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FULL RESEARCH PAPER

Determination of agronomic practices for the management of blight of chickpea caused by *Ascochyta rabiei* in Turkey: 1. Appropriate sowing date

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Abstract In order to determine the most appropriate dates for planting chickpea in central Anatolia, Turkey, six cultivars were planted at three sites that differed in disease pressure. In two of the sites, disease pressure from *Ascochyta rabiei* was promoted by spreading infected chickpea debris on the soil surface at the time of planting and, at one of these, sprinkle irrigation was applied. In the third site, where conditions were dryer, no artificial inoculum was provided. Plants from seeds sown in early March had the most disease and in the sprinkle irrigated plots the disease severity ranged from 7.8 on the most susceptible cv. Canitez to 3.3 on the least susceptible Gokce as scored on the 1–9 scale where 1=no disease and 9 represents a plant killed by the fungus. There was an inverse relationship between disease severity and yield, production from blight resistant cultivars of around 2,000 kg ha^{-1} being more than twice that of susceptible ones. Delaying planting for 3–5 weeks reduced the severity of ascochyta blight but also reduced the yields in four of the six cultivars. In contrast, reduction in disease severity by delayed sowing resulted in yield increases for the susceptible cvs Canitez and Local, although yield level was not as much as those of the less susceptible cvs sown early. Delay of 6–9 weeks almost eliminated ascochyta blight but yields of all cultivars were seriously compromised by drought stress. In consequence, chickpea farmers are recommended to use resistant or tolerant cultivars and sow early in March. For less resistant cultivars, sowing in early April is recommended. Further delay is not recommended unless irrigation is provided and fungicide spraying is recommended where signs of infection are present under conditions conducive to the disease.

Keywords Integrated management · Planting time · Ascochyta blight

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Introduction

Chickpea is the third most widely grown grain legume commodity in the world (Anonymous 2006) and is an important crop for farming communities in Asia, Middle East and north Africa (Dusunceli et al. 2007). In Turkey, chickpea is the major grain legume crop, occupying about 630,000 ha. Annual production during the last decade has been nearly 630,000 tonnes, the yield being just under 1,000 kg ha^{-1}. The crop is grown in arid and semi-arid areas under rainfed conditions especially in central parts and transitional zones of the Anatolian plateau.

Blight caused by *Ascochyta rabiei* is the major disease of chickpea in most areas of he world where the crop is grown and may cause serious or total loss (Nene 1984; Singh et al. 1981; Singh and Reddy 1990; Solh et al. 1994). In some years, the disease has even affected international trade (Dusunceli et al. 2007). The extent and severity of disease depends on production practices and weather conditions. The most favourable conditions for the pathogen are frequent rainfall; wind and temperatures of 20–25°C (Hawtin and Singh 1984) and sowing time largely influence plant development (Saxena 1984) and ascochyta blight severity (Meyveci et al. 1993). There are many reports indicating the occurrence and importance of the disease in different parts of Turkey (Karahan 1968; Acikgoz 1983, 1994; Dusunceli et al. 1995; Kinaci and Dalkiran 1987; Eser et al. 1991; Toker and Canci 2003) and in some years, such as 2001 and 2002, there have been serious losses in some locations. The importance of seed infection and its role in disease development has also been demonstrated (Maden et al. 1975).

The disease determines the production system of chickpea in Turkey and efficient control measures are needed for its management. Farmers who practice early sowing and use large-seeded susceptible cultivars because of their high market value face complete losses in years that are favourable to the disease. For this reason, the majority of farmers delay sowing in order to escape the disease, but this usually results in significant yield losses due to exposure of the crops to high temperatures and droughts in late spring and summer. Control of the disease by fungicides may require several sprays, increasing the cost of production. Moreover, breeding for resistance has been hampered by physiological variation in pathogen populations (Dolar and Gurcan 1992a, b) caused by the presence of the teleomorph stage (Kaiser and Kusmenoglu 1997).

Sowing time has been reported to affect yields significantly and the advantages of early sowing in Turkey have been shown (Ozdemir and Karadavut 2003; Meyveci et al. 1993). However, these studies were conducted under natural conditions with insignificant disease pressure and on chickpea genotypes that are no longer in production. The advantages of early sowing is based on mainly better utilization of winter and spring precipitation but in this case ascochyta blight becomes an important constraint to consider as the disease is also favoured by humid conditions. Therefore appropriate sowing dates may differ according to cultivar (Gan et al. 2006) and location (Regan and Siddique 2006), and there is a need to determine the most appropriate sowing date for current chickpea cultivars. The aim of this study was to determine the most appropriate sowing dates for management of ascochyta blight and improvement of productivity of current chickpea cultivars in central Anatolia, Turkey.

Materials and methods

The study was carried out during the 4 years from 2000 to 2003 at two sites on the research farm of the Central Research Institute for Field Crops, Haymana, 45 km south west of Ankara and one site in Kadinhani-Konya. For the experimental plots, a field on which wheat had been grown previously was ploughed using a moldboard plough in October in all 4 years. The fields were prepared for sowing by cultivation with a spring harrow prior to sowing. Different levels of disease pressure were achieved as follows: In Kadinhani, near the province of Konya (referred to as Kadinhani-dryland), no artificial inoculum or irrigation was provided in order to keep disease pressure to a minimum. In the two trials conducted on the research farm of the Central Research Institute for Field Crops near Haymana, Ankara, artificial inoculum was provided at the time of sowing by scattering diseased plant debris (27 g/m^{-2}) which had been collected the previous year from infected fields. One of these was conducted under dryland conditions (referred to as Haymana-dryland), and, the other was conducted with sprinkle irrigation facility (referred to as Haymana-irrigated) in order to achieve moderate and high levels of disease pressure, respectively.

In all trials, six cultivars with different levels of resistance to ascochyta blight were sown on three dates in all 4 years (1st sowing date: in early March; 2nd sowing date: in early April; 3rd sowing date: late April to early May). Gokce and Er were selected as the most resistant cultivars, Uzunlu and Akcin as moderately susceptible and Canitez and Local as the most susceptible. The experiments were designed in a randomised complete block design with cultivars split on sowing date plots. Sowing was done in 6×1.5 m^2

plots with a machine driller in four rows at 35 plants m^{-2} density. Weeds were removed by hand and sprinkle irrigation was provided only in the irrigated-Haymana site. Disease development was monitored and scoring was done using the 1–9 scale developed by Singh et al. (1981) and later improved by Nene (1984). Evaluation was made as follows: 1= no disease; 2–3=low level of disease (rare to few scattered lesions); 4–5=moderate level of disease (some to common lesions, defoliation not great); 6–7=high level of disease (lesions common to very common, up to 25% of the plants killed) and 8–9= extensive lesions in all plants, >50% of the plants killed). A pictorial hand key was also used for easy scoring. Analysis of variance was performed on data from the three sowing dates, combined over the 4 years for each location separately, using MSTAT C statistical software. Least significance test was used for comparison of the sowing dates and cultivars.

Results

The effect of sowing date, disease pressure and cultivar on disease severity

Disease development varied slightly among the 4 years at the three sites due to variation in weather conditions but the differences were not significant. Overall disease severity followed similar trends in all four seasons for the three experimental sites, sowing dates and cultivars. Therefore the results were aggregated. Sowing date profoundly affected disease severity with an overall average for the six cultivars of 3.9 for the first sowing date, 2.5 for the second and 1.1 for the third. Disease pressure also varied among the experimental sites with overall averages for the six cultivars of 3.4 on the Haymana-irrigated plots, 2.8 on the Haymana-dryland and 1.3 at Kadinhani-dryland plots.

Differences in disease severity among cultivars were clearly evident in plots sown on the first planting date at all three sites, but most of all under the high disease pressure of the Haymana-irrigated plots. Here the ratings ranged from 3.3 for cv. Gokce to 7.9 for cv. Local. On the moderate disease pressure of the Haymana-dryland plots, disease severity ranged from 2.8 for cv. Gokce to 6.3 for cv. Canitez. At Kadinhani-dryland site there was only a low level of disease for plants from the first sowing date, disease severity ranging from 1.0 for Gokce to 3.0 for Canitez whereas, at the second sowing date, low levels of disease (1.2) were found only on Canitez and Local. No disease was present on any cultivar in plots planted on the third sowing date at this location. The data clearly support the designation of cv. Gokce and cv. Er as the most resistant of the six cultivars, cv. Uzunlu and cv. Akcin as of intermediate resistance and cv. Canitez and cv. Local as the most susceptible (Fig. 1).

The reduction in disease severity in the second and third sowing dates, compared to the first sowing date, was not clear at the Kadinhani location as the disease development was not favoured by natural conditions. However, reduction in disease severity was clearly demonstrated in experiments in the Haymana location both in irrigated and rainfed experiments. Decrease in disease severity, on 1–9 scale, of cultivars in the second sowing date compared to early sowing reached 1.8 units (Uzunlu and Canitez) and 2.3 (Uzunlu) in dryland and irrigated experiments respectively, while for the third sowing date it reached 5.0 units (Canitez) in dryland and 6.4 units (Canitez) in irrigated experiments. The reduction in disease severity was <2.8 units for the more resistant cvs Gokce and Er, but was more pronounced for more susceptible cvs Uzunlu, Akcin, Canitez and Local especially in the irrigated experiment. The data indicated that chickpea plants may escape from ascochyta blight if sowing is delayed about 3 weeks from the first sowing date and that the effect is more pronounced on susceptible cultivars than on more resistant cultivars. The disease severity on susceptible cultivars can be reduced still further by delaying sowing for 3–4 weeks, but with the risk of drought stress and consequent yield losses.

The effect of sowing date, disease pressure and cultivar on yield

The yields of cultivars in the trials conducted under dryland conditions in Haymana and Konya locations were mostly influenced by drought while those under irrigation in Haymana were influenced mainly by ascochyta blight. Sowing dates affected the yields with an overall average of 1,009.1 kg ha^{-1} for the first sowing date, 915.0 kg ha^{-1} for the second and 636.1 kg ha^{-1} for the third sowing dates. The yield differences were not significant at P=0.05 for replicates in all three sites but the differences among

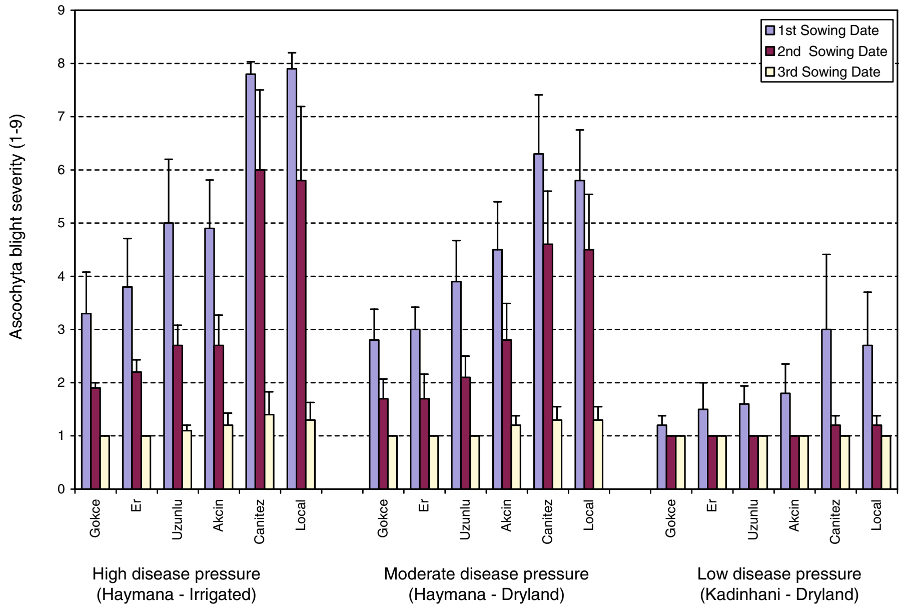

Fig. 1 The effect of sowing date, disease pressure and cultivar on ascochyta blight development

sowing dates were significant at $P=0.01$ for the sites of Kadinhani-dryland (LSD, 68.9), Haymana-dryland (LSD, 71.6), Haymana-irrigated (LSD, 207.9) as well as among cultivars in Kadinhani (LSD, 97.5), Haymana-dryland (LSD, 101.3) and Haymana-irrigated (LSD, 294). In general, yield trends of cultivars in dryland experiments in Haymana and in Kadinhani were similar, except that cvs Canitez and Local sown at the first sowing date gave distinctly lower yields in Haymana as a consequence of ascochyta blight development in early spring (Fig. 2).

At the first sowing date in the Haymana-irrigated plots, the disease clearly depressed yields, particularly of the susceptible cvs Canitez and Local and there was a reciprocal effect, the more resistant cultivars giving yields of around 2,000 kg ha^{-1} which were more than double those of the most susceptible ones (Fig. 2). This effect was similar for the first sowing

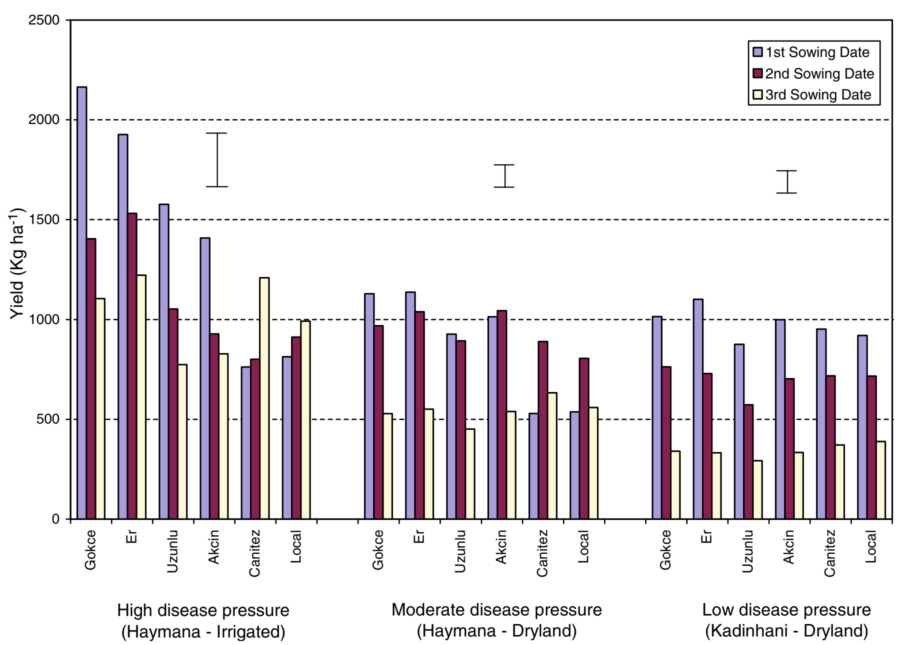

Fig. 2 Effect of sowing date, disease pressure and cultivar on yield of chickpea (*vertical bars* represent LSD values)

date at Haymana-dryland, but yields here were much lower with the two most susceptible cvs Canitez and Local yielding only about 500 kg ha^{-1}. At the first sowing in Kadinhani location, yields of all six cultivars were about 1,000 kg ha^{-1}, the low level of blight severity having little effect.

At the second sowing date the benefit of the partial resistance of cvs Gokce and Er were still apparent at the Haymana-irrigated site with yields of around 1,500 kg ha^{-1} compared with little more than half this amount for the two most susceptible cultivars, Canitez and Local. This effect had almost disappeared at the Haymana-dryland site and was absent at the Kadinhani location (Fig. 3) where the yields were around 750 kg ha^{-1} for all cultivars except Uzunlu where it was 572.3 kg ha^{-1}.

At the third sowing date in the Haymana-irrigated site where disease pressure was low, the yields of the two susceptible cvs Canitez and Local were comparable with those of the most resistant cultivars, Gokce and Er at around 1,000 to 1,200 kg ha^{-1}. The yields of the cultivars of intermediate resistance, Uzunlu and Akcin were lower at around 800 kg ha^{-1}. All cultivars yielded less at the Haymana-dryland site at about 500 kg ha^{-1} and still less at the Kadinhani location where yields ranged between 292.5 and 389 kg ha^{-1}, mainly as a consequence of drought effect.

The experiments indicated that ascochyta blight can cause serious yield losses on susceptible cultivars under suitable conditions and there was a strong correlation (r^2=−0.96) between disease severity and yield under high disease pressure (Fig. 4). The correlation between disease severity and yield of cultivars was strong in first sowing date in Haymana under irrigation and rain fed experiments with r^2 values of −0.96 and −0.91 respectively (Table 1). The correlation between disease severity and yield was not evident in any sowing dates in Konya location and in second and third sowing dates in Haymana rain fed experiments due to less disease development and more influence of drought effect. This illustrates that disease severity can play a major role for determination of the yield level under conditions suitable for disease development.

Discussion

The data presented in this paper highlight the importance of four factors which influence the production of chickpea in Turkey. These are planting date, ascochyta blight, water availability and cultivar preference.

Early planting favours the crop as it prevents the crop from running into drought and heat stress later in the growing cycle, but it also favours ascochyta blight development. The importance of ascochyta blight in this interaction was particularly apparent in the experiments in Haymana (Ankara) location, owing to promotion of the disease by spreading infected debris on the ground at the time of sowing. In one of these trials, disease was exacerbated by sprinkle irrigation (Haymana-irrigated) and in the other disease was allowed to develop naturally (Haymana-dryland). Although disease was less severe in the latter, the

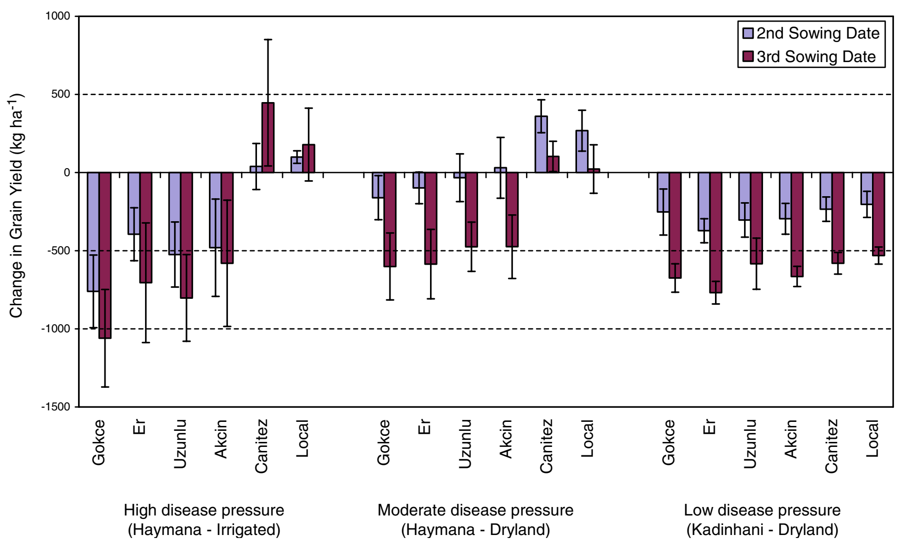

Fig. 3 Changes in yield of cultivars in second and third sowing dates compared to first sowing date in three sites with different disease pressure

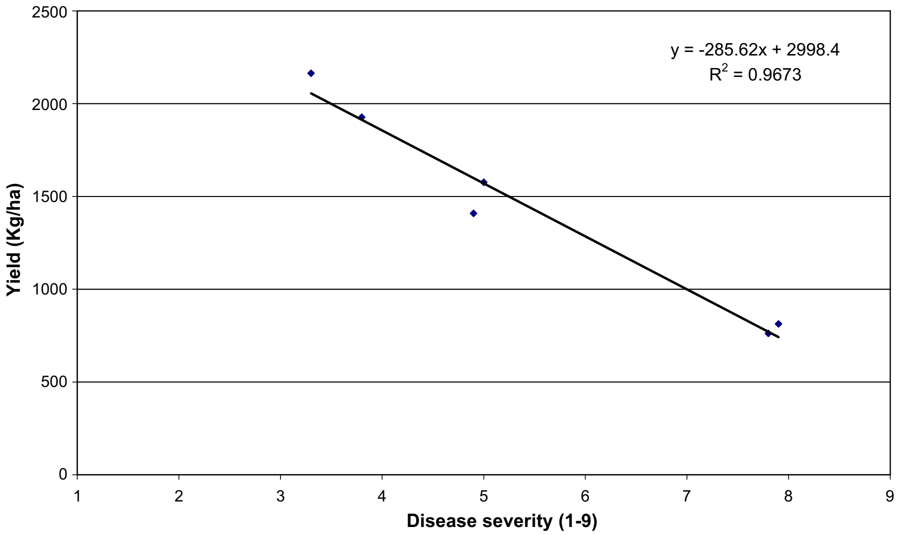

Fig. 4 Correlation between the disease severity and yield of cultivars in first sowing in Haymana-irrigated plots with high disease pressure

ranking order of the differential reactions of the six cultivars, owing to their different levels of blight resistance, was essentially similar. This was also true of the first planting at the Kadinhani-dryland site, although here disease pressure was much lower (Fig. 1). These results are similar to those of Akem et al. (2004) who found that ranking of severity ratings of cultivars did not differ with sowing dates. However, in our findings disease severity on each cultivar differed significantly at different sowing dates, being highest at first sowing and essentially absent at the third sowing date in all sites and also at the second sowing in Kadinhani-dryland site. Moreover, while they found that regardless of presence of ascochyta blight the highest yields were obtained at early sowing with resistant or moderately susceptible cultivars in Syrian conditions, our results indicated that sowing date was crucial especially with susceptible cultivars under conditions suitable for disease development. Therefore it is concluded that choice of cultivar and sowing date should be considered together for management of the disease in central Anatolian conditions. Similar results were found on older cultivars by Meyveci et al. (1993) following a study in Tokat, Sivas, Çorum and Ankara locations.

Plants for which water was most available were those of the first sowing in the irrigated-Haymana plots. Here the importance of high levels of ascochyta resistance was paramount as there was an inverse relationship between blight severity and yield (Figs. 1 and 2). The effect of lack of water on yield was clearly apparent in the third sowing in dryland experiments being worst at Kandinhani location. However, at the two experimental sites in Haymana, yields of the two most susceptible cvs Canitez and Local were actually considerably higher in the late sowing than those in

Table 1 Correlation equilibrium for disease severity and yield in each experiment

	1st Sowing Date	2nd Sowing Date	3rd sowing date
High disease pressure (Ankara - irrigated)	y = -285.62x + 2,998.4 $R^2 = 0.9673$	y = -120.38x + 1,532.2 $R^2 = 0.5671$	y = 322.48x + 661.37 $R^2 = 0.1078$
Moderate disease pressure (Haymana – rain fed)	y = -185.09x + 1,689.9 $R^2 = 0.9117$	y = -47.566x + 1,077.8 $R^2 = 0.4582$	y = 268.32x + 239.45 $R^2 = 0.4819$
Low disease pressure (Konya – rain fed)	y = -47.08x + 1,069.6 $R^2 = 0.1819$	y = 127.12x + 564.6 $R^2 = 0.0398$	0

the first planting and there was also a lesser effect in plants at the second sowing (Fig. 3). This indicates that the susceptible cvs Canitez and Local may be considered for late sowing to escape from the disease provided that irrigation is available to avoid the drought effect. However, it must be noted that despite this, their yields were lower in plots at the third sowing date than those of early-sown more resistant cultivars resulting from drought stress. Therefore excessive delay with the objective of escaping from ascochyta blight is not found to be practical under dry environments of central Anatolia, unless irrigation is provided. However, the findings indicate that there is a need to give more emphasis to improvement of drought-tolerant cultivars for the region.

These experiments clearly showed the highly deleterious effect of ascochyta blight and lack of water availability on the yield of chickpea. Although the disease may be largely avoided by later planting of the crop, there is a high price to be paid in terms of yield as also found by Akem et al. (2004) and Meyveci et al. (1993). Therefore the seeds must be sown at an appropriate time considering the importance of cultivar preference. If the cultivar used has resistance to the disease then the best approach would be to sow the seeds as early as possible in March. This facilitates better utilization of winter and spring precipitation and completion of grain maturity before the severe droughts in summer. However, if the cultivars do not have adequate disease resistance, early sowing would bring about an ascochyta blight risk. In this case, with spring precipitation, ascochyta blight can develop and cause serious yield losses even under rain fed conditions. Such risks would be greater under increased precipitation or sprinkle irrigation.

As a result of this study, following recommendations are made for the central Anatolian chickpea producers: (1) to use certified clean seeds and preferably cultivars with ascochyta blight resistance such as Gokce and Er; (2) to sow them early i.e. the first half of March; (3) to delay sowing until late March to early April if cultivars with inadequate resistance have to be used; (4) not to delay sowing until late April in any case unless irrigation is provided and (5) to monitor weather forecasts and disease development in order to determine if fungicide spraying would be practicable.

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