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Breeding for resistance to *Septoria tritici* in durum wheat

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SUMMARY – *Septoria tritici* blotch is the most important disease of durum wheat in Tunisia. Control of this disease focuses mainly on the use of genetic resistance of the host plant. Continuous screening in Tunisia lead to the identification of lines with partial resistance. Crosses of this genetic material to high yielding and widely adapted germplasm resulted in the selection of high yielding and resistant durum wheat lines. Accumulation of gene effects and detection and use of tolerance are also important components of this breeding activity.

Key words: *Septoria tritici* blotch, durum wheat, resistance, breeding, Tunisia.

RESUME – *"Amélioration pour la résistance à* Septoria tritici *chez le blé bur". La septoriose est la plus importante maladie du blé dur en Tunisie. La lutte contre cette maladie repose essentiellement sur la résistance génétique de l'hôte. La recherche de sources de résistance en Tunisie a conduit à l'identification de quelques lignées possédant une résistance partielle. Les croisements de ce matériel à du germoplasme productif et possédant une large adaptation ont permis de sélectionner des lignées productives et résistantes à la septoriose. L'accumulation des effets géniques, la détection et l'utilisation de la tolérance sont aussi des composantes importantes de l'amélioration de la résistance du blé dur à cette maladie.*

Mots-clés : *Septoriose, blé dur, résistance, amélioration génétique, Tunisie.*

Introduction

Durum wheat is traditionally the main cereal crop in Tunisia. It covers an average of 850,000 ha, accounting for around 55% of the cereal area grown each year. Most of the acreage planted to durum wheat is rainfed and approximately 70% is under semi arid conditions with less than 450 mm rainfall. Average production is around 10.5 million quintals, which represent approximately 80% of the country needs. Though improved varieties have been released and widely used in farmers fields, durum wheat production and yields are still low and highly variable. This is mostly due to the negative effect of biotic and abiotic stresses and to the non optimum cultural practices under which durum wheat is being produced. Developing high yielding varieties with better drought tolerance and resistance to the most prevalent diseases is a priority of the breeding program. More emphasis was given during the last few years to the identification and selection of germplasm with the desirable traits. The outcome of these efforts was the release of Oum Rabia with better drought tolerance, in 1996. Recently, a durum wheat variety with better resistance to septoria was proposed for registration under the name Nasr 99. The present paper reports on the strategy and the recent achievements in breeding for disease resistance in durum wheat.

Constraints to durum wheat production

Durum wheat production increased substantially during the last two decades (Fig. 1). This was the result of the improved crop management and the wide use of high yielding and better adapted cultivars. In spite of the production and yield increases, average grain yield of durum wheat is still low and highly variable. Drought is the most limiting abiotic stress in semi arid zones, while diseases, mainly septoria, leaf rust and powdery mildew frequently cause yield losses to durum wheat in the favorable zones and under irrigation. Average grain yield of durum wheat was only 2.8 q/ha under the dry conditions of the 1987-1988 season and was 15.9 q/ha under more favorable conditions of the 1991-1992 season, while yields as high as 60 q/ha and 80 q/ha were obtained in favorable zones and under irrigation respectively. This reflects the highly variable climatic and management conditions under which durum wheat is produced in the country. It also indicates that there is good scope for further productivity gains

through improved crop management in favorable and irrigated areas and the breeding of more drought tolerant and disease resistant varieties. These are the major goals of the breeding program (Gharbi and Maamouri, 1998).

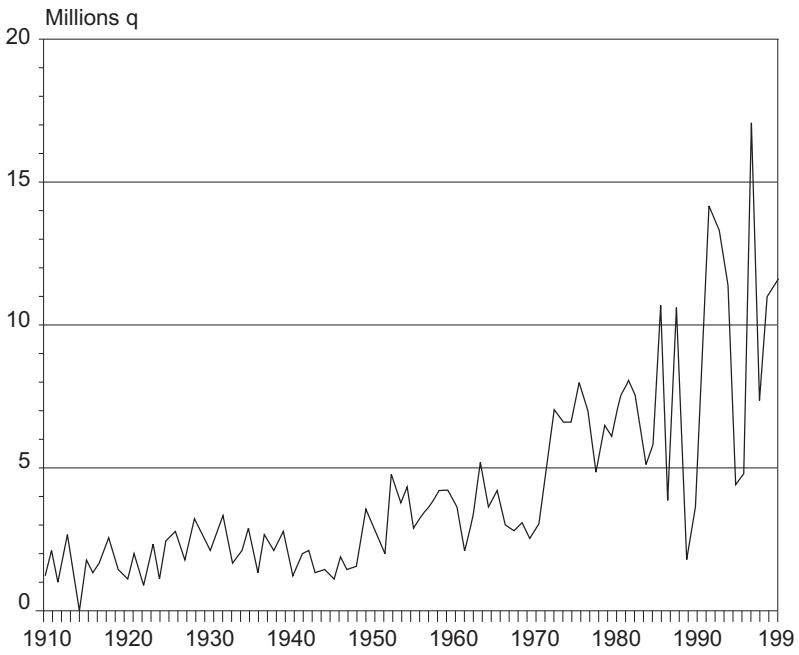

Fig. 1. Durum wheat production in Tunisia.

Breeding for improved disease resistance

Compared to rusts, smuts and bunt, septoria diseases were considered of minor importance on the durum varieties grown in Tunisia in the 1930's (Petit, 1935). Djerbi and Ghodhbane (1975) reported that *Septoria tritici* blotch, incited by *Septoria tritici* (Rob. ex Desm) [sexual stage *Mycosphaerella graminicola* (Fuckel) Schroeter] was described by Viennot-Bourgin in 1949 as an endemic disease with negligible importance in North Africa. Apparently, the disease became more important in Tunisia with the introduction of the early maturing, semi dwarf, high yielding cultivars (Djerbi and Ghodhbane, 1975; Maamouri, 1975). During the last two decades *Septoria tritici* has always been reported as the major cause of septoria leaf blotch of wheat in Tunisia (Djerbi and Ghodhbane, 1975; Kamel *et al.,* 1984; Chalghaf *et al.*, 1993), with greater incidence on durum than on bread wheat (Djerbi and Ghodhbane, 1975; Kamel *et al.*, 1984; Gharbi and Deghaies, 1996). *Septoria nodorum* was recently reported by Harrabi (pers. comm.). The greater incidence of septoria leaf blotch on durum compared to bread wheat in Tunisia suggests a specialization of the pathogen which may be the result of the ever more important durum acreage compared to bread wheat. Such specialization was reported by Eyal *et al.* (1985), Jlibene *et al.* (1995), Kema *et al.* (1995) and Sayoud (1995). Sources of resistance have been identified in the early seventies (Djerbi *et al.,* 1974) but lack of continuous efforts devoted to this problem have lead to little success in breeding durum wheat with satisfactory level of resistance.

Currently the most widely grown durum wheat cultivars Karim, Razzak and Khiar are very susceptible to septoria and leaf rust (Table 1). Karim, a Bittern sib was released in 1980, while Razzak is a local selection from a cross of Karim with a high yielding line from CIMMYT. Khiar, a selection from the cross Chen''S''/Altar84 made by CIMMYT, was released in 1996. It showed high yield potential and wide adaptation in Tunisia.

In six out of the last nine cropping seasons starting from 1990-1991, high infestations with septoria were noticed on durum wheat. Those caused by leaf rust often exacerbate yield losses during wetter seasons. Poor durum wheat quality was obtained in the 1995-1996 season as a result of heavy infestations by both diseases. On the other hand, more durum production should come from increased input use in favorable and irrigated areas to meet the increasing demand. These conditions are also

conducive to more disease development. The release of cultivars with better resistance to septoria would avoid disease breakouts and maintain the inoculum at lower levels. This is supported by observations of *Septoria tritici* attacks on wheat in a hot spot area in Australia where the disease occurrence was reduced to minimum with use of a resistant cultivar (Murray *et al.*, 1990). The same study showed that severity of *Septoria tritici* is influenced by the relative susceptibility of the wheats grown in the area in the previous season when long term data were considered.

Table 1. Reaction to *Septoria tritici* of the main commercial durum cultivars in Tunisia

	Karim	Razzak	Khiar
1991	8-7	8-7	8-6
1992	8-8	8-7	7-6
1993	8-6	7-6	7-6
1996	9-9	9-8	9-8
1998	9-8	9-7	9-8

Under moderate and high septoria and leaf rust incidence farmers are using more and more fungicides to control these diseases. More than 20,000 ha were treated with fungicides in 1992, 29,000 ha in 1997, 50,000 ha in 1998 and around 27,000 ha in 1999 (unpublished data of the Ministry of Agriculture). Efficiency of these sprays is not too high and, in many cases, not easy to demonstrate in an environment where erratic rainfall during spring is often the cause of low grain yields. Moreover, application of fungicides increases production cost which jeopardizes the competitiveness of durum wheat production. Increased reliance on pesticides in cereal production is undoubtedly not a safe solution because of the possible side effects on human and animal health and the harm that it may cause to the environment. Host plant resistance has been always regarded as the cheapest, most practical and the least environmentally damaging control method (Rosielle, 1972; Eyal *et al.,* 1987; Cook and Veseth, 1991; Hogenboom, 1992). However when available, genetic resistance should be used with other control measures, such as appropriate cultural practices that reduce disease pressure, in an integrated pest management scheme to ensure a sustainable wheat production. Screening for sources of resistance to septoria and leaf rust has been an increasing activity within the Tunisian durum wheat breeding program. Germplasm developed by the program or introduced from ICARDA and CIMMYT is evaluated each year under favorable conditions in Beja (600 mm). Septoria development is enhanced by artificial inoculation using infested straw and early sowing. Data collected during many seasons showed that no complete resistance was found in the screened germplasm. However few sources with moderate levels of resistance to *Septoria tritici* have been identified (Gharbi and Maamouri, 1994). Disease scores taken on this germplasm ranged from “traces’’ of the disease to “6-5’’ (scale of Saari and Prescott, 1975). This confirms the partial resistance reported by Gilchrist *et al.* (1995) in durum wheat and El Bouami *et al.* (1996) in bread wheat. Some of the first identified sources of resistance in our program gave 10% less yield than the widely grown cultivars. Later many lines having GdoVZ 512/Cit//Ruff/Fg as a parent showed consistent lower disease scores together with grain yields equivalent or slightly higher than that of the commercial varieties. One line selected from the cross GdoVZ 512/Cit//Ruff/Fg/3/Pin/gre//Trob showed better resistance to septoria leaf blotch and higher average yield than Karim. On an average of 31 yield trials conducted in five sites between 1992 and 1999, its grain yield was approximately 5% higher than that of Karim. Under high infestation by septoria in Beja, where regular attacks are observed on durum, average grain yield of this line over five years was 14.3% higher than that of the same check (Table 2). In Bou Salem and Krib, its grain yield was approximately 5% higher than Karim on an average of four and three seasons respectively. This line will be released under the name Nasr 99 and recommended for the northern and coastal areas of the country.

A breeding program was undertaken to upgrade disease resistance of durum wheat. It includes crosses of these sources of resistance to high yielding adapted germplasm and other material showing resistance to leaf rust. Continuous screening, selection and yield testing in appropriate sites have lead to the selection of germplasm with acceptable level of resistance to septoria and/or leaf rust with yield potential slightly higher than that of the susceptible commercial varieties. Performance of promising lines with resistance to septoria and leaf rust are reported in Table 3.

Table 2. Grain yield (GY) (q/ha) of Nasr and Karim (K) under high infestation by *Septoria tritici*

		Beja		Bou Salem		Krib		Average	
		GY	% K	GY	% K	GY	% K	GY	% K
1992	Nasr	62.15	117.40	–	–	–	–	62.15	117.40
	Karim	52.94		–	–	–	–	52.94	
1993	Nasr	62.02	109.60	44.20	89.46	45.71	102.60	50.64	100.92
	Karim	56.59		49.41		44.55		50.18	
1996	Nasr	30.99	103.58	23.73	141.00	41.75	101.71	32.16	109.87
	Karim	29.92		16.83		41.05		29.27	
1998	Nasr	57.89	129.62	39.77	104.00	41.95	110.98	46.54	115.65
	Karim	44.66		38.24		37.80		40.24	
1999	Nasr	62.32	109.64	45.14	110.98	–	–	53.73	110.21
	Karim	56.84		40.67		–	–	48.75	
Average	Nasr	55.07	114.27	38.21	105.29	43.14	104.88		
	Karim	48.19		36.29		41.13			

Table 3. Reaction to *Septoria tritici* and yield performance (q/ha) of promising durum wheat lines

Cross	Septoria score Beja 1999	Grain yield (q/ha)	% of Karim
D93-57-9b-6b-0b = Krf/Baladia Hamra//Krf/3/ ALTAR84	4-2	54.32	107.36
D93-60-1b-11b-0b = Krf/Baladia Hamra//Krf/3/ STN''S''// YAV''S''/TEZ''S''	3-2	53.71	106.02
D93-57-3b-8b-0b = Krf/Baladia Hamra//Krf/3/ ALTAR84	5-3	59.66	110.34
D93-67-15b-9b-0b = Nasr/ Khiar	4-3	58.97	109.06
D93-21-7b-1b-0b = ALTAR84//FD8419-126-1-2/Razzak/3/ Krf/Baladia Hamra//Krf	4-3	55.61	103.10
Karim (check)	8-7		

However, given the high pressure of septoria leaf blotch in the favorable zones of the country and the high genetic variation of the pathogen (Kema *et al*., 1995; Jlibene *et al*., 1995), breeding activities within the program are concentrating on the diversification of the sources of resistance and the accumulation of gene effects that would ensure more effective and durable resistance.

Some very susceptible lines (scores higher than 7-7) gave grain yields 10 to 15% higher than the check Karim. This suggests that tolerance to *Septoria tritici* blotch in these varieties may be effective in reducing the disease impact. The presence of effective tolerance in a given germplasm should, however, be demonstrated before being used in breeding programs.

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