# Plant Pathology Journal

ISSN 1812-5387

Plant Pathology Journal 3 (2): 105-110, 2004
ISSN 1680-8193


# Integrating Cultivar Resistance with a Single Fungicide Spray to Manage Ascochyta Blight for Increased Chickpea Yields

C. Akem, S. Kabbabeh and S. Ahmed
Germplasm Program, International Center for Agricultural Research in the Dry Areas,
P.O. Box 5466, Aleppo, Syria

**Abstract:** Field trials were conducted at 3 Mediterranean environments in Syria, during the cropping seasons of 1997 and 1998, to evaluate the control of chickpea Ascochyta blight with a single fungicide spray on 4 chickpea genotypes. Ascochyta blight disease epidemics were produced at the different locations and plots with the spread of Ascochyta-infected chickpea debris soon after crop germination. The plots were sprayed with a single application of the fungicide, Chlorothalonil at 4 different growth stages, starting from seedling stage to podding growth stage, to determine the effect of the fungicide application timing on Ascochyta blight severity, chickpea grain yield and grain quality. Generally, single applications made before flowering significantly ($p<0.05$) reduced disease severity in the 2 susceptible genotypes, Ghab1 and Ghab 3. Plot yields of these genotypes were also significantly greater than the untreated controls when applications were made at seedling or vegetative growth stages. There was no significant difference in disease severity and grain yield, between the untreated control and time of application on the resistant genotypes, F 90-96 and F 85-88. The timing of application had a significant effect on pod infection but generally no effect on seed weight. There were no significant effects of seed infection by *Ascochyta rabiei*. The results suggest that single fungicide sprays made before flowering are most effective in Ascochyta blight control under Mediterranean conditions and can also result in higher grain yields than applications made at the reproductive phase of the crop.

**Key words:** Ascochyta blight, chickpea, chemical control, *Ascochyta rabiei*, fungicide timing

## INTRODUCTION

Ascochyta blight caused by *Ascochyta rabiei* (Pass.) Labrousse (teleomorph: *Didymella rabiei* (Kov.) v. Arx.) is the most important disease of chickpea (*Cicer arietinum* L.) worldwide[1,2]. In the Mediterranean region, the disease can cause significant yield losses varying from 10% among resistant chickpea cultivars to 100% in susceptible cultivars especially when grown during winter[3]. In winter, conditions that favor the growth of the crop also favor the development and spread of the disease. Generally, however, the severity of the disease on chickpea cultivars varies from location to location and from one season to another.

Control of Ascochyta blight has been achieved mainly through the use of resistant cultivars[4]. However, because of the high pathogenic variability of *A. rabiei*, many varieties identified to be resistant soon become susceptible to new races or pathotypes of the pathogen after deployment. Reddy and Kabbabeh[5] identified 6 races of the pathogen in Syria and Lebanon. Reddy *et al.*[6], established 13 pathogen groups based on an analysis of reactions to common chickpea lines grown across 48 locations through regional Ascochyta blight disease nurseries. The reported races of the pathogen have been re-classified into pathotype groups using molecular markers and differences in virulence on a set of cultivars[7-9]. Effective control of the disease has not been attained by reliance on host-plant resistance alone.

Fungicide use for the control of Ascochyta blight on chickpea, continue to be an option in the absence of good levels of resistance. Chlorothalonil (Bravo$^R$) has been shown to be the most effective fungicide for the control of the disease in most places where it occurs[10,11]. Multiple applications of the fungicide give good field control, but the results are often not consistent from location to location and from year to year. Yield response from foliar fungicide applications on chickpea in general, is highly dependent on the presence of foliar diseases and can range from a significant yield increase[3] to little increase[11]. Most researchers have recommended the use of two or more sprays of effective fungicides for the

**Corresponding Author:** Dr. Chrys Akem, Department of Primary Industries and Fisheries, Horticulture and Forestry Sciences, P.O. Box 591, Ayr, Qld 4807, Australia
Tel: 61 7 4783 2355 Fax: 61 7 4783 3193 E- mail: Chrys.Akem@dpi.qld.gov.au

control of Ascochyta blight. However, cost of multiple spray applications may not be consistently offset by proportionately higher yields, even though disease control may be improved[11]. There is also a growing concern to reduce environmental pesticide hazards and to economize production costs and meet the demands of subsistence farmers. Thus, the need to determine the optimum time of minimal fungicide applications so as to optimize disease control and maximize grain yield.

Beauchamp *et al.*[12] recommended 2-3 fungicide applications at early flowering under temperate environments to achieve good control of *A. lentis* on lentils (*Lens culinaris* Medik.) for better yields and seed quality. Reddy and Singh[11] did not obtain a consistent response to foliar sprays with Chlorothalonil applied at different growth stages to control Ascochyta blight. They could not thus make a spray recommendation, but suggested the need for further refinement of the time of foliar application using other epidemiological aspects of the disease. No information is thus, presently available on the timing of minimal fungicide sprays to control Ascochyta blight of chickpea in the Mediterranean region for optimum yields. The purpose of this study was therefore, to (a) determine the optimum time of making a single fungicide spray on chickpea cultivars to control Ascochyta blight and (b) determine the yield effect and seed quality associated with single applications at different growth stages of chickpea cultivars. This information is vital for integrated Ascochyta blight disease management strategies on chickpea, especially for the Mediterranean region, where a lot of chickpea is presently grown during winter.

## MATERIALS AND METHODS

The investigations were conducted at three research sites in Syria. These were 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. The Hermo station site is located in a zone with potential for winter chickpea production, even though there is a high risk of Ascochyta blight epidemics due to heavy annual rainfall, averaging more than 500 mm per season in the northeastern region. The Al-Ghab station site is where the national program conducts most of the chickpea improvement research in Syria. It is located in the center of the Fertile Crescent with adequate moderate rainfall averaging 400-450 mm per season in the Ghab valley. The Tel-Hadya site is on the research farm of ICARDA and this is where most of the chickpea improvement research for the Mediterranean region is carried out. Rainfall here averages 300-350 mm per year and when well distributed, is ideal for winter chickpea cultivation, especially in the surrounding Aleppo and Idlib provinces.

The experiments were carried out during the 1997/98 and 1998/99 cropping seasons. For both seasons, four chickpea genotypes selected on the basis of their agronomic adaptation and host reactions to Ascochyta blight, were used. Ghab 1, is a medium maturing cultivar, the first to be released for winter cultivation in Syria, but now susceptible to Ascochyta blight under winter conditions. It is however, still being extensively cultivated as a winter cultivar in many countries in the Mediterranean region. Ghab 3, is currently recommended for winter cultivation in Syria because of its higher yields and moderate resistance or tolerance to Ascochyta blight. The other genotypes, F 90-96 and F 88-85, were both in on-farm trial evaluations at multi-locations in Syria for possible release for winter cultivation. Both also have moderate levels of resistance to Ascochyta blight.

A split-plot design was used in the experiments at all the locations in both years, with genotypes as main plots and fungicide sprays as sub-plots in a randomized complete block design with three replications. Seeds were hand-planted at a depth of 3-5 cm and a rate of 10 seeds per meter in six rows, each 4 m long and 0.35 m apart. To ensure uniform disease spread within the trials, plots at each site were inoculated soon after seed germination, by spreading Ascochyta blight-infected chickpea debris collected from Ascochyta blight screening nurseries at each site, in the previous season.

The following timings of minimal fungicide applications were evaluated during the two cropping seasons of the study: (1) Untreated control – no fungicide applications; (2) Seedling – one fungicide application at seedling stage; (3) Vegetative – one fungicide application at vegetative stage; (4) Flowering – one application at about 50% flowering and (5) Podding – one application at pod initiation. Two unsprayed guard rows of a highly susceptible check (ILC 263) were planted between the treated rows of each plot. They served as spreader rows and also as barriers to reduce fungicide drift from one plot to the other. The fungicide, Chlorothalonil (Bravo 500) (5 ml $L^{-1}$ water), was sprayed only once in each plot at the appropriate time of application, using a knapsack back-sprayer, delivering about 400 L $ha^{-1}$. Normal agronomic practices for chickpea production in each region, including fertilizer use and weed control were followed.

Ascochyta blight severity ratings for each plot were made at near crop maturity, just before the early-maturing genotypes started yellowing. The ratings were based on the following subjective scale of 1-9, modified from Singh *et al.*[13], where 1= no infection; 2 = some leaf infection observed; 3 = some stem infection with 2-6 mm lesions; 4 = stems start to girdle with larger lesions but no breakage; 5 = stem girdling with <50% breakage; 6= stem girdling with about 50% breakage; 7 = stem girdling with >50% breakage; 8 = nearly all stems broken but still green and 9 = all plants killed. During the 1997/98 cropping season, late rains during podding at all the 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 infection; 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 four middle 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. Yield loss for each genotype and spray application was calculated by subtracting the yield of a given genotype non-spray from the yield of that genotype with each spray application and represented as a percentage. During the 1997/98 season, ten plants were randomly selected from the two outer rows of each plot, from which 100 pods were randomly taken and the pod infection severity recorded, based on the visual Ascochyta blight symptoms observed on the pods. The weight of 100 seeds from each genotype and spray schedule was taken to determine the effect of the spray treatment on the seed weight.

The possible effect of the fungicide spray timings on the seed incidence of *A. rabiei* was also determined for each genotype and time of spray application. This was done by estimating the percentage of seeds that gave colonies of *A. rabiei* on Potato Dextrose Agar (PDA) growth media. To do this, the 100 seed samples from each pod lot used to determine the seed weight were surface-sterilized and plated in 4 replications on PDA plates. The plates were incubated at 25±2°C on laboratory benches and the seed infection counts taken after 7 days.

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 fungicide application timings.

## RESULTS

Weather conditions were favorable for the development of *A. rabiei* during the 1997/98 and 1998/99 cropping seasons at all the locations where the trials were conducted. In the 1997/98 season, above – average rainfall during the winter months of December to February favored high crop yield potential and epidemic levels of Ascochyta blight. The mean temperatures for this period were within the 5-year mean. Late precipitation in the month of May favored pod infection as it coincided with podding. In the 1998/99 season however, precipitation was slightly below normal for the Hermo and Al-Ghab locations but still enough to favor Ascochyta bight development, especially in the early part of the season. Mean temperatures during the 1998/99 season were warmer than normal, with a 2°C above the five year mean.

The average severity of Ascochyta blight differed significantly ($p<0.05$) among chickpea genotypes in both years and fungicide spray treatments. Disease severities were generally higher for the Al-Ghab location when compared to the other locations during the 1997/98 season (Table 1). During the 1998/99 season, the values were higher for the Tel Hadya location (Table 1), as evidenced by the disease severity values for Ghab 1 and F90-96. The mean disease severity values were smallest when the fungicide spray was made at the seedling growth stage for both years (Table 1).

Yields taken during the 1997/98 season showed that there was generally an increase in grain yield for all the genotypes with a single fungicide application (Table 2). This yield increase was significant ($p<0.05$) for all applications at the Al-Ghab location, with grain yield ranging from a mean of 2270 kg ha$^{-1}$ in the unsprayed controls to 3,349 kg ha$^{-1}$ in the spray treatments made at the seedling growth stage (Table 2). The level of significance was mostly for the early growth stage applications at the Tel Hadya and Hermo locations. Generally, ranking among times of spray applications for their effect on yield was in the order Seedling > Vegetative > Flowering > Podding. Not all the genotypes responded the same way in yield, to the fungicide spray applications, as also reflected in the disease interactions. For all the 3 locations, the greatest yield response was by F90-96, which showed a significant ($p<0.05$) increase in yield for all early single spray applications in the seedling and vegetative growth stages (Table 2). Comparing the grain yields of the unsprayed controls, this genotype also showed a great yield potential under diseased conditions as compared to the others at most of the locations. It thus could be selected as a tolerant cultivar even under high Ascochyta epidemic conditions.

Fungicide spray treatments affected the severity of Ascochyta blight on chickpea pods at the Tel Hadya and Hermo locations for which this was recorded (Table 3).This did not however, reflect in an effect in the seed weight, as there was generally no consistent effect on the seed weight of the genotypes by the fungicide spray treatments. At the Tel Hadya location, there were

Table 1: Effect of timing of a single fungicide spray on Ascochyta blight severity of chickpea genotypes during 1997/98 and 1998/99 seasons

| | | Disease severity (1-9)[a] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FLIP 88-85 | | FLIP 90-96 | | Ghab 1 | | Ghab 3 | | Mean | |
| Location | Growth stage of fungicide spray | 97/98 | 98/99 | 97/98 | 98/99 | 97/98 | 98/99 | 97/98 | 98/99 | 97/98 | 98/99 |
| Tel Hadya | Seedling | 2.3 | 3.0 | 2.0 | 3.0 | 2.6 | 4.0 | 2.3 | 3.6 | 2.3 | 3.4 |
| | Vegetative | 2.5 | 4.0 | 2.2 | 3.7 | 3.1 | 4.0 | 2.7 | 4.0 | 2.6 | 3.9 |
| | Flowering | 3.8 | 5.6 | 2.8 | 4.6 | 4.1 | 5.3 | 2.7 | 4.6 | 3.4 | 5.0 |
| | Podding | 5.0 | 6.0 | 3.0 | 4.3 | 4.3 | 6.3 | 3.5 | 5.3 | 3.9 | 5.5 |
| | No spray control | 5.5 | 6.0 | 3.5 | 5.3 | 6.0 | 7.2 | 4.8 | 5.8 | 4.9 | 6.1 |
| | LSD (0.05) | 1.1 | 0.6 | 0.9 | 0.7 | 0.9 | 0.7 | 1.1 | 0.7 | | |
| Hermo | Seedling | 2.0 | 2.0 | 2.1 | 1.6 | 2.3 | 2.0 | 2.0 | 2.0 | 2.1 | 1.9 |
| | Vegetative | 2.3 | 2.0 | 2.0 | 2.0 | 3.5 | 2.0 | 2.6 | 2.0 | 2.6 | 2.0 |
| | Flowering | 2.6 | 2.6 | 3.0 | 2.0 | 5.7 | 2.0 | 2.6 | 2.0 | 3.5 | 2.1 |
| | Podding | 3.2 | 3.0 | 3.3 | 2.6 | 5.5 | 3.6 | 3.5 | 3.3 | 3.9 | 3.1 |
| | No spray control | 4.5 | 4.5 | 3.5 | 3.3 | 6.0 | 5.7 | 4.0 | 4.9 | 4.6 | 4.6 |
| | LSD (0.05) | 0.6 | 0.6 | 0.5 | 0.8 | 1.2 | 0.7 | 1.1 | 0.5 | | |
| Al-Ghab | Seedling | 3.3 | 2.6 | 3.0 | 2.3 | 4.0 | 3.7 | 3.5 | 3.0 | 3.4 | 2.9 |
| | Vegetative | 4.5 | 3.3 | 3.7 | 3.0 | 5.5 | 4.0 | 4.1 | 3.0 | 4.4 | 2.9 |
| | Flowering | 5.1 | 4.3 | 4.3 | 4.0 | 6.0 | 5.0 | 4.8 | 4.0 | 5.0 | 4.3 |
| | Podding | 5.6 | 4.7 | 5.0 | 4.3 | 6.5 | 5.3 | 5.3 | 4.3 | 5.6 | 4.7 |
| | No spray control | 5.8 | 5.7 | 5.0 | 5.0 | 7.2 | 6.7 | 6.6 | 5.3 | 6.1 | 5.7 |
| | LSD (0.05) | 1.2 | 1.1 | 1.0 | 1.0 | 1.1 | 1.3 | 0.9 | 1.1 | | |

[a]Based on a rating scale of 1-9 where 1= no infection and 9= plants killed

Table 2: Effect of timing of a single fungicide spray on grain yield of chickpea genotypes infected by Ascochyta blight during 1997/98 season

| | | Seed yield (Kg/ha) | | | | |
|---|---|---|---|---|---|---|
| Location | Growth stage of fungicide spray | FLIP 88-85 | FLIP 90-96 | Ghab 1 | Ghab 3 | Mean |
| Tel Hadya | Seedling | 1730 | 2390 | 1502 | 1890 | 1878 |
| | Vegetative | 1622 | 2198 | 1364 | 1597 | 1695 |
| | Flowering | 1506 | 2261 | 1197 | 1439 | 1601 |
| | Podding | 1523 | 2138 | 1011 | 1388 | 1515 |
| | No spray control | 1404 | 1841 | 1038 | 1390 | 1418 |
| | LSD (0.05)=349 | CV=23.7 | | | | |
| Hermo | Seedling | 2109 | 2169 | 1687 | 1911 | 1969 |
| | Vegetative | 1909 | 2129 | 1537 | 1741 | 1829 |
| | Flowering | 2020 | 2183 | 1449 | 1509 | 1790 |
| | Podding | 1911 | 1850 | 1523 | 1754 | 1759 |
| | No spray control | 1761 | 1768 | 1380 | 1407 | 1579 |
| | LSD (0.05)=412 | CV=18.2 | | | | |
| Al-Ghab | Seedling | 3030 | 3559 | 2928 | 3881 | 3349 |
| | Vegetative | 2601 | 3797 | 2047 | 2899 | 2836 |
| | Flowering | 2988 | 3022 | 2327 | 3166 | 2876 |
| | Podding | 3119 | 2565 | 2506 | 3166 | 2839 |
| | No spray control | 1851 | 2506 | 1922 | 2803 | 2270 |
| | LSD (0.05)=624 | CV=19.2 | | | | |

Table 3: Effect of timing of a single fungicide spray on pod and seed infection by Ascochyta blight on chickpea genotypes during 1997/98 season

| | | Pod severity (1-5) and seed weight (g) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FLIP 88-85 | | FLIP 90-96 | | Ghab 1 | | Ghab 3 | | Mean | |
| Location | Growth stage of fungicide spray | PS[a] | SW[b] | PS | SW | PS | SW | PS | SW | PS | SW |
| Tel Hadya | Seedling | 2.3 | 34.8 | 2.0 | 35.5 | 3.0 | 30.0 | 2.0 | 28.7 | 2.3 | 32.3 |
| | Vegetative | 2.3 | 34.2 | 1.8 | 35.0 | 2.7 | 28.8 | 1.5 | 27.0 | 2.1 | 31.2 |
| | Flowering | 2.0 | 33.5 | 1.5 | 34.8 | 2.0 | 27.0 | 1.0 | 26.8 | 1.6 | 30.5 |
| | Podding | 1.7 | 33.5 | 1.0 | 33.5 | 2.3 | 28.3 | 1.5 | 26.5 | 1.6 | 30.5 |
| | No spray control | 3.3 | 33.6 | 2.0 | 34.2 | 3.5 | 23.8 | 3.0 | 25.0 | 2.9 | 29.1 |
| | LSD (0.05) | 0.9 | NS | 0.6 | NS | 1.0 | 2.1 | 0.8 | 2.2 | | |
| Hermo | Seedling | 1.2 | 34.3 | 1.5 | 35.7 | 2.0 | 30.0 | 1.2 | 30.3 | 1.5 | 32.6 |
| | Vegetative | 1.2 | 34.7 | 1.2 | 36.6 | 2.7 | 30.0 | 1.2 | 29.0 | 1.6 | 32.6 |
| | Flowering | 1.0 | 35.0 | 1.0 | 34.0 | 2.3 | 32.0 | 1.0 | 31.0 | 1.3 | 33.0 |
| | Podding | 1.5 | 35.7 | 1.0 | 36.0 | 2.5 | 30.7 | 1.8 | 28.3 | 1.7 | 32.7 |
| | No spray control | 2.0 | 32.7 | 1.8 | 33.0 | 4.0 | 29.0 | 2.0 | 27.7 | 2.4 | 30.6 |
| | LSD (0.05) | 0.6 | 2.8 | 0.7 | 3.2 | 0.9 | NS | 0.8 | NS | | |

[a]Pod severity based on a scale of 1-5; where 1= no infection and 5= shrievelled pod, [b]Seed weight (g) based on weight of 100 seeds

significant differences ($p<0.05$) between the unsprayed control and spray applications made at the early growth stages in the 2 genotypes, Ghab 1 and Ghab 3, but at the Hermo location, there were no significant differences on these genotypes and spray treatments (Table 3).

There was no significant difference between seed infections of unsprayed plots and those of all the fungicide spray schedules for any of the genotypes. Seed infection values were generally very low for all the entries.

## DISCUSSION

Chlorothalonil was quite effective in controlling Ascochyta blight in these experiments. Its effectiveness in controlling this disease has been shown in other studies[10,11]. Usually within 7-10 days after spray treatments, visible differences in leaflet and stem lesion numbers and stem girdling could be detected, resulting in lower assessment scores for the fungicide-spray plots.

Although disease severity scores were relatively low in unsprayed plots at flowering, significant yield increases ($p<0.05$) were detected over the untreated controls as a result of the fungicide spray applications. Yield response to fungicide spray applications was generally greater at the Al-Ghab location where there was a significant response to all single spray applications as compared to the unsprayed control (Table 2). The lower yield response at the Tel Hadya location was probably due to the occurrence of a dry spell that was experienced for about 2 weeks during the grain-filling period, suggesting that soil moisture probably became a more limiting factor to yield than, or in addition to, Ascochyta blight. The late May rains at these locations, following the dry spell, allowed for pod infection, which could be assessed based on the spray treatments.

Above normal rainfall favored high disease severity at the Al-Ghab location during the 1997/98 season as can be compared with the lower disease severity scores during the 1998/99 season because of the drought period. The drought period experienced during grain filling to maturity at the 3 locations also introduced soil moisture as another limiting factor to yield, besides disease severity during 1998/99. The yield data across locations and genotypes for this season were inconsistent with the disease severity scores recorded and thus were not included in the interpretations.

Results of this study indicate that a single fungicide spray application for Ascochyta blight control on chickpea susceptible to *A. rabiei* should be made either at the seedling or vegetative growth stages during early infection in the winter months. A single spray application at the seedling growth stage provided the greatest disease control on the four genotypes tested for both years and at all locations. It also generally, resulted in the highest grain yield, as shown in the 1997/98 yield data. Later applications attempting to control the disease during the reproductive growth stages under Mediterranean conditions could result in non-significant yield increases. These results agree with Beauchamp *et al.*[12] on scheduling of fungicide applications on Ascochyta blight and yield of lentils, where they established that yield losses and seed infection were prevented by early as opposed to late fungicide spray applications. They are also in line with the findings of Reddy and Singh[11] where early spray applications gave a high cost/benefit ratio than late applications. The added value of the present study was the use of a single spray as compared to double or multiple sprays in the previous studies. The results are generally consistent with previous results from other studies in demonstrating that foliar applications of fungicides prevent yield losses due to Ascochyta blight in chickpea.

In most situations, two fungicide spray applications appear economical and have been recommended. On an economic basis, the difference In yield when a single application is made at seedling or at podding is significantly larger (Ghab 1=491 kg $ha^{-1}$ and Ghab 3=502 kg $ha^{-1}$) for the Tel Hadya location (Table 2). The strategy of one spray application of Chlorothalonil on Ascochyta blight control was therefore very cost effective in both seasons. Late applications would also be beneficial in areas where there are late infections from late rains. In areas where yield losses from early season infections are expected to be high, single fungicide spray applications would be more beneficial on moderately resistant cultivars, if made before the reproductive growth stages, as established in this study.

The non-significant increase in seed weight for the most part in fungicide spray treated plots, especially on the widely grown cultivars Ghab 1 and Ghab 3, suggests that late pod infection may not play a role in seed weight loss, even though it may increase the level of seed infection. The possible role of late pod infections in seed infection was confirmed by infection levels of up to 2% in each infected control sample, even though there were no significant differences between the spray treatments and the non-spray controls.

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