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Integrating Cultivar Resistance and Seed Treatment with Planting Dates to Manage Chickpea Ascochyta Blight

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Abstract: The influence of chickpea (*Cicer arietinum*) planting date on seasonal epidemics of Ascochyta blight caused by *Ascochyta rabiei* (Pass.) Labrousse and on grain yield was evaluated during the 1997 and 1998 cropping seasons. Two chickpea cultivar (Ghab 1 and Ghab 3) and 2 breeding lines (FLIP 90-96 and F 88-85) were used in the field trials at 3 different locations representing the different agro ecological zones in which winter chickpea is grown in Syria and in most of the Mediterranean countries. Four field plantings were made at 14-day intervals from mid November to mid March. All plots were initially inoculated with infected debris and disease development followed natural prevailing environmental conditions. Ascochyta blight disease severity ratings were taken at early flowering and again at podding and grain yield for each plot was measured at harvest. There was a significant ($p<0.05$) increase in disease severity between the first and third planting in all the entries at all the locations and for both years. The difference in disease severity resulted in significant yield differences but not in differences in seed quality. Under Syrian and Mediterranean conditions, an increase in Ascochyta blight severity can be expected with early planting of chickpea before January and this can result in a corresponding big loss in crop yield. The loss in yield from disease through early plantings however, is more than compensated for, by the reduction in yield due to other environmental parameters in late spring planting, if moderate resistant cultivars are planted.

Key words: Chickpea, planting date, *Ascochyta rabiei*, disease control, resistance

INTRODUCTION

Under Mediterranean growing conditions, *Ascochyta rabiei* (Pass.) Labrousse (teleomorph: *Didymella rabiei* (Kov.) v. Arx.) causes severe blight epidemics on chickpea (*Cicer arietinum* L.), particularly when the crop is planted under winter conditions[1]. Outbreaks of the disease can reduce chickpea yields by up to 100% when susceptible chickpea cultivars are grown[2].

Numerous studies[3-5] have evaluated the reaction of chickpea cultivars to Ascochyta blight in an attempt to identify cultivars with resistance to the disease. Data from these studies have been variable and results depended on the location and year of evaluation. Effective levels of resistance to Ascochyta blight have been reported[5] but currently, there are few cultivars under cultivation with high levels of resistance to the disease. This is partly due to pathogen variability, as resistant cultivars become susceptible soon after deployment[6]. Several races and pathotype groups have been reported from different studies carried out in the Mediterranean countries[7-9]. Thus effective control of the disease cannot be attained by complete reliance on host-plant resistance alone.

Ascochyta rabiei is both seed-borne and debris-borne and infected seed has been implicated in the introduction of the disease into new areas or in the rapid spread of the disease within fields. The highly seed-borne nature of the pathogen in chickpea, makes fungicidal seed treatment essential and useful. Seed treatment with effective fungicides can greatly help in reducing the initial inoculum level and preventing the spread of the disease. Seed treatment of tolerant cultivars may be much more effective to prevent the increase in pathogen population during conducive weather conditions. Different studies have evaluated fungicides as seed treatments for the control of Ascochyta blight of chickpea[10-12]. Some fungicides have been identified with good efficacy on seed-borne infection[13].

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In the Mediterranean region, small-scale subsistence farmers employ diverse methods for cultural control of disease, but there are few published data on the efficacy of these methods. Chickpea for example, has traditionally been grown as a spring crop in the region, even though research has shown that yields could be increased by up to 100% if the crop could be grown in winter[14]. Farmers have been avoiding winter planting with its associated Ascochyta blight risks and planting in spring even with the consistent low yields that average less than 700 kg ha^{-1}. From the start of winter to the end of spring there is a potential production period of up to 5 months in the cropping season, beginning from start of November when the winter rains stabilize to the start of April when they end. Some isolated agronomic studies have been carried out in different countries in the region, to determine the most suitable time to plant chickpea during this potential period to optimize yields. Few of the studies have been published[14,15] but none has come up with recommendations on planting time based on risk of Ascochyta blight epidemics and grain yield of chickpea during these periods. Published reports have shown that varying the planting date of crops can delay the development of different diseases and thus increase yields[16,17]. There are no such published reports on the effects of planting date on Ascochyta blight disease development and corresponding grain yield and quality in chickpea. This information is needed in the development of effective Ascochyta blight management strategies that combine host resistance with the use of cultural practices.

This study was therefore, undertaken to determine the effects of different planting dates of chickpea on: (a) the severity of chickpea Ascochyta blight under Syrian field conditions, (b) the crop yield potential under the different planting dates and varying disease scenarios and © the effect of the disease on seed quality.

MATERIALS AND METHODS

The investigations were conducted during the 1997/98 and 1998/99 cropping seasons at three research sites in Syria; Hermo Agricultural Research Station, Al-Ghab Research Station and ICARDA Tel Hadya research farm. Choice of these sites was influenced by two factors; the annual rainfall distribution and their representation of the major chickpea-growing areas of Syria and other Mediterranean locations.

For both seasons, four chickpea genotypes selected on the basis of their agronomic adaptation and host reactions to Ascochyta blight were used. These were: Ghab 1, a medium maturing cultivar which was the first cultivar released for winter cultivation in Syria, but now susceptible to Ascochyta blight under winter conditions. The other cultivar was Ghab 3, which is currently recommended for winter cultivation in Syria because of its high yields and moderate resistance to Ascochyta blight. The other genotypes were F 90-96 and F 88-85, both selected because of their potential for winter cultivation under Mediterranean environments. Both also have moderate levels of resistance to the disease. Seeds of each genotype were either treated with the fungicide Thiabendazole (Tecto^R) at the rate of 3 g kg^{-1} of seed, or not treated.

Five planting dates were staggered four weeks apart starting from the last week of November and ending in the last week of March during each cropping season. The recommended dates for planting chickpea in Syria are mid-November for winter plantings and early March for spring plantings. Planting dates for this study were thus arranged to cover all possibilities in winter and spring plantings.

The field design was a split-split plot with three replications in three randomized complete blocks. Planting dates were the main plots, genotypes the sub-plots and seed treatments the sub-sub-plots. Seeds were hand-planted at a depth of 3-5 cm and a rate of 10 seeds per meter. Each plot consisted of four rows, each 4 m long with 0.35 m spacing. To ensure uniform Ascochyta blight disease inoculum and spread in the plots, the plots at each site were inoculated soon after germination, by spreading blight-infected chickpea debris collected from Ascochyta blight screening nurseries of the previous season.

Ascochyta blight severity ratings for each plot were made at near maturity, just before the early-maturing genotypes started yellowing. The ratings were based on a modified subjective scale of 1-9, as described by Singh *et al.*[18], where, 1= no infection and 9 = all plants killed. In the 1997/98 cropping season, late rains during the podding stage in May, favored pod infection at all three sites. Pod disease severity ratings were also taken based on a 1-5 scale where, 1 = no pod infection; 2 = slight pod infections; 3 = few concentric rings seen on pods; 4 = several concentric rings on pods; 5 = pods completely shriveled.

At pod maturity for each genotype, all four rows in each plot were hand-harvested, placed in cloth bags and left for two weeks on the plots, for further grain drying to less than 12% moisture content. Mean seed yield per plot was determined and seed yield per hectare calculated for each planting date. During the 1997/98 season, ten plants were randomly selected from each plot, from which 100 pods were randomly taken and their percent pod infection recorded based on visual Ascochyta symptoms on the pods.

The effect of planting date on the seed incidence of *Ascochyta rabiei* was determined for each genotype and planting date, by estimating the percentage of seeds that showed lesion symptoms of *Ascochyta rabiei* and gave colonies of *Ascochyta rabiei* on Potato Dextrose Agar (PDA) growth media, using 100 seed samples from each pod lot.

Disease severity ratings, plot yields, seed weights and seed infection data were subjected to an analysis of variance using Genstat release 5.3 packages, to determine main and split plot effects. Mean separations were performed on disease severity, yield, seed weight and seed infection with Fischer's least significance tests to compare planting dates effect.

RESULTS

In both years of the study, stem lesions from Ascochyta blight were first observed on plants during the vegetative growth stages for the first 2 plantings. These lesions generally increased in severity through the podding growth stages. Stem lesions were not usually observed on plants of the first two plantings during the seedling growth stages.

Plots were hand-harvested during the second week of June for the first plantings to the first week of July for the last plantings. Because of slight differences in the maturity of the genotypes used, plots were harvested as they matured regardless of the order in which they were planted. Because each maturity group was separated from the others by less than 10 days, each main plot

Table 1: Influence of planting date and fungicide seed treatment on Ascochyta blight severity of chickpea genotypes during 1997/98 season

			Disease severity (1-9)[a]				
Locations	Planting dates	Seed treatments	F 88-85	F 90-96	Ghab 1	Ghab 3	Mean
Tel Hadya	15 Nov.	T	5.0	3.5	4.3	4.0	4.2
		NT	5.0	3.8	5.8	5.0	4.9
	22 Dec.	T	5.3	3.3	5.0	4.2	4.5
		NT	5.5	3.1	5.5	4.7	4.7
	15 Jan.	T	3.7	2.7	4.0	3.7	3.5
		NT	4.0	3.5	5.0	4.2	4.2
	13 Feb.	T	2.5	2.7	2.8	2.5	2.6
		NT	3.2	2.6	3.2	2.7	2.9
	14 Mar.	T	3.0	2.0	3.1	2.0	2.5
		NT	2.0	2.0	3.6	2.5	2.5
	LSD (0.05)	T	1.0	0.9	1.3	1.2	
		NT	1.2	1.2	1.1	1.3	
Hermo	16 Nov.	T	3.7	3.3	6.7	3.0	4.2
		NT	4.3	4.3	7.0	4.3	5.0
	18 Dec.	T	2.7	3.3	4.0	2.7	3.2
		NT	3.0	3.0	4.5	3.0	3.4
	14 Jan.	T	1.7	1.7	2.3	1.7	1.9
		NT	2.0	1.7	2.7	2.0	2.1
	15 Feb.	T	1.0	1.0	1.0	1.0	1.0
		NT	1.0	1.0	1.0	1.0	1.0
	13 Mar.	T	1.0	1.0	1.0	1.0	1.0
		NT	1.0	1.0	1.0	1.0	1.0
	LSD (0.05)	T	1.1	0.9	1.1	0.7	
		NT	0.5	0.6	1.0	0.5	
Al-Ghab	15 Nov.	T	6.3	5.7	7.1	6.3	6.4
		NT	6.5	6.0	7.7	6.5	6.7
	17 Dec.	T	6.3	5.3	6.7	5.5	6.0
		NT	6.8	5.3	7.3	5.8	6.3
	14 Jan.	T	3.0	3.3	4.1	3.3	3.4
		NT	3.8	3.7	4.5	3.5	3.9
	15 Feb.	T	2.8	2.3	2.6	2.3	2.5
		NT	3.0	2.5	2.6	3.0	2.8
	14 Mar.	T	1.0	1.0	1.0	1.0	1.0
		NT	1.0	1.0	1.0	1.0	1.0
	LSD (0.05)	T	0.7	0.7	1.0	0.9	
		NT	0.9	1.2	0.7	0.5	

[a]Disease severity based on a scale of 1-9[18]; where 1= no infection, 9= plants killed, T = Treated seed with the fungicide, Thiobendazil at rate of 3g kg^{-1}, NT= non-treated seed

Table 2: Influence of planting date and fungicide seed treatment on Ascochyta blight severity of chickpea genotypes during 1998/99 season.

			Disease severity (1-9)[a]				
Locations	Planting dates	Seed treatment	F 88-85	F 90-96	Ghab 1	Ghab 3	Mean
Tel Hadya	7 Nov.	T	6.0	4.3	5.0	4.0	4.8
		NT	6.3	4.0	6.0	5.0	5.3
	19 Dec.	T	5.7	4.7	5.0	4.6	5.0
		NT	6.0	4.3	6.0	4.6	5.2
	15 Jan.	T	4.6	4.0	4.3	4.3	4.3
		NT	5.3	4.3	5.6	5.3	5.1
	16 Feb.	T	4.3	3.6	4.3	3.3	3.9
		NT	4.6	4.0	5.3	4.0	4.5
	14 Mar.	T	3.0	3.0	3.0	3.0	3.0
		NT	3.0	3.0	3.3	3.0	3.1
	LSD (0.05)	T	1.0	1.1	1.1	0.7	
		NT	0.7	0.7	0.9	1.1	
Hermo	15 Nov.	T	2.6	2.3	3.6	2.3	2.7
		NT	5.6	4.0	6.6	4.0	5.1
	17 Dec.	T	3.0	2.0	3.3	2.3	2.7
		NT	5.0	3.3	6.0	5.0	4.8
	15 Jan.	T	1.3	2.0	2.6	2.3	2.1
		NT	3.0	2.6	3.3	4.0	3.2
	18 Feb.	T	1.6	2.0	1.6	1.3	1.6
		NT	2.6	2.6	2.6	2.0	2.5
	15 Mar.	T	1.3	1.3	1.3	1.3	1.3
		NT	2.0	1.6	2.0	2.0	1.9
	LSD (0.05)	T	1.1	0.6	1.0	1.0	
		NT	1.3	1.0	1.2	1.5	
Al-Ghab	17 Nov.	T	5.7	4.6	6.7	5.3	5.8
		NT	5.7	5.7	7.0	6.0	6.1
	15 Dec.	T	5.3	4.6	6.3	5.0	5.3
		NT	5.7	5.7	6.0	6.3	5.9
	16 Jan.	T	4.0	3.0	5.0	4.7	4.2
		NT	5.3	4.0	5.3	4.7	4.8
	14 Feb.	T	3.0	3.3	3.0	2.7	3.0
		NT	3.3	3.0	3.3	3.0	3.2
	14 Mar.	T	1.3	1.3	1.3	1.3	1.3
		NT	1.3	1.3	1.3	1.3	1.3
	LSD (0.05)	T	1.0	1.2	1.2	0.7	
		NT	1.1	0.8	0.7	1.1	

[a]Disease severity based on a scale of 1-9[18]; where 1= no infection, 9= plants killed, T = Treated seed with the fungicide, Thiobendazil at rate of 3 g kg^{-1}, NT= non-treated seed

(planting date) was completely harvested before the next, except for the last two plantings.

The reactions of genotypes to Ascochyta blight among planting dates were significantly different ($p<0.05$) in both years (Table 1 and 2). As a general interpretation covering all planting dates for the 2-year study, the genotype least affected by Ascochyta blight was F 90-96. Ghab 1 was the most affected, closely followed by F88-85, while Ghab 3 was intermediate.

During the 1997/98 cropping season, disease severity differed significantly ($p<0.05$) between the first and the fourth planting dates for treated seeds and between the first and third planting dates for untreated seeds of the 3 susceptible genotypes, Ghab 1, Ghab 3 and F88-85 (Table 1). In the 1998/99 season, however, a significant difference in disease severity was observed only with early plantings of treated seeds of Ghab 1 and F88-85 and untreated seeds of all the four genotypes (Table 2). Delayed planting did not significantly change genotype reactions to Ascochyta blight with respect to disease severity and the ranking of the genotypes remained the same (Table 1 and 2).

Late planting significantly reduced the yields of all the genotypes relative to early plantings even in the absence of high Ascochyta blight disease pressure (Table 3), showing the importance of environmental conditions on grain yields. Seed treatments did not appear to significantly decrease Ascochyta blight severity in some cases. In 1997/98, the highest yields for the untreated seeds of the 3 susceptible genotypes came from the early November to January plantings for the Tel Hadya and Hermo locations and for the November to February plantings for the Al-Ghab location. The highest yields under treated and untreated seeds were obtained with the early plantings of November and December even in the presence of high disease pressure while the lowest

Table 3: Influence of planting date on yield of chickpea genotypes infected by Ascochyta blight during 1997/98 season.

			Seed yield (kg ha^{-1})				
Locations	Planting dates	Seed treatments	F 88-85	F 90-96	Ghab 1	Ghab 3	Mean
Tel Hadya	15 Nov.	T	1814	2504	1380	1686	1846
		NT	1189	2258	1202	1491	1535
	22 Dec.	T	1295	2157	1117	1489	1515
		NT	1157	1870	578	1055	1165
	15 Jan.	T	1244	2060	625	1213	1286
		NT	1230	1888	512	806	1109
	13 Feb.	T	814	1152	469	774	802
		NT	698	1120	352	669	710
	14 Mar.	T	695	981	491	775	736
		NT	624	643	351	530	537
	LSD (0.05)	T	254	378	391	458	
		NT	353	420	477	405	
Hermo	16 Nov.	T	1437	1927	891	1401	1414
		NT	1306	1694	850	1143	1248
	18 Dec.	T	1054	1136	884	1013	1022
		NT	1170	869	673	1136	962
	14 Jan.	T	966	979	850	789	896
		NT	864	821	945	626	814
	15 Feb.	T	884	503	530	470	597
		NT	762	632	565	337	574
	13 Mar.	T	517	279	265	252	328
		NT	550	346	306	333	384
	LSD (0.05) =412 and CV = 18.2						
Al-Ghab	15 Nov.	T	2786	3224	2250	2636	2724
		NT	2815	2744	2184	2583	2582
	17 Dec.	T	3285	3244	2743	3175	3112
		NT	3182	3159	2053	3309	2926
	15 Jan.	T	3119	3071	3053	2867	3028
		NT	3137	2774	2653	2267	2708
	18 Feb.	T	2041	2119	2136	2047	2086
		NT	2107	2101	1678	1637	1881
	15 Mar.	T	893	840	685	881	825
		NT	720	690	756	916	771
	LSD (0.05) = 624 and CV = 19.2						

Table 4: Influence of planting date on pod infection by Ascochyta blight and on 100 seed weight (g) of chickpea genotypes during 1997/98 season.

		Pod severity (1-5) and 100 seed weight (g)									
		FLIP 88-85		FLIP 90-96		Ghab 1		Ghab 3		Mean	
Location	Planting dates	Ps[a]	Sw[b]	PS	SW	PS	SW	PS	SW	PS	SW
Tel Hadya	17 Nov.	3.3	30.2	2.6	33.3	3.0	28.8	3.0	28.2	3.0	30.1
	19 Dec.	2.6	30.0	2.0	36.0	3.3	24.8	2.6	28.0	2.6	29.7
	15 Jan.	1.5	34.5	1.0	35.3	2.3	29.5	1.0	27.5	1.5	31.7
	16 Feb.	1.0	30.2	1.0	34.0	1.5	24.3	1.0	22.8	1.1	27.8
	14 Mar.	1.0	27.7	1.0	31.8	1.0	21.8	1.0	25.3	1.0	26.7
	LSD (0.05)	0.9	NS	0.5	NS	1.2	6.8	0.5	4.6		

were under treated and untreated seeds with late plantings of February and March. January yields were intermediate as were disease severity values for this period.

Planting dates also had an effect on pod infection with severity on the early first 2 plantings of the 3 susceptible genotypes significantly ($p<0.05$) higher than on the later plantings (Table 4) as exemplified by the Tel Hadya location. There was no significant effect on seed weight by delayed planting for the resistant and moderately susceptible genotypes F90-96 and F88085 respectively, for both treated and untreated seed.

DISCUSSION

In both seasons and in all planting dates and genotypes, symptom expression of *Ascochyta rabiei* was tied to plant development and environmental conditions rather than calendar date. Lesion symptoms were not observed on stems before plants reached the vegetative growth stage regardless of planting date or genotype. Leaflet infection could be observed on seedlings of later plantings when environmental conditions were more favorable for disease development and spread, but subsequent unfavorable conditions (high temperatures and low moisture) did not allow for lesion development on the stems of these late plantings. Disease severity scores were thus generally low on the late plantings. Delayed plantings to January significantly ($p<0.05$) decreased the disease severity of *Ascochyta rabiei* on the genotypes for all the locations in 1997/98. Decrease in Ascochyta blight severity for 1998/99 season was only significant with delayed plantings to February for the genotypes and locations. In both years, disease severity was generally low for the March plantings of all the locations with virtually no infections observed on the genotypes on March plantings of Hermo and Al-Ghab locations during 1997/98 season. This was despite end of season rains which favored pod infection of earlier plantings.

The difference in disease severity with delayed planting may be explained by the fluctuations in the inoculum source and build-up of *Ascochyta rabiei* during the season. Crops planted early were exposed to more diverse and aggressive inoculum coming mostly from ascospores within infected debris in the plots. Late planting inoculum was mostly from secondary conidia resulting from cyclic infections. *Didymella rabiei*, the teleomorph stage of *Ascochyta rabiei* has been reported in Syria[8] and has been frequently detected within infected debris in field plots.

In the early plantings of November and December, the winter low temperatures (5-10°C) and high humidity (<80%) generally favor the development and maturation of pseudothecia[8] which release ascospores that infect plants as soon as temperatures start to rise with humidity increase during winter rains. Thus early plantings get exposed to ascospores under favorable conditions for infection and spread of the pathogen. With later plantings, conditions are unfavorable for ascospores formation and maturation and infection depends on the secondary conidia, whose spread is restricted and disease development limited by low humidities and rising temperatures above 25°C. The winter rains that favor crop growth also favor Ascochyta blight development. On the other hand, conditions of the late spring plantings that do not favor Ascochyta blight development do not also favor good crop growth. This is reflected in the very low grain yields of late plantings even in the absence or low incidence of the disease.

The planting date of chickpea greatly affects the yield potential of the crop under Syrian and Mediterranean conditions. Data collected in the past few years from international chickpea yield nurseries from countries in the Mediterranean region generally show a marked reduction in yield from plantings delayed passed February to .late spring[8]. Results from present study also showed a high percentage loss in yields for every monthly delay past the optimum winter planting date of December. Thus, the benefit of delayed planting for whatever reason should compensate for the loss in yield associated with this practice. Yield loss was greatly increased with delayed planting during 1997/98 season. Furthermore, in the presence or absence of severe disease from *Ascochyta rabiei*, the highest yields for the resistant and moderately susceptible genotypes were obtained with the early planting dates.

Because the ranking of genotype reaction to *Ascochyta rabiei* with respect to disease severity and yield did not change with different planting dates, plant breeders and pathologists screening germplasm for resistance to *A. rabiei* do not need to consider this effect on their selections. Rather, for investigations involving different planting dates, Ascochyta blight severity should be assessed at the same growth stage and not the same calendar date. Late planting significantly accelerates crop maturity, with an approximate 10-day increase in flowering for each 4-week delay in planting. Thus, data for Ascochyta blight severity will be biased against early planting dates if collected on the same calendar date because of more infection pressure at this time.

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