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Evaluating Chickpea Genotypes for Resistance to *Ascochyta* Blight in Nebraska

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Abstract

Ten irrigated or dryland chickpea field trials in the Nebraska Panhandle over the three year period (2005-2007) assessed parental genotypes and cultivars for disease resistance to *Ascochyta* blight caused by *Ascochyta rabiei*. The most promising genotypes for all aspects of disease resistance were the breeding lines PI 17256 and CA0090B347C. PI 17256 had significantly better disease ratings in two of the four dryland trials and five of the six irrigated trials compared to the three standard commercial cultivars (Dylan, Dwelley, and Sierra). Overall, breeding line CA0090B347C was intermediate between PI 17256 and the other entries in terms of disease resistance, with similar ratings to PI 17256 but better than the commercial cultivars in two of the four dryland trials and two of the six irrigated trials. PI 17256 produced the highest yields in three trials, while CA0090B347C produced significantly higher yields than the commercial cultivars in three other trials. These two lines should be useful as germplasm sources for ongoing breeding efforts to develop new, adapted blight-tolerant cultivars for Nebraska.

Introduction

Interest in chickpea (*Cicer arietinum* L.), also known as the garbanzo bean, as an alternative crop to spring cereals has been on the increase in areas of the United States where rainfall is marginal (9). The leading producing states are Idaho, Washington, California, and North Dakota. Chickpea production began to substantially increase in Nebraska from 1998-2000, due in part to this crop's ability to fit well within existing production systems in this area as a rotational crop. Acreage increased from 1,500 acres in 2000 to almost 10,000 acres in 2001 and 2006 and continued production increases are expected.

Fig. 1. *Ascochyta* blight symptoms on chickpea: elongate lesions on stem (top), and circular lesions on leaves (bottom right) and pods (bottom left).

Agronomic, processing and marketing constraint issues are responsible for sporadic production in Nebraska (9). However, another major factor affecting the fluctuation of chickpea acreage in this region over the last decade is *Ascochyta* blight. The first severe region-wide blight epidemic occurred in 2001 (4) and since that time this disease has been the largest constraint to increased acreage in Nebraska. *Ascochyta* blight is caused by the fungal pathogen *Ascochyta rabiei*, and is also considered the most serious chickpea disease worldwide (1,11). The pathogen attacks all aerial

portions of the plant (Fig. 1), and causes economic losses due to reduced yields as well as reduced quality (Fig. 2) (5,10). For a crop like chickpeas, quality may be more important than gross yields, as payments for small discolored seeds

(result of pod and seed infection) are significantly lowered. Seed infections can be either internal or external on the seed surface, and both types of infections are equally capable of transmitting the pathogen to emerging seedlings (1,11). Infected seeds serve as a major mechanism for pathogen survival, long distance movement, and initiation of new infections (5). The pathogen may also overwinter in crop residues for several years, and be disseminated in spring to other fields via wind-blown spores (10). Early in the season, infected seedlings are found scattered in fields (4,5,10). These plants are sources of inocula for secondary spread during periods of conducive environmental conditions.

Fig. 2. Effect of *Ascochyta rabiel* infection on chickpea seed size: seeds (top) harvested from pods (bottom) collected from the severely infested field, healthy (left) and infected (right).

Currently, there are few viable management options for Nebraska producers. Fungicide seed treatments have been shown to improve initial stands, but do not protect from disease that develops later in the season from the infected seeds (8). Because of the small profit margins for chickpeas in Nebraska, growers have additionally been reluctant to make multiple fungicide applications for blight control, which is often needed for profitable crop yields. Therefore, unless new cultivars with adequate levels of resistance are identified and implemented by growers, chickpea production in Nebraska will not likely continue.

Resistance to *Ascochyta* Blight

Developing new resistant cultivars will additionally be a challenging task as numerous conflicting reports concerning the genetics of *Ascochyta* blight resistance have been made by researchers working with this disease. Tewari and Pandey (13) found that resistance was controlled by three independently segregating genes in three distinct genotypes. Dey and Singh (3) determined that resistance to blight in two separate lines is governed by two dominant genes, whereas resistance in a black seeded line was controlled by one dominant and one recessive independent gene. Vir et. al (14) found that blight resistance in one line was controlled by a single dominant gene pair. Other studies have concluded that resistance found in cultivars is partial and incomplete (2,12).

Identification of genotypes with improved resistance to the disease is critical to rapid development of new blight resistant cultivars and the future of this crop in Nebraska, and other areas of the Central High Plains. The objective was to assess *Ascochyta* blight reaction and yield for selected chickpea parental genotypes and cultivars.

Multi-Site Field Trials

Ten trials were conducted in the Nebraska Panhandle from 2005 to 2007. These included four dryland trials (Scottsbluff 2006; Sidney 2006; and Alliance 2005 and 2006), and six irrigated trials (Scottsbluff 2005, 2006, and 2007; Sidney 2006; and Alliance 2005 and 2006]. The Alliance trials were conducted on a grower's farm, while the other six were conducted on experiment farms affiliated with the University of Nebraska, including the Panhandle Research

and Extension Center, Scottsbluff, and High Plains Agricultural Laboratory, Sidney, NE.

Each trial included 14 entries (genotypes), but for this report we chose to present the 9 genotypes common to all trials over the 3 year period (Table 1). Genotypes consisted of six advanced breeding lines and three commercial cultivars, all of which were obtained from the chickpea breeding program at Washington State University. All genotypes in these trials were the large-seeded Kabuli type, but leaf type varied from the single unifoliate to the compound "fern leaf" type. Chickpea market types "Kabuli" or the smaller "desi" are based on seed size, shape, and color.

Table 1. Chickpea genotypes common to ten Nebraska field trials evaluating *Ascochyta* blight resistance (2005 to 2007).

Genotype	Leaf type	Source ^x
Dwellely	Unifoliate	Commercial cultivar
Dylan	Compound	Commercial cultivar
Sierra	Unifoliate	Commercial cultivar
CA9783163C	Compound	Washington State University
CA9990B1579C	Unifoliate	Washington State University
CA0090B347C	Unifoliate	Washington State University
CA9890233W	Compound	Washington State University
Troy	Compound	Washington State University
PI 17256	Compound	USDA Plant Introduction, Pullman, WA

^x All entries provided by Western Regional PI Station, Pullman, WA

Genotypes were assigned to experimental units (plots) using a randomized complete block design with four replications for each trial. All plots were eight rows spaced 1.7 m wide. Plot lengths varied by location (Alliance 6 m; Scottsbluff irrigated 3 m and dryland 6 m; and Sidney irrigated 7.4 m and dryland 10 m). Starter fertilizer (11-51-0) was broadcast applied preplant to the irrigated tests to achieve 11 kg/ha P₂O₅. Sulfentrazone (FMC Corp., Philadelphia, PA) was applied preplant to the soil surface at 280 g ai/ha for broadleaf weed control and 72 g ai/ha of quizalofop (Dupont, Wilmington, DE) was used post-plant for grass weed control. All tests were planted in late April to achieve a final population of three to four plants/ft² and harvested in late August or early September with a Wintersteiger plot combine (Wintersteiger Inc., Salt Lake City, UT). Yield parameters were assessed on individual samples in the lab.

Blight ratings in mid-July used a 1 to 5 scale where 1 = 100% stand and no disease, 2 = 75% stand and < 25% of plants showing symptoms, 3 = 50% stand and 50% of plants showing symptoms, 4 = 25% stand and up to 75% of plant showing symptoms, and 5 = no stand or > 75% of plant showing symptoms (Tables 2 and 3). This scale takes into account the estimated disease incidence within plots, but also includes estimated plant stands. *Ascochyta* blight can readily affect final established stands if unprotected seeds are severely infected (Figs. 3 and 4).

Table 2. Ascochyta blight ratings (1 to 5 scale, 1 for no disease) for six chickpea irrigated trials in Nebraska (2005 to 2007).

Genotype	Scottsbluff 2005-2007 ^x	Sidney 2006	Alliance 2005	Alliance 2006
Dwelley	2.8 a ^y	3.9 b	1.5 bc	2.8 a
Dylan	3.0 a	4.9 a	2.3 a	2.0 cd
Sierra	2.8 a	3.4 bc	2.1 ab	2.4 ab
CA9783163C	3.2 a	3.4 b	1.1 c	2.0 cd
CA9990B1579C	2.9 a	2.6 cd	2.3 a	2.4 ab
CA0090B347C	2.7 a	2.4 de	2.4 a	1.9 d
CA9890233W	2.8 a	3.3 bc	1.8 abc	2.3 bc
Troy	2.8 a	3.4 b	1.8 abc	1.8 de
PI 17256	1.6 b	1.5 e	2.3 a	1.5 e
Mean	2.7	3.2	1.9	2.1

^x Data for 3 Scottsbluff trials were combined for analysis due to no trial × genotype interactions.

^y LSD mean separations are based on the PROC RANK transformed rankings.

Table 3. Ascochyta blight ratings (1 to 5 scale, 1 for no disease) for four dryland chickpea trials in Nebraska (2005-2006).

Genotype	Scottsbluff 2006	Sidney 2006	Alliance 2005	Alliance 2006
Dwelley	1.8 bc ^x	3.0 ab	1.8 c	2.8 ab
Dylan	1.9 ab	3.3 a	2.6 a	2.4 bc
Sierra	1.9 ab	2.5 bc	2.3 ab	3.0 a
CA9783163C	1.5 c	2.5 bc	2.5 bc	2.1 cd
CA9990B1579C	2.3 a	2.4 bcd	2.0 abc	2.8 ab
CA0090B347C	2.0 ab	2.0 de	2.4 ab	2.0 de
CA9890233W	1.5 c	2.4 cd	2.1 abc	2.1 cd
Troy	1.5 c	2.5 c	2.1 abc	2.0 de
PI 17256	1.5 c	1.5 e	2.5 ab	1.6 e
Mean	1.8	2.4	2.2	2.3

^x LSD mean separations are based on the PROC RANK transformed rankings.

Table 4. Chickpea yields from six irrigated trials in Nebraska (2005-2007).

Genotype	Yield (kg/ha)					
	Scottsbluff 2005	Scottsbluff 2006	Scottsbluff 2007	Sidney 2006	Alliance 2005	Alliance 2006
Dwelley	851	2190	138	71	1704	1387
Dylan	871	2319	188	18	1348	1403
Sierra	1509	2354	358	215	1526	1738
CA9783163C	716	2134	104	41	1579	1471
CA9990B1579C	1645	2332	69	390	1721	1503
CA0090B347C	1954	2289	327	874	2105	1795
CA9890233W	484	2445	126	138	1330	1523
Troy	329	2134	261	44	1140	1236
PI 17256	1661	1048	341	1456	1846	1574
Mean	1097	2138	213	360	1576	1514
LSD (0.05)	366	380	103	198	352	352

Fig. 3. Effect of seedborne *Ascochyta rabiei* on early chickpea stand establishment. Note the poor stands in those plots planted with seeds without fungicide seed treatments.

Fig. 4. Chickpea plots ready for harvest. Plot with severe *Ascochyta* blight disease (center) was planted using a susceptible genotype without fungicide seed treatment.

Data Analysis

The disease rating variances for the three irrigated Scottsbluff sites (2005 to 2007) were homogeneous and no trial $\times$ genotype interactions were observed. Therefore, the data were pooled for analysis for these three sites only (Table 2). All other disease ratings and yield data are presented separately by year and location, due to trial $\times$ genotype interactions (Tables 2 to 5). Because the disease ratings were based on an ordinal scale, the data were transformed using PROC RANK before performing an analysis of variance using PROC GLM (SAS Institute Inc., Cary, NC). Differences among the ranked entries were then separated by LSD tests at $P < 0.05$. Yield analyses for all trials utilized the GLM procedure, and means were also separated by LSD ($P < 0.05$). Correlation analyses were additionally performed comparing the disease ratings with the yield results from each trial.

Table 5. Chickpea yields from four dryland trials in Nebraska (2005-2006).

Genotype	Yield (kg/ha)			
	Scottsbluff 2006	Sidney 2006	Alliance 2005	Alliance 2006
Dwellely	63	525	1160	130
Dylan	105	361	1049	272
Sierra	172	686	1240	216
CA9783163C	14	521	1425	198
CA9990B1579C	297	745	1255	265
CA0090B347C	157	845	1681	285
CA9890233W	77	584	1268	250
Troy	61	441	1123	147
PI 17256	336	936	1228	332
Mean	142	627	1270	233
LSD (0.05)	138	172	256	140

Entry Performance

The incidence and severity of blight varied considerably among the trials. The average severity ratings for all entries ranged from 1.8 at the Scottsbluff dryland trial in 2006 to 3.2 at the Sidney irrigated trial in 2006 (Tables 2 and 3). Overall, the irrigated trials resulted in slightly higher ratings (average of 2.5) compared to the dryland trials (average of 2.2). Yield results likewise varied widely and ranged from a low of 142 kg/ha at the dryland Scottsbluff trial in 2006 to a high of 2138 kg/ha at the Scottsbluff irrigated site in 2006 (Tables 4 and 5). Average yields across all entries were higher from the six irrigated trials (1150 kg/ha) than from the four dryland trials (568 kg/ha) (Tables 4 and 5). Eight of the ten trials resulted in inverse relationships between blight ratings and yield, with five of these being statistically significant (Table 6). Two genotypes showed promise for resisting disease and yielding adequately under

western Nebraska conditions, including PI 17256 and CA0090B347C. The PI 17256 line consistently demonstrated the greatest degree of resistance to the pathogen, regardless of the type of production. It produced significantly better disease ratings in two of the four dryland trials (Sidney 2006, and Alliance 2006) and five of the six irrigated trials compared to the three standard commercial cultivars (Dylan, Dwelley, and Sierra) (Tables 2 and 3). The breeding line CA0090B347C was intermediate between PI 17256 and the other entries in terms of disease resistance. It produced ratings that were similar but statistically insignificant from PI 17256 but better than the commercial cultivars in two of the four dryland trials and two of the six irrigated trials.

Table 6. Correlations between Ascochyta blight ratings and chickpea yields for irrigated and dryland trials in Nebraska.

	Irrigated	Dryland
Scottsbluff 2005	-0.38 ^x	—
Scottsbluff 2006	-0.63 ^x	-0.21
Scottsbluff 2007	-0.41 ^y	—
Sidney 2006	-0.79 ^x	-0.74 ^x
Alliance 2005	-0.02	-0.13
Alliance 2006	-0.13	-0.32

^x Significant relationship ($P < 0.01$).

^y Significant relationship ($P < 0.05$).

Yield results also illustrate the potential benefits of these two breeding lines. At least one of the two lines resulted in significantly higher yields compared to the three commercial cultivars in six of the ten trials. PI 17256 produced the highest yields in three trials (2006 Sidney irrigated, 2006 Sidney dryland, and 2007 Scottsbluff dryland), while CA0090B347C produced significantly higher yields than the commercial cultivars in three other trials (2005 Scottsbluff irrigated, 2005 Alliance dryland, and 2005 Alliance irrigated (Tables 4 and 5).

The commercial cultivar Sierra did not exhibit the same high levels of resistance that PI 17256 did. However, it yielded similarly to PI 17256 and/or CA0090B347C in four trials, including 2006 and 2007 Scottsbluff irrigated, 2006 Alliance irrigated and 2006 Alliance dryland (Tables 4 and 5).

Conclusions

Chickpeas have several advantages that make them an attractive alternative crop for producers in western Nebraska. They fit well with existing equipment, dry bean processors and regional infrastructure. Furthermore they serve as an excellent rotational crop that can fit into either dryland or irrigated cropping systems in Nebraska. This would be particularly valuable in the dryland areas dominated by grass crops (winter wheat and proso millet).

Previous research from Nebraska has indicated that a great deal of variability exists in some economically important traits within potential cultivars, including yield, seed size, quality, and disease resistance (6,7,8). Identifying disease resistant genotypes with acceptable yield and quality will help this region (Colorado, Nebraska, and Wyoming) become a more competitive production area.

Of those genotypes tested, the most promising for all aspects of disease resistance and production were breeding lines PI 17256 and CA0090B347C. Although both are Kabuli-types, seed sizes were smaller than the commercial standard. PI 17256 exhibits better disease resistance than CA0090B347C, but produces smaller seed. Nevertheless, these two lines should still be useful as parental germplasm sources for ongoing breeding efforts to develop new blight-resistant cultivars with the desired agronomic traits for Nebraska and other areas of the Central High Plains. In the meantime, we have also determined that the cultivar Sierra may be an acceptable alternative for many producers until

more resistant high yielding cultivars are developed, but its use would likely have to be integrated with both fungicide seed treatments and foliar applications for disease management.

Evaluation of more genotypes for resistance and developing new cultivars will remain a priority in the hope of stimulating more interest in irrigated and dryland chickpea production. Both dryland and irrigated trials are necessary for *Ascochyta* blight evaluations because substantial disease and yield variations were observed among trials. Because the pathogen is almost always seedborne to some extent, inoculations were not required to initiate disease. For future germplasm evaluations for disease resistance, we will continue to omit seed treatment fungicides but rotate with unrelated crops for at least 3 years. Estimating yield is useful for evaluating genotype response to the pathogen, since it was correlated with disease severity ratings from the majority of the trials.

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