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The history of wheat breeding in Algeria

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Abstract. Research on wheat in Algeria started several centuries ago. In the pre-colonization period (before 1830) it was just a botanical curiosity and from then acquired the status of real plant breeding using most of the modes to increase genetic variability in new varieties (i.e. hybridization, selection, testing, release), to develop better varieties for a rapidly increasing population. For a long time researchers thought that bread wheat did not exist in North Africa before the arrival of the Arabs. In 1930, during the French occupation of Algeria, only durum wheat was cultivated in the plain areas. Bread wheat was considered a separate crop and was only found as undesired mixtures in durum fields. From the end of the XVIIIth and early XIXth century, only durum wheat was given importance by the farmers and was largely cultivated. There are archeological, historical and phylogenetic arguments that support the presence of durum wheat in Algeria.
After the colonists and first botanical studies era to the post independency period, several germplasm enhancement programs were launched aimed at good adaptation and high yield potential. Collaboration with International Centers, from the late 1960's (FAO, European CC and CIMMYT) was very strong and interactive and achieved all planned objectives. In 1980 ICARDA participated in contributing to Algeria's field crops research and development.
In light of achieving the main government goal to ensure food security by 2015 by producing 10 million tons of wheat a new bilateral (INRAA/ITGC) research approach (NWIP) was launched with the collaboration of ICARDA. Regional and multidisciplinary approaches have been adopted and several promising cultivars were developed through a participatory approach as a final step. This material helped in evolution of good yields during this last decade.

Keywords. Durum wheat – History – Germplasm enhancement – Yield – Production.

L'histoire de l'amélioration du blé en Algérie

Résumé. *La recherche sur le blé en Algérie a commencé il y a plusieurs siècles. Dans la période de pré-colonisation (avant 1830), il s'agissait juste d'une curiosité botanique et c'est successivement qu'on a commencé à réaliser une véritable sélection, en utilisant la plupart des moyens connus pour augmenter la variabilité génétique des nouvelles variétés (hybridation, sélection, tests, diffusion des obtentions végétales). Et ce, afin d'obtenir des variétés meilleures pour satisfaire aux besoins d'une population qui s'accroît de plus en plus rapidement. Pendant longtemps, les chercheurs avaient pensé que le blé tendre n'existait pas en Afrique du Nord avant l'arrivée des Arabes. En 1930, pendant l'occupation française de l'Algérie, seul le blé dur était cultivé dans les zones de plaine. Le blé tendre était considéré comme une culture distincte, qui poussait spontanément dans des champs de blé dur. Entre la fin du XVIIIe et le début du XIXe siècle, les agriculteurs ne s'intéressaient qu'au blé dur qui était donc largement cultivé. De nombreuses données archéologiques, historiques et phylogénétiques révèlent la présence du blé dur en Algérie.*

Après la période coloniale et la première ère des études botaniques jusqu'à la période post-indépendance, plusieurs programmes d'amélioration génétique ont été entrepris pour améliorer l'adaptation et accroître le potentiel de rendement. La collaboration avec les centres internationaux, depuis la fin des années 1960 (FAO, CC européenne et CIMMYT), a été très forte et interactive et a atteint tous les objectifs prévus. En 1980, l'ICARDA a participé en contribuant à la recherche et au développement des grandes cultures en Algérie.

En vue d'atteindre l'objectif principal du gouvernement pour garantir la sécurité alimentaire à l'horizon 2015, en produisant 10 millions de tonnes de blé, une nouvelle approche de recherche (NWIP) bilatérale (INRAA/ITGC) a été lancée avec la collaboration de l'ICARDA. Des approches régionales et multidisciplinaires ont été adoptées et un certain nombre de cultivars prometteurs ont été mis au point grâce à l'utilisation d'une approche participative dans la phase finale. Ce matériel a contribué à faire augmenter le rendement au cours de cette dernière décennie.

Mots-clés. *Blé dur – Histoire – Amélioration du matériel génétique – Rendement, production.*

I – Introduction

Algeria is the largest country in Africa covering more than two million square kilometers. Most agricultural activities in Algeria are situated in the north of the country due to the large non-arable desert areas stretching towards the south. The dominant crops are annual in nature and involve mainly field crops such as, cereals, forages, food legumes, and potatoes. With 238 million ha of arable land, Algeria has only 3.4% of potentially arable land, of which less than 20% is actually cultivated (about 8.6 million ha). Of the remaining area 4.3 million ha is used for forestry, 34.3 million ha for rangelands, and 191 million ha is unproductive land.

Cereals are the predominant crops grown by Algerian farmers covering annually 3 to 3.5 million ha which is nearly 40% of Algeria's total agricultural land. Irrigated cereals cover about 245,000 ha. However, the country depends on imports for 45% of its food consumption. Although agriculture does not contribute significantly to the country's Gross Domestic Product (8.1%), it is an important sector as it contributes to food security for its 35 million people, of which 14% are employed in agriculture. Therefore, since independence in 1962, Algeria has continued to give high priority to agricultural research and development both for social and economic reasons.

Wheat research has been conducted in Algeria since several centuries. It was just a botanical curiosity before 1830, but got the status of real plant breeding efforts using hybridization, selection, testing, release etc… to develop better varieties. For a long time researchers thought that bread wheat had not existed in North Africa until the arrival of the Arabs. However, Porteres (in Laumont and Erroux, 1961) indicated that due to its better resistance to drought and its use in semolina, durum wheat replaced actually existing bread wheat cultivation.

In 1930, during the French occupation of Algeria, only durum wheat (Laumont *et al*., 1961) was cultivated in the plains. Bread wheat (Trabut in Laumont and Erroux (1961), Boeuf (1925), Ducellier (1921), Miège (1922) was only found as undesired mixtures in durum fields (Ducellier (1930), Trabut in Laumont *et al*., 1961. R. Desfontaines, who explored the regencies of Tunis and Algiers during the period 1773-1786, mentioned only durum wheat in his remarkable book on Flora Atlantica. Schousboe in Ducellier 1921, who studied the flora of Morocco during the same period (1771-1793), also reported only the production of durum wheat.

It is important to notice that the Arab invasion in the 7th and 8th centuries did not affect the whole of the country, as the countryside mostly remained settled by the autochthonous Berber people.

II – Evidences

1. Archeological arguments

The numerous ruins of settlements built and occupied by Romans did not reveal any durum wheat grains. According to samples found at Timgad and Djmila ruins, Ducellier advanced the conclusion that durum wheat had not been cultivated in Algeria until the Arab invasion.

2. Historical arguments

We know that during the Roman occupation era North Africa furnished to the empire's capital, Rome significant quantities of grains representing taxes taken from local communities. This is why North Africa was called "Rome's granary.

3. Phylo-genetical arguments

The historical documents allow us to determine the species that formed the basis of present-day wheats. We consider most often that these wheats were *Triticum diccocum, T. spelta,* and *T. turgidum* or *T. vulgare*.

In fact, the large species diversification in the North African region made Vavilov himself consider the region to be a secondary center of origin of *T. durum*, the primary center being Abissinia.

The numerous botanical varieties (more than 20), each comprising of a multiple number of types could be explained by spontaneous hybridization according to Ducellier (1921, 1930). In addition, it seems possible that even more diversity may have arisen from natural mutations, which would have required more time to stabilize and could have resulted in the novel types found in the early 19th Century. One such product was an inter-generic cross of *Aegilops ovata* x *T. durum* found near the city of Guelma, and studied by Laumont and Errox (1961).

Historical arguments reviewed by Jasny (1944) using old texts and work by predecessors, established a sound argument in favor of the existence of wheat in North Africa before the Arab invasion. Jasny (*l. c.*) concluded that during classical antiquity, durum wheat was the most cultivated crop in the Mediterranean region. It is also interesting to note that Loret (1892) cited that durum wheat existed in Egypt as far back as during the Pharaohs' era. In summary, it seems clear that durum wheat has a long history in North Africa.

III – Variations in the durum wheat group

Because we ignore the authors from antiquity and their allusions to durum wheat, we had to wait according to Kornicke (1885) till 1566 to find a first description of durum wheat made by Dodoens (Dodonaeus in Latin). In 1913, Schulz refers to Dodonaeus in his publication "*historia frumentorum, leguminum, palustrium, and aquatilium herbarum*". But it is only in 1798 that durum wheat was recognized as a specific species by Desfontaines in "Flora Atlantica". Among the main characteristic traits indicated by Desfontaines, there are the solid stem, pubescent lemma, and the vitreous and elongated kernels. Desfontaines addresses Kornicke's classification in his book "The Wheat Plant" (1921).

The pubescent trait (*glumis pubescentibus spica villosa*) was described by Orlov as occurring in 11 Algerian varieties, with 13 others being glabrous. Orlov's classification retained pubescence/glabrousness among the primary traits for species identification (Orlov, 1923).

In other words, the durum species from the *Triticum* genus includes numerous cultivated forms not only in North Africa but also in other Mediterranean areas (e.g. Bulgaria, Greece, Italy, Portugal, Spain, and Turkey.

Within all durum wheats cultivated all over the world, Flaksberger's (1935) classification distinguished two sub-species: subsp. *abessinicum* var. and subsp. *expansum* var. These two sub-species are subdivided in three groups, including several races or "proles" characterized by ecological and morphological considerations, as in this following list:

Subsp. *abessinicum*

1. *Proles tenerum*
2. *Proles expansoïdes*
3. *Proles tenero-expansoïdes*

Subsp. *expansum*

1 Group *commune*

a. Series *prolum mediterranea*

i. Proles jordanica
ii. Proles syriaca
iii. Proles sardinicum
iv. Proles intermedium

b. Series prolum europaea

i. Proles densiusculum
ii. Proles taxiusculum
iii. Proles cyprium
iv. Proles asiaticum
v. Proles endemicum
vi. Proles villosum
vii. Proles melitense

2. Group *duro-oblungum*

a. Proles orientale
b. Proles falacatum

3. Group *orientale*

a. Proles duro-compactum
b. Proles maroccanum
c. Proles horanicum
d. Proles aegyptiacum

Algerian wheat belongs to the sub species: *expansum commune*.

IV – Cultivated durum wheat in Algeria and general traits

The diversity among Algerian durum wheat is large. Orlov indicated the presence of 22 out of 34 known botanical varieties. Within these botanical varieties we can also distinguish more “races” according to morphological and physiological traits. This explains why Algeria has to be considered as a secondary center of diversity of durum wheat (Boeuf, 1932). This extensive polymorphism in the durum wheat was also observed by the native farmers, who found several mixtures in their fields and separated them under such names as “Kahla”, “Hamra”, “Adjini”, “Mahmoudi”, etc.

A study of durum wheat in Algeria therefore must comprise:

1. Inventory and recognition of botanical varieties according to Orlov,
2. Recognition of the diverse cultivated types (descriptions, nomenclature used and regional names)

This description recalls different traits, such as the primary ones indicated by Orlov in 1923 (pubescence or glabrousness of spikes or awns, and grain color), and several other traits indicated by Orlov, Boeuf and Miège that require in-depth observations using a microscope.

Spike density of the different durum wheat types: It is important to point out that Abyssinian wheats are very dense. *T.durum* Desf. *aristantum duro compactum* Flaksb with short stature and

small grains had not been inventoried in Algeria by Orlov, who could only find forms belonging to *T. durum* Desf. *aristantum commune* Flaksb.

Lemma and palea traits: These traits are also used to discriminate botanical groups from agricultural varieties. The awns that extend from the palea are parallel (e.g., Hedba 3), or diverging and deviating on one side of the spike (e.g. Adjini 9-19, Mekki 14.970).

Vegetative traits: Vegetative traits such as plant (erect or prostrate), type of leaves, grain and leaf glaucescens, leaf color, plant height and straw structure contribute also to the determination of the different varieties.

V – Wheat introduction into Algeria

The first colonists (French farmers that came to settle in Algeria) brought with them seeds of the varieties they used to grow in their country of origin (Tuzelle from south-west France, Mahon from the Baleares islands). These old introduced wheat were called wheat of the country or white wheat because of their adaptation to the environment. The needs of modern flour mills focused on strong wheat in terms of mixing and dough properties. The national research center that has the duties to perform breeding oriented then its activities towards developing new lines through intercrossing, while continuing the introduction of new varieties and advanced lines from abroad. This research work continued by INRA, France until Algeria's independence in 1962. The Algerian Center for Agronomic, Scientific and Economic Research (CARASE) or INRA, Algeria took over the selection work at the different stations (1963 -1969) where the existing collections were maintained. In the mean-time testing of different varieties and/or populations was increased (INRAA-CNRA, 1970).

Since 1969, as stakeholders became increasingly aware of the importance of cereal production to national food security, the Ministry of Agriculture (MOA) started to evaluate new improved and high-yielding germplasm introduced mainly from the International Maize and Wheat Improvement Center (CIMMYT).

Overall cereal production intensification could not be pursued without a concerted and harmonized plan of action through the entire intensification chain to be transferred to farmers. Thus, in August of 1971 the "Projet Céréales" (Cereals Project) was created with the purpose of integrating the different elements within a technological package. This project that involved FAO (Projet Algérie/37) and the CCCE (Central Cash of European Community), was the real beginning of a new research-for-development process targeting cereal production intensification and dryland field crop diversification.

Three years later (1974) this cereal project evolved into the creation of the Field Crops Development Institute (IDGC) that took up this major responsibility and ever since has been in charge of organizing the development of cereals, forages and food legumes within the country.

We may recall that in the early 1970s cereal production was increased through new varieties obtained using natural populations or selections from within these populations, such as:

- Durum wheat: Bidi17, Oued Zenati368, Hedba3, and Mohamed Ben Bachir,
- Bread wheat: Mahon Demias and Florence Aurore,
- Barley: Saïda183 and Tichedrett.

During this same period, science-based genetic improvement began, but was confined mainly to varietal development through either mass selection within local populations or through line derivation from crosses among local populations. The IDGC's germplasm enhancement program targeted good adaptation of new varieties to diverse conditions (sufficiently long vegetative growth

cycle to avoid frost during flowering in spring, while avoiding damage due to the hot sirocco winds in early summer), high fertility/productivity, disease and pest resistance, good end-use quality (French type breads) with good baking quality. The wheat types that were cultivated could be classified into four groups.

Wheats cultivated before the arrival of botanists and French researchers, old introduced wheats, newly introduced wheats, and new wheats derived from cross-hybridization (Benbelka cem 1993).

IDGC proceeded by the conservation of botanical collections, the conservation and utilization of local landraces, and plant selection in early generations and the introduction of new genotypes from abroad for adaptation trials and use in crosses.

The collaboration with CIMMYT was very strong and interactive from the very start, and starting from 1980, the International Center for Agricultural Research in the Dry Areas (ICARDA) participated in contributing to Algeria's field crops research development.

VI – ITGC and INRAA Research approaches

To ensure food security by 2015, the Algerian government set the official goal of producing 10 million tons of wheat annually in the early 2000. The main approach was genetic improvement to create more new varieties with all desirable attributes. The available genetic resources collections were characterized. Plant physiological studies were undertaken to understand their response to abiotic environmental stresses. An inventory of the major diseases and insects affecting wheat was assembled and an integrated disease and pest management program was started. Biochemical, mixing and baking studies were considered to establish the end-use qualities of all improved genotypes.

Almost all genetic material existing at INRAA (Institute National de la Recherche Agronomique d'Algérie), i.e. before the creation of the Institute Technique des Grandes Cultures (ITGC) from the IDGC, originated from improved local populations, which had been established through pure-line selection, aiming for homogeneity and stability of the resulting lines. Such selections had been carried out on the cultivated populations of Bidi17, Hedba3, Oued Zenati368, Mohamed Ben Bachir, and others. The other varieties developed by INRAA in its National Center for Agronomic Research (CNRA) were created through cross-hybridization and selection of outstanding lines from such crosses. The initial crosses included Zenati/Bouteille, *T. polonicum*/Zenati Bouteille, Florence Aurore/Mahon, and Pusa/Mentana, yielding stable lines that were kept pure through maintenance selection.

By the time the Cereals Project was completed, the IDGC had made significant advances in breeding efficiency. The most utilized breeding/selection methodology was achieved by experienced breeders in segregating populations following hybridization, initially using the pedigree selection method, and later the modified bulk method. The back-cross method was only occasionally used. Among other approaches to creating genetic variability, the earlier ITGC tried also a mutation breeding program, but it achieved no lasting success.

VII –Varietal achievements

With the introduction of semi-dwarf varieties from CIMMYT during 1968 to 1971, and by a more intensive varietal development program, numerous new cultivars have been developed and cultivated on a large acreage by farmers. They replaced for a majority the old traditional varieties by getting much higher yields even under the local dry land conditions, expressing a good level of resistance to diseases (mainly to all rusts). Peak yields of 5.2t/ha were obtained in breeder seed plots with the bread wheat variety Hidhab = HD1220/*3Kal//Nac, and around 4.5t/ha with

the durum varieties Hoggar and Sahel. The number of newly registered and cultivated varieties increased from six in 1975/76 to 33 in 1991, 49 in 2010 and 61 in 2012. New durum wheat and bread wheat varieties accounted for about 75% of the total number of these newly released varieties (Table 1).

Table 1. List of new varieties released since 1975 in Algeria.

Durum Wheat		Bread Wheat	
Chougrane	Boussellem	Hodna	Aïn Abid
Rahouia80	Simeto	Zidene	Orion
Guemgoum Rkhem	Ofanto	Nesser	Almirante
Sebaou	Gur/Dur.	Mimouni	ElWiffak
Ar bs	Eider	Soummam	Hamam-1
Righa	Carioca	Chelif	Anapo
Sahel	Cirta	Anza	Tiddis
Chen'S'	Orjaune	Tessalah	Massine
Bibans	Poggio	Rhummel	Boumerzoug
Khroub 76	Wahbi	Sidi Okba	Akhamokh
Z bans	Beni Mestina	Ziad	Yacine
Tassili	Sigus	Isser	
Hoggar	Aïn Lehma	Arz	
Kebir03	Ammar 6	Hidhab	
Belikh2	Setifis		
OumRabi	Megress		
Sham3	Tejdid		

Since 2005, the wheat improvement programs of the ITGC and INRAA merged to a single and unique National Wheat Improvement Program (PNAB), and further strengthened through collaboration with ICARDA.

Most of latest breeding efforts in Algeria are now concentrating on maximizing yield potential under more favorable rain fed production conditions, (investments should go to an irrigated wheat system). Efforts are on intensifying higher potential areas in the north of Algeria (rainfall >400mm), in addition to breeding for tolerance to major biotic and abiotic stresses (Benbelkacem 1996). In the low rainfall areas, the priority is given to tolerance to drought and resistance to biotic and abiotic stresses, such as cold and frost. More than 50% of the improved genetic material is derived from new selections or crosses in the national wheat improvement breeding program involving interdisciplinary inputs.

All deliverables (i.e. varietal development) were to involve a participatory approach with farmers to better target and promote new products. During this latest period (2005-2012) germplasm development has progressed very well and several new varieties were released (Table 1). These varieties improved consequently farmers' wheat production.

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