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Integrating Cultivar Resistance with Row Spacing to Manage Ascochyta Blight for Increased Chickpea Yields

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Abstract: The influence of different row spacings on the development of Ascochyta blight and on the grain yield of chickpea *(Cicer arietinum)* was evaluated during the 1997 and 1998 cropping seasons. Two chickpea cutivars (Ghab 1 and Ghab 3) and 2 breeding lines (FLIP 90-96 and F 88-85) were used in the field trials at 3 locations, representing the different agroecological zones in which winter chickpea is grown in Syria and in most of the Mediterranean countries. Four row spacings, (15, 30, 45 and 60 cm), were evaluated in all the trials at the different locations. All plots were initially inoculated with infected chickpea 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 ($p<0.05$) decrease in disease severity as the row spacings were increased, in most of the entries at all the locations, for both years. There was a corresponding significant increase in grain yields with less disease at wider row spacings. The increase in grain yield was due to the added factor of increased plant branching at wider row spacings, than from less disease alone. This was noted in the more resistant entry (F90-96) which showed no significant change in disease severity with increased row spacings but still had a significant yield increase at wider row spacings at all the 3 locations. It would appear from this study that under Syrian and Mediterranean conditions, an increase in grain yield is expected when chickpea is planted at wider row spacings during winter. This increase is due both to lower Ascochyta blight severity and increased plant branching.

Key words: Chickpea, row spacing, *Ascochyta rabiei*, disease control, resistance

INTRODUCTION

Ascochyta blight caused by *Ascochyta rabiei* (Pass.) Labrousse (Teleomorph: *Didymella rabiei* (Kov.) v. Arx) causes severe blight epidemics on chickpea (*Cicer arietinum* L.) under Mediterranean growing conditions. It is particularly severe when the crop is planted in winter, as conditions that favor the growth of the crop at this time also favor the development and spread of the disease[1,2]. Outbreaks of the disease can reduce chickpea yields by up to 100% when susceptible chickpea cultivars are grown[3].

Several studies have been carried out in the Mediterranean region over the years[4,5] evaluating the reaction of chickpea cultivars to Ascochyta blight, in an attempt to identify cultivars with durable resistance to the disease. Data from these studies have been variable and results depended on the location in different countries and the year of evaluation. Effective levels of resistance to the disease have been reported from some of these studies[6] but currently, there are only few cultivars under cultivation with high or acceptable levels of resistance to the disease. This is partly due to the variable nature of the pathogen, as resistant cultivars become susceptible soon after deployment. Several races and pathotype groups have been reported from different studies carried out in the Mediterranean countries[7,8]. Thus effective control of the disease cannot be attained by complete reliance on host-plant resistance alone because of this instability in the resistance.

A. rabiei is seed-borne[9] 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. Different studies

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have evaluated fungicides as seed treatments for the control of Ascochyta blight of chickpea[10,11] and some have been identified with good efficacy on seed-borne infection[12,13].

The development and spread of Asccochyta blight is greatly influenced by cool temperatures and high relative humidities[14]. The manipulation of any agronomic practice that could lead to a significant alteration of any of the environmental factors to dis-favor disease development would be useful in an integrated management of the disease. In the Mediterranean region, subsistence farmers employ diverse methods for cultural control of the disease. There are however, only few published data on the efficacy of these methods. Agronomic studies on optimum plant populations of chickpea have been carried out in different countries in the region[15] but none of these studies has directly related the influence of canopy closure on Ascochyta blight development. There are thus no published reports on the direct effect of integrating seed treatments with row spacings to manage Ascochyta blight and increase seed yield 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 row spacings of chickpea cultivars on (a) the severity of chickpea Ascochyta blight under Syrian field conditions, (b) the crop yield potential under the different row spacings and varying Ascochyta blight disease scenarios.

MATERIALS AND METHODS

The experiments were carried out during the 1997/98 and 1998/99 cropping seasons. They were conducted 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 mainly by the annual rainfall distribution and their representation of the major chickpea-growing areas of Syria and other Mediterranean environments.

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 that was the first to be released for winter cultivation in Syrian, but now susceptible to Ascochyta blight under winter conditions. The other cultivar was Ghab 3, currently recommended for winter cultivation in Syria because of its high yields and moderate resistance to Ascochyta blight. The other genotypes in the trial were F 90-96 and F 88-85, both selected because of their potential for winter cultivation in Mediterranean environments. Both also have moderate levels of resistance to Ascochyta blight. 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.

Experimental treatments consisted of four row spacings; 30, 45, 60 and 75 cm, used to vary the canopy closure between rows. The normal recommended row spacing from agronomic studies, for optimum yields, is 35 cm. Seeds were hand-planted at a depth of 3-5 cm and at a rate of 10 seeds per meter. Each plot consisted of six rows, each 4 m long with the appropriate row spacings. To ensure uniform disease spread in the plots, the plots at each site were inoculated soon after seed germination, by spreading blight-infected chickpea debris collected from Ascochyta blight screening nurseries at the site from the previous season. Normal agronomic practices for chickpea production in each region, including fertilizer use and weed control were followed.

The field experimental design was a split-split plot with three replications in Randomized Complete Blocks. Row spacings were the main plots, genotypes the sub-plots and seed treatments the sub-sub-plots. In all plots, weeds were controlled by one application of Fusilade, applied as a post-emergence herbicide and targeting the narrow-leafed weeds from proceeding cereal volunteers in the plots. Two hand-weedings supplemented the herbicide treatments at the vegetative and flowering growth stages. No other chemicals were sprayed on the plots.

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 the subjective scale of 1-9, as described by Singh *et al.*[16] where, 1= no infection and 9 = all plants killed. During the 1997/98 cropping season, late rains during the podding stage, at all three sites in May, favored pod infection. Pod disease severity ratings were also taken using a 1-5 scale as follows: 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 in early or late June, depending on the genotype and location, the center four rows in each plot were hand-harvested and placed in cloth bags. The bags were left on each plot for an additional two weeks after harvesting, 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 row spacing. 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 row spacing on the seed incidence of *A. rabiei* was determined for each genotype and row spacing, by estimating the percentage of seeds that had lesion symptoms of *A. rabiei* or that gave colonies of *A. 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 row spacing and seed treatment effects.

RESULTS AND DISCUSSION

At the Al-Ghab and Tel Hadya locations, symptoms of Ascochyta blight initially appeared on chickpea foliage at the seedling growth stage when plants were just 4 weeks old in 1997/98 and on 6 week old seedlings in 1998/99. This was apparently influenced by the rainfall pattern during the 2-years of the study, where the first rains in 1997/98 came in mid-October while the first rains of 1998/99 were recorded during the first week of November. Seedling infections were only observed at the Hermo location during 1997/98 but not in 1998/99 because of delayed rains right into mid-November when the first stable rains came. In both years stem lesions were only observed on the plants at the vegetative growth stage. Generally, disease developed rapidly once symptoms were detected on stems and girdling and stem breakage soon followed on the susceptible checks.

During 1997/98, row spacings had a significant ($p<0.05$) effect on the development of Ascochyta blight within the canopy of the susceptible and 2 moderately resistant genotypes at the Al-Ghab and Tel Hadya locations (Table 1). At the Hermo location, a significant effect was only observed on one moderately resistant genotype. In all cases the wider row spacings had less disease severity than the closer spacings. For all locations there was more disease development on the untreated than the fungicide-treated seed for all row spacings, even though the differences were not significant between the seed treatments (Table 1 and 2).

In the 1998/99 season, a similar pattern as observed during 1997/98 was noted (Table 3). Lowest disease scores for all row spacings were recorded at the Hermo location where the rainfall was below the 5-year seasonal mean. Even with this pattern, significant differences ($p<0.05$) were observed between the 30 cm row spacing and the 75 cm spacing. As in 1997/98, differences were also observed on disease severity of fungicide-treated and untreated seed, though not significant for any of the row spacings and thus only data for the untreated seeds is presented.

Table 1: Effect of row spacing on Ascochyta blight severity of untreated chickpea genotypes at different locations in Syria during 1997/98 season

Location	Row spacing (cm)	Disease severity (1-9)[a]				
		FLIP 88-85	FLIP 90-96	Ghab 1	Ghab 3	Mean
Tel Hadya	30	6.1	3.5	4.5	3.5	4.4
	45	4.0	2.8	4.2	3.8	3.7
	60	3.2	2.5	2.8	2.7	2.8
	75	3.7	2.5	2.7	2.2	2.8
	LSD (0.05)	1.2	1.4	1.1	1.0	
Hermo	30	3.7	3.3	5.4	3.3	4.0
	45	3.7	3.0	5.0	3.3	3.8
	60	3.3	2.6	5.2	2.6	3.4
	75	2.6	2.3	4.3	2.5	2.9
	LSD (0.05)	0.6	1.2	1.2	1.1	
Al-Ghab	30	6.2	4.8	7.2	5.5	5.8
	45	5.7	4.5	7.0	5.2	5.6
	60	5.7	4.3	6.3	5.0	5.3
	75	4.5	4.0	5.2	4.0	4.6
	LSD (0.05)	1.3	1.1	1.2	1.3	

[a]Disease severity on a scale of 1-9; where, 1= no disease and 9= plants killed

Table 2: Effect of row spacing on Ascochyta blight severity of fungicide-treated chickpea genotypes at different locations in Syria during 1997/98 season

Location	Row spacing (cm)	Disease severity (1-9)[a]				
		FLIP 88-85	FLIP 90-96	Ghab 1	Ghab 3	Mean
Tel Hadya	30	4.5	3.0	4.5	3.7	3.9
	45	4.2	2.7	4.3	3.3	3.6
	60	3.0	2.5	3.3	2.8	2.9
	75	2.7	2.3	3.0	3.0	2.7
	LSD (0.05)	1.2	0.9	1.5	1.2	
Hermo	30	3.0	3.0	5.2	3.3	3.6
	45	2.7	2.7	4.3	3.2	3.2
	60	2.0	2.7	4.0	3.0	2.9
	75	2.5	2.3	4.3	3.0	3.0
	LSD (0.05)	0.6	0.7	1.2	1.0	
Al-Ghab	30	4.5	5.0	7.0	5.3	5.6
	45	4.3	4.5	6.2	4.2	4.8
	60	4.3	4.2	6.2	3.8	4.6
	75	4.3	3.5	6.3	4.0	4.5
	LSD (0.05)	1.3	1.1	1.2	1.2	

[a]Disease severity on a scale of 1-9; where, 1= no disease and 9= plants killed

Chickpea yields taken for the different row spacings during the 1997/98 season showed that generally as row spacings increased yields tended also to increase (Table 4). This was somehow a reverse of the expected trend. Closer examination of individual plants revealed that increased plant branching influenced higher yields with wider row spacings more than by the absence of Ascochyta blight alone. This was particularly true at the Tel Hadya location where highest yields for all the 4 genotypes were obtained with the highest row spacing of 75 cm (Table 4). At the other 2 locations the results were mixed with no consistent pattern between genotypes or row spacings. An examination of the weather data suggests that the heavy rains recorded at the Tel Hadya

Table 3: Effect of row spacing on Ascochyta blight severity of untreated chickpea genotypes at different locations during 1998/99 season

Location	Row spacing (cm)	Disease severity (1-9)[a] FLIP 88-85	FLIP 90-96	Ghab 1	Ghab 3	Mean
Tel Hadya	30	6.0	5.3	6.7	6.0	6.0
	45	6.3	5.0	6.7	4.3	5.6
	60	5.8	4.3	6.3	4.3	5.2
	75	5.6	4.3	6.3	4.3	5.1
	LSD (0.05)	1.3	1.1	1.2	0.9	
Hermo	30	4.0	3.0	4.3	4.0	3.8
	45	4.7	2.7	5.3	4.0	4.2
	60	3.3	3.0	4.3	3.3	3.5
	75	3.3	2.7	4.0	3.0	3.2
	LSD (0.05)	1.3	0.8	1.1	1.3	
Al-Ghab	30	4.7	5.3	6.3	5.3	5.4
	45	5.3	5.0	6.7	5.0	5.5
	60	4.7	4.3	5.3	4.7	4.7
	75	4.3	4.3	5.0	4.3	4.5
	LSD (0.05)	1.2	1.3	1.3	0.9	

[a]Disease severity on a scale of 1-9; where, 1= no disease and 9= plants killed

Table 4: Effect of row spacing on yield of untreated chickpea genotypes infected by Ascochyta blight at different locations during 1997/98 season

Location	Row spacing (cm)	Yield (kg ha^{-1}) FLIP 88-85	FLIP 90-96	Ghab 1	Ghab 3	Mean
Tel Hadya	30	1635	2353	1571	2021	1895
	45	2270	2925	1667	2001	2216
	60	2238	2915	1563	1885	2150
	75	2653	3436	2373	2759	2805
	LSD (0.05) = 738		CV-21.5			
Hermo	30	1780	2143	1421	1341	1671
	45	1397	1699	1217	1280	1398
	60	1321	1377	1115	1032	1211
	75	1162	1121	918	1019	1055
	LSD (0.05) = 387		CV=23.7			
Al-Ghab	30	2757	2931	1676	2806	2542
	45	2208	2729	1347	2574	2214
	60	1856	2056	1394	1993	1824
	75	2014	2628	1717	2380	2185
	LSD (0.05) = 878		CV=18			

Seeds were treated with the fungicide Tecto at the rate of 3 g kg^{-1} of seed

location during vegetative development tended to favor more stem branching than was the case at the other 2 locations where this was not the case. The Hermo location actually went through a brief drought period during vegetative growth, which affected plant growth and was reflected in the generally poorer yields than at the other 2 locations. Here also the trend observed at Tel Hadya was reversed with lower yields recorded with increased row spacings even with lower disease as branching played little or no role (Table 4). For all locations, seed treatment did not reflect in any yield differences even where there were differences in disease development.

Based on the data collected from this study, a wider row spacing of above 45 cm appears to be the best generic recommendation to account for losses from Ascochyta blight infections. Smaller row spacings than this resulted in both higher disease severity and in most cases lower yields. Even though there is an increased plant population at closer row spacings, this is more than compensated by increased branching at wider row spacings resulting in higher yields.

This study supports the role of adequate agronomic studies in the adoption and cultivation of winter chickpea in the Mediterranean region. The normal recommended row spacings for optimum yields from agronomic studies without taking disease into consideration, is 35 cm between rows. Several small-scale farmers, however, use hand planting and broadcast their seeds with no real consistent spacings. The population used is usually more than the recommended and when inoculum is present under winter conditions, Ascochyta blight epidemics are common and can be disastrous.

In addition to increased branching for higher yields, wide row spacings increases canopy aeration, which reduces humidity build-up, needed for Ascochyta blight epidemics. Wider row spacings can also make inter-row cultivation easier, thus giving an added advantage for weed control.

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