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Breeding for dual resistance to *Ascochyta* and wilt diseases in chickpea

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SUMMARY - Chickpea yields are characterised by wide fluctuations and lack of stability due mainly to diseases. The two major diseases in Tunisia are *Ascochyta rabiei* and wilt caused by *Fusarium oxysporum*, *Verticillium albo-atrum* and other *Fusarium* species. Therefore attempts are made to combine, through breeding, resistance for both diseases, for this a "shuttle" screening method was developed.

RESUME - "Amélioration pour la résistance à l'anthracnose et aux flétrissements chez le pois chiche". En Tunisie, les rendements du pois-chiche se caractérisent par des fluctuations importantes. Ce manque de stabilité reflète la variation des conditions climatiques du Nord de la Tunisie, mais également la sensibilité de la culture à de nombreuses maladies notamment l'anthracnose causée par l'*Ascochyta rabiei* et le flétrissement causé par le *Verticillium albo-atrum* et le *Fusarium oxysporum*. L'un des objectifs du programme d'amélioration du pois-chiche est l'obtention des variétés résistantes à ces deux maladies. Pour cela une méthode de sélection appelée "Shuttle screening" a été développée.

Introduction

Many serious diseases which have the potential to destroy chickpea crop have been reported (Nene and Reddy, 1987). Some of these are relevant to North African areas and the most important are *Ascochyta rabiei* and wilt caused by various fungi. Although the former disease is repeatedly reported, the latter was never mentioned as a serious disease until recently (Halila *et al.*, 1984; Halila and Harrabi, 1987; Harrabi *et al.*, 1985). This also applies to Algeria and Morocco where severe wilt in chickpea has also been reported (Solh, personal communication).

Wilt had previously been reported to cause dramatic losses in Spain, (Cubero, 1975, 1980; Trapero-Casas and Jimenez-Diaz, 1981, 1985). Thus, the wilt complex appears to be a dangerous potential disease in the western Mediterranean zones.

Chickpea is traditionally planted as spring crop in all North African countries and yet is still attacked by *Ascochyta*. The concept of shifting the planting from spring to earlier dates will make this hazard even more critical because of much more favourable conditions to the development of the disease. Resistance to *Ascochyta*

will, therefore, be of paramount importance, if not a prerequisite condition for growing chickpea.

If *Ascochyta* can, to some extent, be controlled by other means than breeding (Nene, 1981), wilt resistance could be insured efficiently only by genetic manipulations. At the present time most breeding programs are aimed to incorporate resistance to *Ascochyta* in an adapted genetic material. It is felt, however, that breeding for resistance to a wide range of diseases in order to alleviate yield fluctuations would provide a more reliable stable production of chickpea crop. The Tunisian Food Legume Improvement Program initiated breeding work with the objective of combining, in the same genetic background, a dual resistance to ascochyta and wilt diseases.

Identification of sources of resistance

Resistance to *Ascochyta rabiei*

Using the 1-9 scale, where 9 is most susceptible, all collected local cultivars, introduced accessions from ICARDA and ICRISAT and inbred lines were screened against

the blight disease under field epiphytic conditions. The field screening is complemented by a laboratory screening work at the seedling stage using various other isolates collected in the chickpea growing areas of Northern Tunisia (Harrabi *et al.*, 1988).

The screening work has resulted in the identification of tolerant lines, all of them issued from ICARDA germplasm collection and chickpea breeding program. Two of these lines were selected for seed increase and release for farmers for early planting (Table 1) and many others were used in the breeding program.

Furthermore disease etiology work indicated that the 1-9 scale is suitable to differentiate between resistant and highly susceptible cultivars but not so for the intermediate reactions. Therefore its use in studies on the inheritance of resistance to *Ascochyta* would lead to some difficulties in interpreting the data. Recent results on the genetics of resistance have indicated that ascochyta resistance may be quantitative rather than qualitative in nature (Riahi, unpublished data).

Table 1. Chickpea lines tolerant to *Ascochyta* selected for release to farmers.

Selections	Origin	Diseases		Growth habit	Lodging	Use
		Ascochyta ^a	Wilt			
Chitoui	URSS	4.25	Susceptible	Erect	Resistant	Polyvalent Pastry-coffee
Kassab	ICARDA	3.75	Susceptible	Semi-erect	Tolerant	Polyvalent
Local	Tunisia	9.0	Susceptible	Spreading	Susceptible	Polyvalent

^a/ Recorder on a 1-9 scale where 9 is complete kill.

Resistance to wilt disease complex

The wilt screening is done at the wilt-sick plot (WSP) of Béja station located in the chickpea growing belt. As a routine measure all genetic material is screened in the WSP for identification of lines resistant to wilt with as much genetic variation as possible. Besides, a collaborative project was started with ICARDA involving a wilt screening program of the germplasm collection maintained at Aleppo. The program is still in progress and concerns more than 3,000 lines. It has been shown that at

least two screening cycles are needed before deciding on the variety reaction to wilt.

The main fungi of the WSP are by order of importance *Fusarium oxysporum* f. sp. *ciceri*, *Verticillium albo-atrum*, and other *Fusarium* species.

The wilt screening work has resulted in the identification of low resistant lines to the above fungi (Halila *et al.*, 1984). These lines stemmed from single plants selected in a completely devastated chickpea field in 1980. Seeds of the single plants were planted, during subsequent years, in progeny rows and then in replicated yield trials. The lines kept consistently showed their resistance to wilt but were, however, susceptible to ascochyta blight. One line was selected for release to farmers for spring planting in zones infested by wilt (Table 2). The same line has been used extensively in breeding programs.

Surveys in fields reported by farmers to be infested indicated that the most prevalent fungus causing wilt was *Verticillium albo-atrum* (Halila and Harrabi, 1987). The wilt "pit" is located in the Mateur zone and is expanding every year toward South-East and West.

Table 2. Chickpea wilt resistant line selected for spring infested zones.

Lines	Origin	Wilt	Ascochyta blight	Yield ^a	100 seed weight (g)
Amdoun 1	Tunisia	Resistant	Susceptible	1356	46.52
Local	Tunisia	Susceptible	Susceptible	1230	44

^a/ kg/ha. Average of 4 sites during 1985/86/87 seasons.

Breeding chickpea for dual resistance

Because of the devastating potential of both ascochyta and wilt diseases the chickpea breeding program has set as one of its main objectives the incorporation, in the same background, of resistance for these two diseases.

Hybridization work was initiated in 1982/83 and targeted crosses were made at ICARDA for our program (Table 3). Single crosses, backcrosses and three way crosses were made using identified resistant parents.

The F₁ generation (Fig. 1) was grown under complete ascochyta free conditions as well as wilt free soil. The F₁ is harvested as single plants which are planted as F₂

Table 4. Winter sown (W) versus spring sown (Sp) chickpea. Yields (kg/ha) of two chickpea selections. Average of three sites during 1985-87 period.

Season	Type of crosses			Total
	Simple	Backcross	Three ways	
82/83	12	—	—	—
82/83	12	—	—	12
83/84	22	6	—	28
84/85	20	—	—	20
85/86	24	—	—	24
86/87	—	—	8	8
87/88	—	6	—	6

progenies in the WSP and resistant F_2 plants are advanced to F_3 progenies and screened against *Ascochyta* under artificial inoculation. Resistant F_3 single plants are then selected and taken back to the WSP for a second cycle of screening against wilt and planted as F_4 progenies. Resistant plants are selected and advanced to F_5 - F_6 progenies for *Ascochyta* screening where negative selection is performed. The resistant F_6 rows are bulked and tested for yield performance in an augmented design and then in multilocation advanced yield trials. They are at the same time, retested concomitantly for resistance to *Ascochyta* and wilt.

The remaining of the F_4 and F_5 progenies are bulked and evaluated for yields. Depending on seed availability these bulks could be made available to other national programs in the region.

The system takes five years before reaching the multilocation trial phase. The system allows for at least two screening cycles for both diseases and for screening against other diseases such as virosis.

Perspectives of winter planting in the area

Chickpea is presently sown in spring. The literature indicates however that winter plantings were previously in use by the French colon farmers (Guillochon, 1940) and yields were reasonably good. Why then, did the farmers move from winter planting to the present late spring planting? The hypothetical reason is readily given by the *Ascochyta* disease problem. If this is true then we would assume that the varieties used by the French colon farmers were tolerant to this disease. However, it would be

difficult to know the whole story behind the shift of planting from winter to spring.

Reintroducing the winter planting would then mean a return to the "sources". Research results obtained from early sowing show the important yield increase induced by this technique. The technique itself requires however many prerequisite conditions. Two of them appear to be the most important under our conditions: the use of *Ascochyta* resistant cultivars and weed control (Knott and Halila, 1986).

The potential of winter planting is presented in Table 4 and the detrimental effect of weeds on chickpea yield in Table 5. Table 4 also shows the effect of a better management of a spring chickpea crop which allows for 69% increase over the national average yield, while advancing the plantings from spring to winter would result in a substantial yield increase over the national average. This increase would amount from 50 to 84%.

Table 4. Winter sown (W) versus spring sown (Sp) chickpea. Yields (kg/ha) of two chickpea selections. Average of three sites during 1985-87 period.

Selection	Sp	% increase Sp / NA ^a	W	% increase W / Sp	% increase W / NA
Chitoui	1145	44	2056	79	160
Kassab	1470	86	2714	84	243
Local	1339	69	2010	50	154

^a/ NA: 793 kg/ha, national average yield for chickpea during the last 15 years.

Table 5. Seed yield loss due to weed infestation at Béja and Kef experimental stations. Average for 1983, 84 and 85.

Stations	Yield loss		
	% of weed free treatment	kg/ha/day weedy for 12 weeks after emergence	Equivalent loss in US dollars/day ^c
Béja ^a	46.4	5.6	6.82
Kef ^b	75.7	6.0	7.31

^a/ Low to medium infestation level.

^b/ High infestation level.

^c/ 1 kg of chickpea = 1 TD = 1.21 US Dollar.

Weeds, if not controlled, would still be the bottleneck of the whole winter planting concept. The negative effect of weeds is clearly demonstrated in the table where 75% of the crop could be lost in case of a high infestation (Kef) and half of it lost when the weed infestation is low to medium. In our opinion developing integrated weed control measures is a must in order to succeed in transferring the winter planting techniques to farmers in North African areas.

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