern, will have to face some years, including with regard to water and heat stress. In that context, the stakes involved in breeding wheat varieties that are more tolerant to water and heat stress are obviously very high. However, the breeding programmes carried out in arid areas are producing varieties that certainly need little water, and are able to be productive in extreme conditions, but generally with low yields. This limitation of the yield potential is detrimental in the French, and even the European context, where the favoured ideotype (i.e. the overall characteristics of a variety) is a "mitigating" variety in dry years, but able to utilise favourable weather conditions in good years or when the end of the season is wet.

Joint observations and objective

Contrary to other types of tolerance, the genetic factors that determine tolerance to water stress are complex. The Gréoux

station has been contributing to programmes on that topic since 2012, with trials involving over 200 bread and durum wheat varieties, either irrigated or put in "natural rainfall" conditions (i.e. mainly stress-inducing in Gréoux), then phenotyped in order to characterise their behaviour in field conditions when water stressed. Possible correlations between that behaviour and some of their genetic code regions are then sought out (genetic association).

In order to speed up the study of various possible climate scenarios, and advance varietal choice support towards more tolerant options, a new collaboration with the INIAV⁽¹⁾'s Portuguese "cereal" team was launched in 2012. This led to an original multidisciplinary approach and the creation of the Idéotype SUD project⁽²⁾. Its objective is simple: defining a varietal ideotype for crops in water stress conditions and (for the INIAV's genetic research team) creating new varieties, and identifying and quantifying current and future climatic risks to avoid. It also describes and characterises the cropping systems used by farmers and their sectors, in order to provide them with efficient management tools when faced with chaotic weather conditions.

This collaborative work is taking the form of identical trials undertaken in Gréoux and Elvas (Portugal), with a selection of bread and durum wheat varieties from both countries, which are reputed to be either tolerant or sensitive to water and heat stress, grown and studied according to a joint protocol involving context characterisation (including the stress scenario experienced each year).

Rapid exploration of various stress scenarios, including very early in the season

When the climate scenarios experienced by the Idéotype Sud trial between 2012-2013 and 2016-2017 are being characterised, it appears that 60% of trials belong to the very stressful scenario category, with water stress starting soon after the “1 cm ear” stage and worsening right through to maturity. This collaboration with Portugal is helping to explore stressful scenarios with very early onset, which is rarely the case at the moment in France, even in the South-East.

The trials are showing that yield performance is heavily linked to the “date” of the point of inflexion on the senescence graph, both for irrigated, and non-irrigated crops. The senescence graph is determined using NDVI index measurements based on the differences in the way biomass reflects solar rays in the red and infrared channels. Measured several times a week during the senescence phase, using a portable tool (the Greenseeker) or the Phénomobile, the NDVI index gives access to plant growth density and intensity.

This senescence inflexion date is therefore a reliable wheat performance indicator in conditions giving rise to significant water stress, and can be used by plant breeders and agronomists. The only constraint is the frequent measurement of the NDVI index.



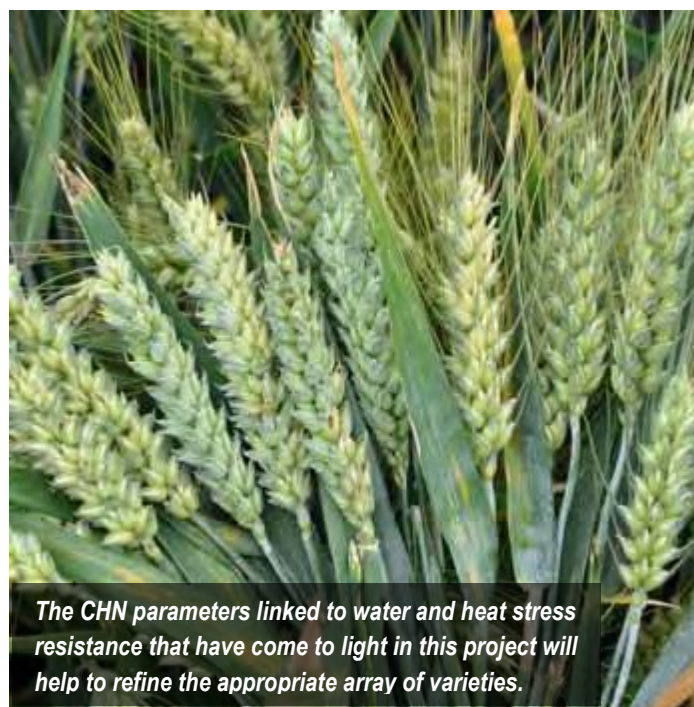
The French and Portuguese teams (pictured here in May 2015 at the INIAV station in Elvas) followed a joint experimental cropping and measurement protocol.

The CHN model now gives access to tolerance characteristics

Usually, varietal resistance to water and heat stress is studied using traditional and visible parameters, such as yield components, earliness or leaf growth characteristics. However, Arvalis’s CHN growth model for cereals gives access to new “hidden”, but functional, parameters: they are those coming into play in wheat growth equations day after day, depending on the environmental resources that the plant can utilise (including solar rays). The model’s functional parameters are adjusted in order to convey the biomass differences that have been observed, for each variety, between the various cropping systems, i.e. with no irrigation (stress) and with irrigation (very little or no stress). Two CHN parameters have emerged as good indicators of varietal behaviour

« 7 years of trials on 2 sites and with two different systems = 28 weather scenarios experienced »

in water stress conditions: the limitation of the leaf surface’s water potential (CHN fHydriqueLAI parameter) and the limitation of the water potential from transpiration (fHydriqueTranspi parameter). As the leaf water potential becomes more limited, leaf growth decreases; whereas water potential limitation through transpiration is linked to photosynthesis, and as the limitation decreases, transpiration increases and photosynthesis becomes more active. With optimum growth conditions (no stress), those limitations do not arise. Having access to the CHN hidden functional parameters involved in adaptation to water stress is helping to paint a totally new picture of varieties with regard to their genetic ability to adapt to stress. For example, they have confirmed the resemblance between Claudio and Celta durum wheat varieties, that, as far as a field observer is concerned, seem to behave similarly and are both known as being able to cope with stressful conditions. When water stress occurs, Claudio continues to “work” by significantly reducing leaf growth, but by continuing to fill the grain; it is therefore able to tolerate severe environmental stress at the end of the season, but will not really make the most of a return to wetter conditions. Conversely, Celta (like Anvergur, the French “all terrain” variety) will be able to benefit from irrigation or rainfall at the end of the season, because it preserves a greater foliar area. Those two CHN parameters have also shown that, from that point of view, Anvergur has a similar “varietal profile” to some bread wheat varieties such as SY Moisson.



The CHN parameters linked to water and heat stress resistance that have come to light in this project will help to refine the appropriate array of varieties.

Towards phenotyping more specific variables of water stress

At this stage, the precision of the data acquired by the Phénomobile is pointing towards refining the wheat development models by variety, by adjusting for each of them the parameters used in the CHN cropping model. It will then be possible to determine phenotypes based on active variables in the CHN model, that are more closely involved in the agronomic performance of water and heat stress resistant wheat, and no longer based purely on the usual visible variables such as NDVI or height.

At the same time, the INIAV team started cross-breeding work focussing on the target ideotype that emerged from the joint trials at the end of phase 1 of the project (2012-2015), using “traditional” parameters. This is durum wheat varieties capable of producing at least 10,000 grains/m², with ear emergence dates ranging between 1st and 15th April in Elvas, SW>82, without any major agronomic drawbacks (sensitivity to lodging or yellow rust, for example), and with a good yield/protein ratio, or at least without a marked risk of loss of the grain’s vitreous aspect.

The possibility of extending this work to other Mediterranean countries as part of future research programmes is being considered, with the start of collaborative work with the Tunisian institute of arable crops (Institut national des grandes cultures de Tunisie) and Spanish and Italian partners, using Phénomobile-type sensors, but “portable” ones.

Editor’s note : Arvalis and INIAV also work on the H2020 SolACE project coordinated by INRA⁽³⁾

(1) INIAV (Instituto Nacional de Investigação Agrária e Veterinária) is a Portuguese research institute active in the field of agronomy.

(2) Work carried out with the support of the Provence-Alpes-Côte d’Azur region.

(3) <https://www.solace-eu.net/>

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