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# Genetic and agronomic approaches to improve durum wheat quality in Morocco

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**SUMMARY –** Improvement of durum wheat grain quality is becoming a major concern in the research efforts in Morocco to better cope with the consumers' needs for making bread and couscous. Local durum wheats are highly appreciated for bread and couscous, while the quality of the recently released cultivars are often affected by the environment factors. The improvement of grain quality through the genetic approach and use of appropriate agronomic packages are investigated. Preliminary results show the possibility of developing mutants from landraces that combine good grain quality and good agronomic traits such as short stature and earliness. Rotation trial conducted at the farmer's fields in the Merchouch region showed an important improvement in protein content, sedimentation test and grain yield in most of durum wheat varieties grown after fallow or food legumes. This research will continue to assess the effects of different preceding food legume crops on the quality of durum wheat varieties particularly, on protein content and types. The research effort on quality improvement is more justified with the intensive use of interspecific crosses to widen the genetic variability of durum wheat and to upgrade the resistance to major pests and the predominant abiotic stresses.

**Key words:** Durum wheat, grain quality, mutation, rotations.

***RESUME –*** *"Approches génétiques et agronomiques pour améliorer la qualité du blé dur au Maroc". L'amélioration de la qualité technologique des céréales et plus particulièrement du blé dur est devenue un axe prioritaire de recherche. Les variétés locales de blé dur sont très appréciées dans la fabrication du pain et du couscous alors que la qualité de la majorité des nouvelles variétés est souvent affectée par les variations de l'environnement. Les approches génétiques et agronomiques pour l'amélioration de la qualité du blé dur ont été adoptées. Les résultats préliminaires montrent la possibilité de créer des mutants à partir des variétés locales, combinant la bonne qualité technologique et un meilleur rendement grain. De même, les variétés de blé dur en rotations avec les légumineuses ou la jachère ont donné des taux de protéines, des indices de sédimentation et des rendements grain meilleurs que quand elles sont semées en monoculture. Ce type de recherche sera renforcé d'autant plus que la création variétale au Maroc est contrainte à l'utilisation des croisements interspécifiques pour améliorer la résistance aux principaux parasites.*

***Mots-clés :*** *Blé dur, qualité, mutation, rotations.*

## Introduction

Durum wheat (*Triticum turgidum* L. var. *durum*) is the traditional wheat species in North Africa. It is used mainly for bread and couscous and, to a lesser extent, as pasta for human consumption. In Morocco, durum wheat is sown annually over 1.2 million hectares, with an average consumption of around 65 kg/inhabitant/year (Ouassou, 1993). Eighty percent of the grain production is used for bread-making, mainly processed at the household level. The local populations of durum wheat, still grown by some farmers in the mountainous areas, are highly appreciated for their excellent bread-making quality. This advantage over the newly released cultivars is remunerated by at least 30% price increase in the local markets.

The new varieties released since 1972 have allowed a grain yield gain of at least 25% over the landraces, but their grain quality is highly affected by the environmental factors; some varieties such as Coccorit are sold at the same price as bread wheat varieties. The improvement of durum wheat quality to fit different end-uses (bread, couscous, pasta, burghul,…) is an important objective of the research conducted by the National Agricultural Research Institute (INRA) and the collaborating International Centers, CIMMYT and ICARDA (Nachit, 1998).

The quality of wheat is highly dependent on the genotypes, the agricultural production technology packages, and fluctuations in biotic and abiotic environmental factors (Autran *et al.,* 1993; Nachit *et al.,* 1993; Pala, 1998). Soil fertility, fertilization and water availability are the main factors affecting the stability of the quality of durum wheat varieties. In fact, field conditions of zero fertilization and full irrigation are advised in screening for susceptibility to yellowberry (Nachit and Asbati, 1987).

While genetic approach and processing were favored in improving the quality of durum wheat, the investigation of the effects of cultural practices on quality are limited.

Protein content, sedimentation test and vitreousness are the parameters largely used to assess the quality of durum wheat (Axford, 1978; Williams *et al.,* 1989). Protein content accounts for 30 to 40% of the variability in cooking quality but the protein types have strong effects on quality, with glutenin and gliadin compounds and mainly the electrophoretic band 45 low molecular weight (LMW) being a main determinant of cooking quality (Porceddu, 1993). The key quality parameters and the quality concept depend on the end products preferred and on the processing industries. Pasta production is the main destination of durum wheat in Europe, but in North Africa couscous and bread-making are more important uses. Most of the research has concentrated on the evaluation of pasta quality and only recently has research focused on the development of bread, couscous and burghul-making quality parameters.

This contribution will present the preliminary results of efforts to improve durum wheat quality, using genetic and agronomic approaches and future concerns about the quality aspects in Morocco.

## Materials and methods

The genetic approach is based on creation of mutants that will keep the quality of landraces while reducing the plant height and the growth cycle. This work was conducted in collaboration with the International Atomic Energy Agency (IAEA, Vienna). Two varieties Keyperounda and Zeramek were irradiated using 150 grays from Cobalt $^{60}$. Six M4 mutant lines were selected from each of the irradiated varieties. These mutants have reduced plant height and growth cycle compared to the original parents. Mutants and parents were evaluated for grain yield, agronomic characteristics, and quality parameters at Merchouch experiment station during 1996-97 and 1997-98 growing seasons, with 374 and 400 mm respective rainfall. The trials were conducted as randomized complete block design with two replications.

For the agronomic approach, a trial was conducted in 1998-99 season on farmer's fields at Merchouch using 23 durum wheat varieties and promising lines and one bread wheat variety (Kheir) grown under different rotations: wheat/wheat, wheat/lentils, wheat/fallow. The growing season was characterized by severe late drought and a total of 364 mm rainfall. Grain and straw yields, protein content and sedimentation test were determined. Each variety was planted in a plot of 20 m x 1.8 m and only 30 units of nitrogen and 40 units of phosphorous were applied at planting. This trial is the new research area on quality conducted in collaboration with ICARDA and Australia. The effects of different agronomic practices including rotations are also assessed by collecting grains from farmer fields with different rotations in Rommani region.

## Results and discussion

Testing the quality of improved varieties and landraces shows clearly the advantage of the local populations 272, 1658 and 2777 in protein content, hydratation in farinograph, and bread-making quality over most of the newly released varieties (Table 1). These data support the farmers' knowledge about the bread-making quality of most of the landraces and the use of these landraces in the improvement of the quality by most of the breeding programs in the region. This quality advantage has justified the use of these landraces in the mutation-breeding efforts aimed at conserving grain quality while improving grain yield through reducing plant height and cycle.

The mutation breeding efforts have led to the development of many mutant lines, most of them are chlorophyll deficient, but 12 are earlier and shorter than the original parents. Grain yield advantage is also observed for some mutants and their quality in terms of protein content, sedimentation test and percent of yellowberry are similar or superior to the original parents (Table 2). These results show clearly that this genetic approach is worth to be more investigated, mainly for the improvement of the bread-making

quality of durum wheat while maintaining grain yield and resistance to some major pests. This approach is complementary to the strategy based on the intraspecific and interspecific crosses used by the breeding programs. The use of crosses with landraces and accessions of *Triticum dicoccoides* should lead to the improvement of the quality and its stability in the new germplasm developed for the North Africa region.

Table 1. Quality of landraces and improved varieties of durum wheat (average over 4 environments)

| Varieties | 1000 KW† | % Proteins | SDS†† | % Y. berry††† | Bread yield | Bread density | Hyd. farino.†††† | Alveo. index††††† |
|---|---|---|---|---|---|---|---|---|
| Landraces | | | | | | | | |
| 2777 | 34.5 | 14.52 | 40 | 12.0 | 1412 | 0.339 | 68.4 | 125 |
| 272 | 46.3 | 14.08 | 39 | 10.6 | 1448 | 0.375 | 69.6 | 100 |
| 1658 | 49.6 | 15.54 | 39 | 3.3 | 1474 | 0.345 | 73.1 | 110 |
| Improved varieties | | | | | | | | |
| Cocorit | 44.7 | 13.21 | 42 | 18.6 | 1370 | 0.438 | 61.5 | 82 |
| Marzak | 50.0 | 13.83 | 51 | 9.9 | 1405 | 0.415 | 66.5 | 110 |
| Karim | 46.9 | 12.51 | 31 | 8.8 | 1375 | 0.404 | 63.8 | 47 |
| Massa | 53.5 | 13.95 | 41 | 8.4 | 1432 | 0.420 | 68.4 | 134 |
| Anouar | 47.1 | 12.81 | 33 | 6.3 | 1416 | 0.409 | 66.6 | 69 |
| Sarif | 40.0 | 13.39 | 31 | 19.0 | 1384 | 0.377 | 64.9 | 78 |
| Bread wheat varieties | | | | | | | | |
| Tegyey 32 | 39.1 | 13.10 | 44 | 99.5 | 1292 | 0.375 | 57.3 | 94 |
| Merchouch | 36.9 | 13.54 | 59 | 89.0 | 1382 | 0.316 | 66.8 | 281 |

†1000 KW thousand kernel weight.
††SDS = sedimentation test.
†††%Y. berry = percent yellowberry.
††††Hyd. farino. = hydration in farinograph.
†††††Alveo. index = alveograph index.

Table 2. Grain yield (kg/ha), agronomic traits and quality parameters of durum wheat mutants (average of 1996-97 and 1997-98 at Merchouch)

| Mutants | Grain yield | Days to head | Plant height | 1000 KW† | % Proteins | SDS†† | % Y. berry††† |
|---|---|---|---|---|---|---|---|
| Zeramek | 1685.8 | 102 | 85 | 48.0 | 12.6 | 21.0 | 15.5 |
| Mutant 53 | 2389.3 | 92 | 67 | 48.0 | 12.3 | 22.5 | 17.0 |
| Mutant 69 | 1618.3 | 98 | 85 | 50.0 | 13.3 | 22.5 | 7.5 |
| Mutant 92 | 1527.8 | 95 | 77 | 47.5 | 14.6 | 24.5 | 3.5 |
| Mutant 98 | 1225.0 | 100 | 85 | 49.5 | 14.5 | 24.5 | 2.0 |
| Mutant 99 | 1816.5 | 98 | 82 | 46.5 | 13.9 | 23.5 | 2.0 |
| Mutant 35 | 1762.6 | 95 | 70 | 38.0 | 13.9 | 24.5 | 7.0 |
| Keyperounda | 1176.6 | 100 | 90 | 35.5 | 14.2 | 24.0 | 8.0 |
| Mutant 20 | 1075.1 | 90 | 70 | 34.5 | 15.0 | 22.5 | 8.0 |
| Mutant 30 | 2126.3 | 97 | 85 | 41.0 | 12.4 | 16.5 | 27.0 |
| Mutant 33 | 2878.8 | 95 | 65 | 42.0 | 12.9 | 22.5 | 15.5 |
| Mutant 52 | 1516.6 | 98 | 77 | 35.5 | 14.2 | 24.5 | 6.0 |
| Mutant 61 | 1437.1 | 98 | 75 | 31.5 | 15.6 | 22.0 | 1.5 |
| Mutant 93 | 2096.3 | 95 | 80 | 37.5 | 12.1 | 18.0 | 39.5 |

†1000 KW thousand kernel weight.
††SDS = sedimentation test.
†††%Y. berry = percent yellowberry.

The improvement of grain quality and its components can also be achieved through the use of appropriate agricultural practices. The preliminary results on the effects of different rotations on quality of durum wheat varieties show an increase of at least 1.5 to 7 points in protein content for durum wheat grown after wheat and durum wheat grown after fallow or lentils. The same trend is observed for the sedimentation test. A slight increase in protein content and sedimentation test is observed for durum wheat after lentils and the same durum varieties grown after fallow. The durum wheat grown under continuous wheat yielded at least 30% less than the varieties grown after lentils or fallow. Overall, the grain yield differences between durum wheat grown after lentils and fallow were not apparent (Table 3).

Table 3. Effects of rotations on grain yield (kg/ha) and quality parameters of durum wheat varieties (Farmer field at Merchouch region, 1998-99)

| Varieties | Grain yield | | | Percent Proteins | | | SDS (ml) | | |
|---|---|---|---|---|---|---|---|---|---|
| | C/C† | C/L†† | C/F††† | C/C | C/L | C/F | C/C | C/L | C/F |
| Ajia/Hora//Jori/3/Gan | 933.3 | 1333.3 | 1366.7 | 10.81 | 16.02 | 16.43 | 48.5 | 72.0 | 61.0 |
| Chagual/Inia | 966.6 | 933.3 | 1066.7 | 11.10 | 18.66 | 15.22 | 33.5 | 65.0 | 46.0 |
| Sabil-1 | 800.0 | 1266.7 | 1116.7 | 12.10 | 16.82 | 16.11 | 39.5 | 60.0 | 49.5 |
| Rok/FG/Shll/3/ | 800.0 | 1266.7 | 1833.3 | 11.57 | 15.95 | 13.28 | 48.0 | 75.0 | 62.0 |
| Altar 84/Stn | 716.7 | 1066.7 | 1533.3 | 11.79 | 17.05 | 13.50 | 56.0 | 78.0 | 63.5 |
| Corm/Ruf//Ru/3/Altar | 833.3 | 1666.7 | 1916.6 | 12.90 | 17.05 | 16.76 | 48.5 | 45.0 | 52.0 |
| Bicri Guerrou | 733.3 | 1266.7 | 1600.0 | 11.90 | 17.55 | 12.41 | 35.0 | 58.0 | 38.5 |
| Celta | 933.3 | 1200.0 | 1616.7 | 13.16 | 15.50 | 13.11 | 35.5 | 50.0 | 36.0 |
| Bushen 3 | 950.0 | 1200.0 | 1116.7 | 13.79 | 16.65 | 13.54 | 56.0 | 52.0 | 54.0 |
| Altar 84/Alto-1 | 1133.3 | 1466.7 | 1800.0 | 11.08 | 18.33 | 12.37 | 48.5 | 44.0 | 58.0 |
| Oum-ruf-1 | 1150.0 | 2000.0 | 1700.0 | 13.56 | 14.98 | 13.11 | 60.0 | 33.0 | 67.0 |
| DHFN 47 | 783.3 | 2200.0 | 1500.0 | 11.98 | 13.74 | 12.94 | 34.0 | 37.0 | 42.5 |
| DHFN 48 | 900.0 | 1733.0 | 1583.3 | 11.94 | 15.28 | 12.74 | 31.0 | 41.0 | 38.5 |
| DHFN 48/2 | 800.0 | 1933.3 | 1416.7 | 11.93 | 15.91 | 12.92 | 30.0 | 60.0 | 45.5 |
| Telset 2 | 766.7 | 1466.7 | 950.0 | 12.92 | 13.41 | 14.60 | 30.0 | 54.0 | 44.5 |
| Telset 3/2 | 783.3 | 1600.0 | 1300.0 | 12.11 | 14.34 | 14.45 | 41.5 | 55.0 | 54.5 |
| Telset 4 | 733.3 | 1800.0 | 1333.3 | 12.52 | 17.12 | 15.36 | 33.5 | 34.0 | 40.0 |
| Telset 4/2 | 633.3 | 1666.7 | 2166.7 | 11.58 | 15.63 | 16.32 | 54.5 | 33.0 | 57.0 |
| Oum Rabia | 883.3 | 1200.0 | 1615.0 | 12.56 | 14.83 | 14.51 | 37.5 | 48.0 | 46.0 |
| Vitron | 816.7 | 1733.3 | 2133.3 | 12.42 | 16.92 | 14.38 | 66.0 | 54.0 | 69.0 |
| Marzak | 866.7 | 1266.7 | 1350.0 | 13.47 | 17.06 | 16.52 | 78.0 | 63.0 | 84.5 |
| Jawhar | 966.7 | 933.3 | 1683.3 | 11.44 | 14.55 | 15.64 | 41.5 | 50.0 | 57.0 |
| Massa | 966.7 | 1066.7 | 1450.0 | 13.20 | 19.20 | 16.22 | 48.0 | 50.0 | 63.0 |
| Khair (bread wheat) | 750.0 | 1533.3 | 1750.0 | 11.87 | 16.15 | 13.70 | 78.5 | 91.0 | 94.5 |

†C/C = continuous wheat.
††C/L = wheat after lentils.
†††C/F = wheat after fallow.

These preliminary data show clearly the advantage of introducing a legume species in rotation with wheat in the favorable and semi-arid areas. This will allow the improvement of both grain yield and quality parameters over the most predominant practice of wheat after wheat. This rotation can additionally lessen the pest incidence and severity. These kinds of results will not be apparent if this type of trials are conducted in the experiment stations known for their high nitrogen and phosphorous contents. Such trials will be conducted more in the future to analyze the effects of rotation, fertilization and other agronomic practices on quality parameters, including protein types.

## Conclusion

Quality aspects are key elements for the promotion of durum wheat in North Africa. This is even relevant after the recent efforts to solve the problem of pests through intensive use of interspecific

crosses. Genetic approach using mutation and landraces as well as the development of appropriate practices will lead to improve both yield levels and the grain quality and their stabilities. Efforts should include the improvement of quality aspects for different uses including pasta, couscous and bread making. The quality characterization in cereals, and particularly in durum wheat, will gain more from the use of molecular markers.

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