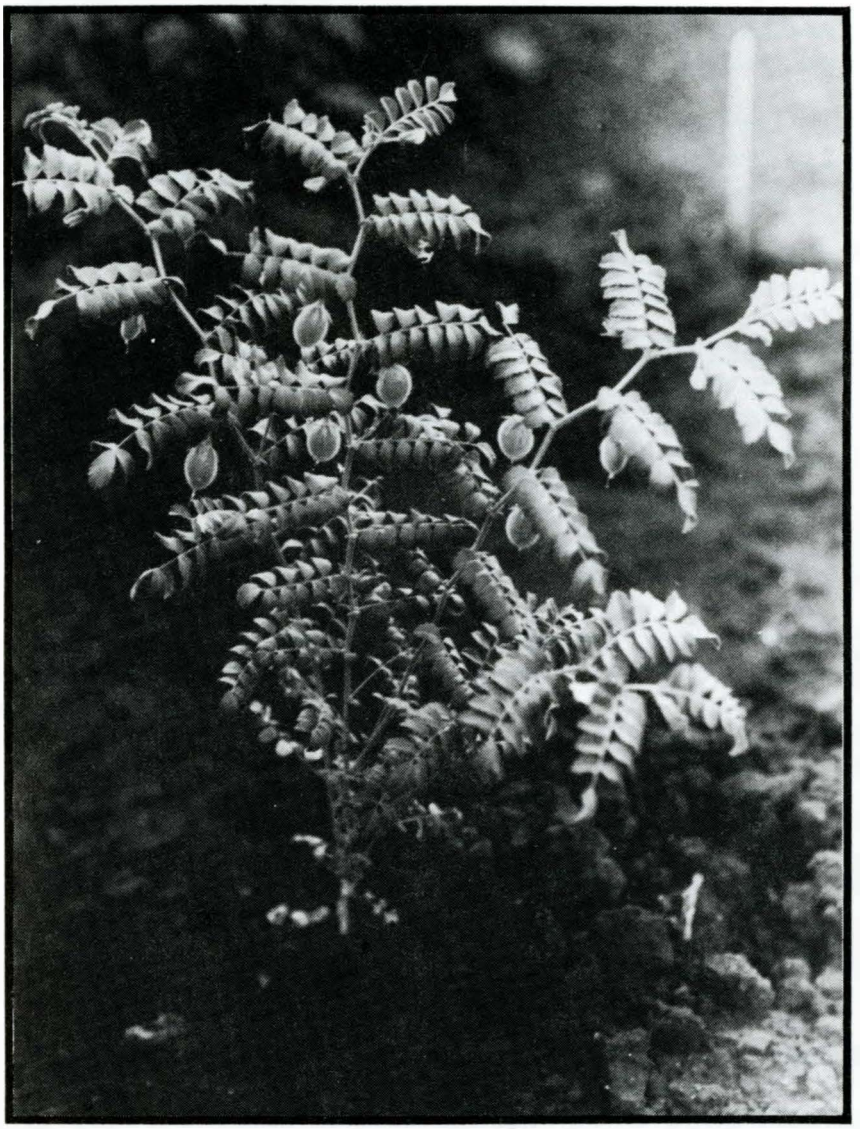
7-1987

Chickpea Research

S. Tuwafe
South Dakota State University

C245



Chickpea Research

Agricultural Experiment Station ● South Dakota State University ● U.S. Department of Agriculture

CONTENTS

The Chickpea Breeding and Cooperating Staff consists of Dr. M Horton, head, Plant Science Department; Dr A.L. Kahler and Dr. A. Boe, project advisors; Dr. S. Tuwafe, principal investigator; and R. Wynia, cooperating assistant.

Cooperating scientists and farmers at the experimental sites were Dr. D. Beck, Redfield; H.A. Geise; Wall; P.D. Weeldreyer, Highmore; Gene Raap, Bristol; and Dr. L.A. Nelson, Sidney, NE.

C245

Chickpea Research

Solomon Tuwafe
Assistant Professor of Plant Science, SDSU

Summary

1. During the 1985 crop season, a total of 288 chickpea lines in screening nurseries and 129 lines in replicated trials were evaluated for adaptability, yield, and reaction to diseases.

2. Several crosses were made to incorporate disease resistance, high yield, and widely adaptable genes into a cultivar.

3. Over 15 lines were identified as resistant genotypes to Ascochyta blight disease at Highmore.

4. More than 20 lines were identified as high yielding and moderately resistant to disease at Highmore, Redfield, and Sidney, NE.

5. In the F3 and F4 populations, over 200 individual plants were selected for early maturity, disease resistance, high pod number, and plant height (tall).

6. Five F2 populations were bulked for yield evaluation in the F3 population nursery.

7. In eastern South Dakota, high seed yield and poor seed quality were demonstrated by the test entries. Good seed quality and lower yield were observed in western South Dakota.

8. SDGI-6 has exhibited the highest seed yield on plots with narrow (6-inch) row spacings at Brookings and Highmore.

9. The depth of planting study at Brookings showed the highest stand of 93 % emergence for plots with 6-inch planting depths.

10. Seed treatment with fungicides resulted in a higher percentage of plant emergence than no treatment.

11. SDGI-6 was increased on¾ acre at Highmore.

Introduction

Chickpeas, (*Cicer arietinum* L.) are grown on approximately 10.8 million hectares in 34 countries for a world production of 7.5 million metric tons of grain. The average yield of 700 kg/ha is rather low.

While there are many reasons for low productivity, this circular addresses just one - the lack of high yielding, disease resistant cultivars in various regions in the world including South Dakota. During the 1985 season SDSU researchers began an attempt to increase the yield level of chickpeas by incorporating resistance genes into susceptible but high yielding genotypes.

Normally, chickpeas are grown with conserved moisture, so the first priority is to generate material suitable to rain-fed conditions.

Fusarium wilt disease is common in some countries, while Ascochyta blight is prevalent in others. Ascochyta blight is found in South Dakota. During 1985, the disease developed uniformly throughout the experimental plots at Highmore, helping us identify lines resistant to Ascochyta blight disease.

Because of low rainfall, low humidity, and high temperature, Highmore is better suited for growing chickpeas than Brookings. However, early drought stress in 1985, followed by unexpected heavy rains at the end of the growing season, caused heavy pod losses in all chickpea experimental sites in the state.

The bulk of the chickpea research was conducted at Highmore because the environment was favorable. In addition, the majority of individual selections made in early generations and/or in advanced materials were carried out at Highmore.

High humidity and continuous rainfall prevented early planting and early maturity at Brookings. However, an effort was made to (1) collect data from one yield trial, (2) make hybridizations, and (3) conduct cultural practice studies. Also, several chickpea lines were tested in different nurseries at four other locations in South Dakota and at one location in Sidney, NE.

Planting began April 13 at Wall and was completed by planting the increase (SDGI-6) on June 6, 1985, at Highmore. Harvesting was started

at Wall on August 8 and completed on September 17 at Bristol. All early generations and screening nurseries were grown in single-row plots with 60-cm (2-ft) spacing between rows.

Replicated trials were planted in four-row plots with 30-cm (1-ft) spacing between rows. Ten-cm (4-inch) spacing between plants within rows was maintained in all nurseries. Treflan at the rate of 1½ pt/acre was preincorporated to control annual grasses and small-seeded annual broadleaves such as pigweed and lambsquarter. The season, as a whole, was very favorable for screening materials for Ascochyta blight disease and for identifying promising high yielding lines.

Climate

Total precipitation during the crop season varied from 8.36 inches in the southwest (Wall) to 19.47 inches at the east-central (Redfield) sites (Table 1). In general, precipitation declined from east to west.

At Redfield, over 72% of the total precipitation was obtained during the last months of the growing season (July, August, and September). Approximately 65% occurred at time of maturity, in July and August. This rainfall caused a reduction in yield due to heavy pod drop. A similar pattern was observed in all sites in the east-central region.

In the central region (Highmore), there was better distribution of precipitation. Drier conditions (1.76 inch) in August helped the crop reach proper maturity. However, the continuous increase of precipitation and the warm temperatures from May through July created a conducive environment for severe disease development. While this would not be acceptable to commercial growers, it assisted us in screening for lines resistant to Ascochyta blight disease.

The experimental sites in the southwest (Sidney and Wall) were much drier, compared to the central and eastern regions. Only 8.36 inches of precipitation were recorded at Wall during 1985, and poor crop stand establishment resulted in a yield reduction. Specifically, the lack of precipitation in April and May (only 0.79 and 0.72 inch of rain respectively) seemed to be the cause for poor stand.

The difference in total precipitation between Wall and Sidney was not the only factor accounting for the increased yield at Sidney. Although low precipitation was recorded at Sidney, the amount was adequate to provide proper pod set and pod filling, which produced greater seed yield. Dry conditions (0.65 inch) in August brought the crop to maturity.

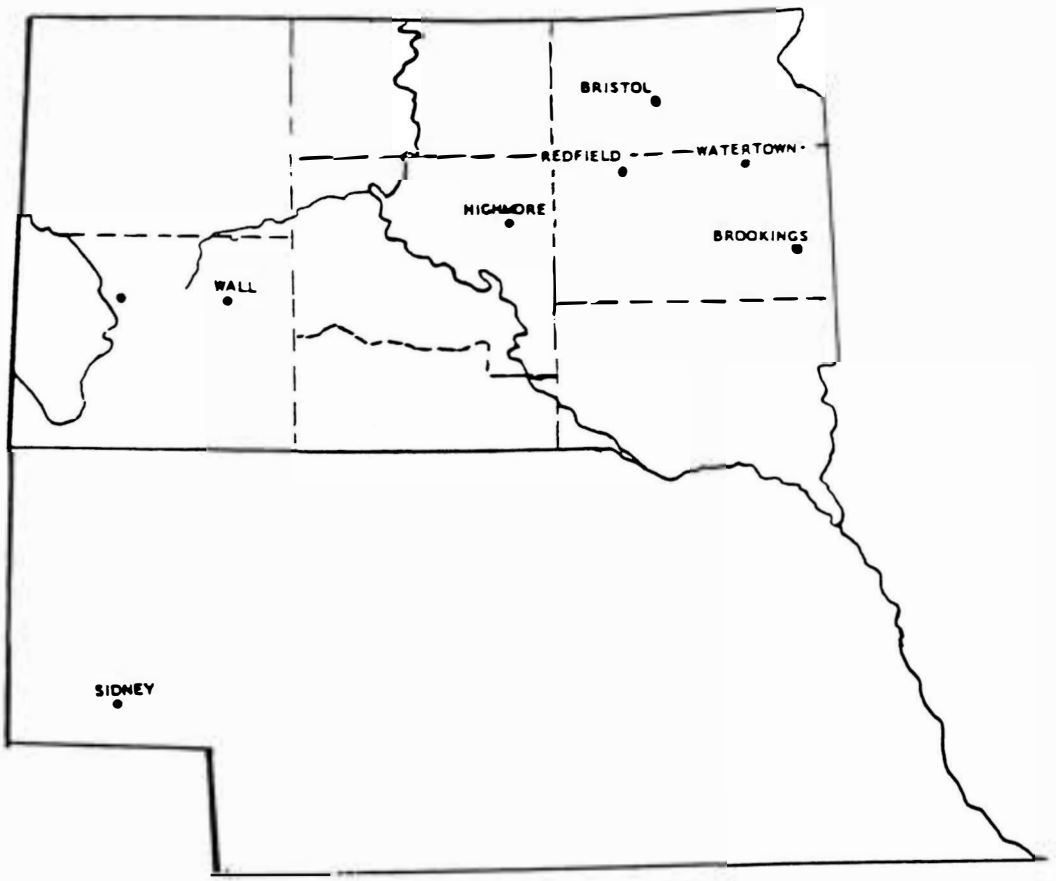


Fig 1. Chickpea experimental sites, 1985.

Table 1. Average temperature (F) and precipitation (inches), 1985.

Month	South West				Central		North East		East Central					
	Sidney(N)		Wall(SD)		Highmore(SD)		Bristol(SD)		Redfield(SD)		Watertown(SD)		Brookings(SD)	
	°F	IN	°F	IN	°F	IN	°F	IN	°F	IN	°F	IN	°F	IN
April	48.8	1.71	50.0	0.79	50.9	0.45	50.1	0.97	49.8	0.74	49.6	1.93	48.5	2.01
May	58.6	2.35	61.8	0.72	63.4	2.15	62.7	2.36	62.1	2.47	61.3	1.27	59.5	3.57
June	63.8	1.88	62.6	1.95	63.0	2.44	63.1	3.02	62.6	2.20	62.5	1.57	61.2	0.82
July	72.7	2.84	76.6	1.89	74.9	4.55	72.6	2.44	72.0	5.20	72.0	5.20	68.3	1.49
August	69.3	0.65	69.4	1.58	68.4	1.76	66.2	3.09	65.3	4.03	65.1	3.65	63.3	3.92
September	57.2	2.54	57.9	1.43	57.5	4.26	56.2	4.99	7.2	4.83	56.6	3.77	56.8	5.09
Total Precipitation		11.97		8.36		15.62		16.17		19.47		17.39		16.9

N = Nebraska
SD = South Dakota

Table 2. Agronomic data for different locations, 1985.

State	Location	Planting Date	Crop duration*	Herbicide
South Dakota	Brookings	5/02	166	Treflan
" "	Bristol	5/06	154	"
" "	Highmore	4/14	117	"
" "	Redfield	4/24	145	"
" "	Wall	4/12	114	"
" "	Watertown	5/06	160	"
Nebraska	Sidney	5/31	125	"

*Crop duration = Total number of days from planting to harvesting; however, in the eastern South Dakota (Brookings, Bristol, Watertown, and Redfield) it was difficult to have early harvest due to wet conditions, hence crop duration is highly exaggerated

Project 1: Breeding chickpea cultivars with high yield and stable performance

1-1. Introduction

What we know about chickpea cultivar performance under varying environmental conditions in South Dakota is limited. However, some high yielding, disease resistant, erect, early maturing, and widely adaptable chickpea lines have been identified. Chickpeas are a rain-fed crop; consequently, generating material suited to low moisture conditions is the emphasis of the breeding program.

Our purpose is to develop chickpea cultivars with high yield and stable performance. Therefore, a hybridization program for introgression of genes for resistance to diseases from low to high yielding varieties, and vice-versa, may produce cultivars that are both high yielding and resistant to Ascochyta blight.

The chickpea is strictly a self-pollinated crop; hence, the traditional breeding methods for self-pollinated crops have been used for cultivar improvement. The pedigree method of breeding has been the primary tactic, but modified and back cross-pedigree methods also have been used. For this project, the pedigree and back cross methods are being used to develop high yielding, disease resistant cultivars.

1-2. Crossing block

When making crosses, the biggest problem a breeder faces is choosing the right parents.

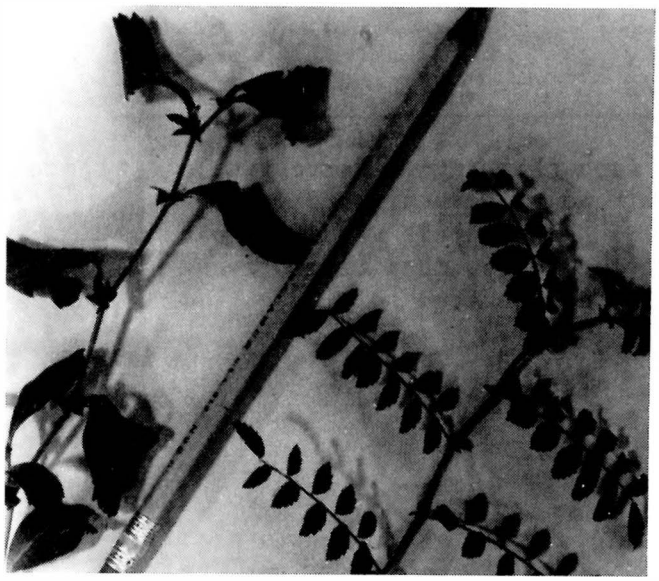
Generally, one parent is chosen for proven capability and the other because it has strengths where the first is weak. Crosses also could be made to capitalize on ecogeographic diversity and create genetic variability. The breeder hopes to get high yielding progenies from divergent crosses. Several types of crosses including multiple (three way, four way, and composite) could be used to incorporate three or more desirable traits into one cultivar.

In 1985, several single crosses were made between selected individuals with desirable characteristics.

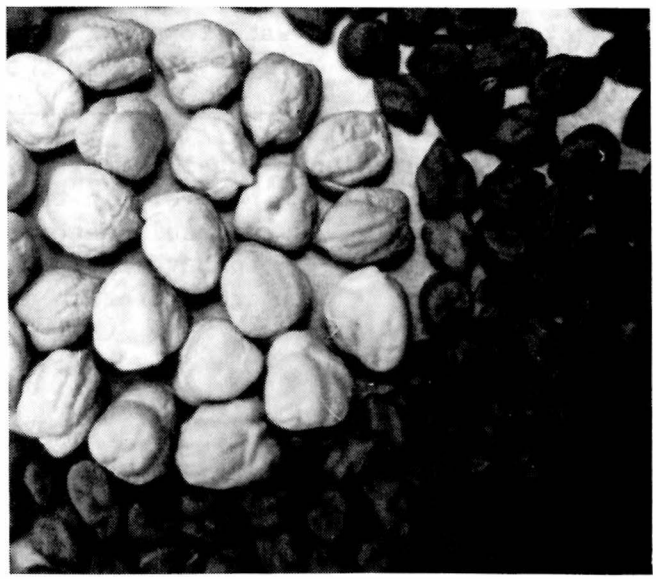
1-3. Procedure and results

In summer 1985, an attempt was made to make large numbers of crosses between commercial

Variability in leaf type: Simple (left) and compound (right) leaves.



Variability in seed color and size: light colored, large seeded and dark colored, small seeded chickpeas.



varieties (UC-5 and Sourtato) and resistant lines (SDGI-6, SDGI-50, and SDGI-131) in the fields at Brookings. Unfortunately, over 75% of the crosses were lost to heavy rains in the latter part of the growing season. Therefore, crosses were continued in the greenhouse during the winter.

Materials for the winter crossing program were selected on the basis of overall performance in nurseries at several locations. Breeding and germplasm materials were grouped according to their yield, resistance to diseases, origin, and other characteristics.

The major characteristics which determined the strains for the crossing program were high yield, resistance to Ascochyta blight disease, wide adaptability, high pod number, and early maturity. The selected lines for the crossing program included two entries from the Adaptability Screening Nursery, seven from the Ascochyta Blight Screening Nursery, one from the Advanced Breeding Trial, one South Dakota selection (SDGI-6), and two commercial varieties (UC-5 and Souratato). The cultivars used in the crossing program during 1985 along with their origin/source and special characteristics are listed in Table 3.

Table 3. Chickpea lines in the 1985 crossing program.

Name	Pedigree	Origin	Plant type	Plant height	Seed type	Special character
SDGI-56	ILC-182	USSR	Semierect	Medium	Intermediate	Resistant to AB at Hgh. High pod number High yielding at Sidney
SDGI-62	ILC-202	USSR	Erect	Tall	Intermediate	Resistant to AB at Hgh.
SDGI -6	ILC-482	Turkey	Semi-spreading	Medium	Kabuli	High pod number Wide adaptable Tolerant to AB at Hgh
SDGI-140	ILC-4421	USSR	Semi-erect	Medium	Intermediate	Resistant to AB at Hgh. High yielder at Sidney
---	UC-5	USA	Semi-spreading	Tall	Kabuli	Commercial variety Large seeded
---	Sourtato	Mexico	Semi-spreading	Medium	Kabuli	Commercial variety Large seeded, Simple leaf
SDB-132	FLIP 82-93c	ICARDA	Erect	Tall	Intermediate	Resistant to AB at Hgh.
SDB-136	FLIP-82-104c	ICARDA	Erect	Tall	Intermediate	Resistant to AB at Hgh.
SDB-137	FLIP-82-191c	ICARDA	Erect	Tall	Intermediate	Tolerant to AB at Hgh High yielding at Sidney
SDB-139	FLIP-83-53c	ICARDA	Semierect	Medium	Intermediate	Resistant to AB at Hgh High pod number
SDB-138	FLIP-83-111c	ICARDA	Erect	Tall	Intermediate	Resistant to AB at Hgh cold tolerant
SDGI-50	ILC-72	Spain	Erect	Tall	Intermediate	Resistant to AB at Hgh.
SDGI-131	ILC-3279	USSR	Semierect	Tall	Intermediate	Resistant to AB at Hgh.

1 AB = Ascochyta blight disease
2 Hgh = Highmore

Project 2: Screening chickpeas for adaptability and resistance to diseases

2-1. Introduction

When a new crop is introduced to a region, genetically diverse germplasm must be evaluated in a screening nursery. Evaluation of the germplasm may be general, where overall adaptability and performance of entries are monitored, and/or specific, where genotypes are screened for specific traits such as pest resistance, drought, cold, and salt tolerance. Generally, unreplicated screening nurseries provide an opportunity to practice selection in a greater range of materials than do replicated trials.

Only a small fraction of genetic variability has been utilized by pulse breeders for the improvement of chickpeas. This is one of the factors limiting attainment of high yields in this crop.

During the 1985 growing season, two types of screening nurseries were used to evaluate germplasm at several locations in South Dakota and Nebraska (Table 4).

The objectives of these nurseries were: (a) to gather information on adaptability, vigor, stand, and yield; (b) to investigate incidence and severity of diseases in the region; and (c) to identify resistant genotypes useful for yield tests and/or for entry into the hybridization program.

2-2. Materials and methods

Five nurseries (Appendix I-V) were used to evaluate germplasm at various locations in South Dakota and at Sidney, NE. Three nurseries were designed for adaptability and yield performance evaluations. SDCSN included 47 entries of breeding material, 35 germplasm lines originating from 11 countries, and a check (SDGI-6) after every 10 test entries at all seven test locations.

CISN-84 had 60 entries of breeding material and three germplasm lines (checks) included within a block of 20 test entries at Watertown and Sidney. CISN-85 had 36 entries of breeding material and three germplasm checks included in a block of 12 test entries at Highmore and Brookings.

All entries in these three nurseries were sown in 3-m single-row plots with 60-cm spacing between rows and 10-cm spacing between plants within rows.

Since most of the entries in SDCSN were destroyed by diseases and heavy rains at Wall, Highmore, Redfield, and Brookings, results of SDCSN from these locations are not reported. Also, due to poor crop stand caused by heavy rains, data were not collected from the CISN-85 nursery at Brookings.

The last two nurseries, CIABN-84 and CIABN-85, comprised of 71 and 41 entries respectively, were designed specifically for screening resistant lines for Ascochyta blight disease and for identifying regions with disease incidence and severity. CIABN-84 was planted at Redfield and Sidney, while CIABN-85 was planted at Highmore and Brookings. These two nurseries included germplasm from Spain, USSR, Turkey, Morocco, Bulgaria, and breeding materials from ICARDA.

Each entry was planted in a single-row 3-m plot in two replications. The susceptible check, SDGI-101, was sown repeatedly after every two test entries to serve as a check and as a disease spreader row.

Plant spacing was 60 cm between rows and 10 cm between plants within rows. A 1-9 rating scale was used to score entries, where 1 = highly resistant; 3 = resistant; 5 = tolerant; 7 = susceptible; and 9 = highly susceptible.

The disease did not develop at Redfield, Sidney, and Brookings, so disease data were not recorded at these locations. However, yield data from CIABN-84 at Sidney is presented in Table 11.

2-3. Results and discussion

Three screening nurseries (SDCSN, CISN-84, and CIABN-84) were evaluated for general adaptability and disease reactions at Sidney, Watertown, Bristol, and Highmore.

2-3-1. Sidney

SDCSN

Data on seed yield, ranking of entries, varietal means, and location means at Sidney, Watertown, and Bristol are presented in Table 5. A range of 433 to 2994 kg/ha was obtained at Sidney. The top five entries originated from Spain, Turkey, Tunisia, and one breeding line (SDB-161) from ICARDA.

Nine entries gave a higher yield than the check (SDGI-6). Top yielding SDB-161 showed a 23% yield increase over the check. Forty-seven entries exhibited higher yields than the location mean (1841 kg/ha). A total of 68 entries had yields greater than 1000 kg/ha; the check (SDGI-6) exhibited seed yield of 2430 kg/ha.

CISN-84

Data for the chickpea international screening nursery (CISN-84) at Watertown and Sidney are presented in Table 7.

Entries at Sidney exhibited very high yields; a range of 1039 to 3044 kg/ha was obtained. Entries SDB-201 and SDB-185 gave the highest and the lowest yields, respectively.

The top yielding entry, SDB-201, exhibited 38 and 46% yield increases (Table 9) over the yield of the best check (SDGI-6) and the location mean,

respectively. The location mean (2085 kg/ha) at Sidney was relatively high.

There was not as great a difference between the yield (2207 kg/ha) of the best check (SDGI-6) and the location mean (2085 kg/ha) at Sidney; almost all test entries showed superior performance. Of the 60 test entries, 27 showed higher yield than the yield of the best check.

Although yields of the best check and the location mean were high, an increase of up to 30% over the best check and 46% over the location mean was recorded for SDB-201 at Sidney (Table 9).

CIABN-84

Table 12 gives seed yield of entries in the Ascochyta blight screening nursery at Sidney. There was no incidence of disease at Sidney; hence the entries were not screened for resistance to Ascochyta blight disease. However, the yield performance of the entries was very promising. There was a range of 450 to 2922 kg/ha for seed yield.

Thirty-seven entries exhibited yields over 1500 kg/ha; among these 19 entries had yields over 2000 kg/ha.

2-3-2. Watertown

SDCSN

Almost all entries in this nursery exhibited very low yields (Table 5).

The location mean of 574 kg/ha at Watertown was the lowest compared to mean yields at Sidney and Bristol. A range of 211 to 1237 kg/ha was observed for yield. Only four entries exhibited higher yields than 1000 kg/ha.

The check had the highest mean yield, and the next four high yields were recorded for breeding materials SDB-169, SDB-163, SDB-77, and SDB-162. The location mean was relatively low (574 kg/ha); 26 entries had higher yields than the location mean.

Among the 83 test entries planted at Watertown, 15 failed to grow and produce seed. Although SDB-169 had a lower yield than the check, its yield was 105% greater than the location mean.

CISN-84

Seed yield at Watertown ranged from 406 to 1844 kg/ha (Table 7). Checks SDGI-131, ILC-482, and SDGI-6 gave similar yields of 932, 1050, and 970 kg/ha, respectively. The location mean (988 kg/ha) was not significantly different from the checks.

Entry SDB-199 had the highest yield and SDB-204 had the lowest yield. However, 26 entries had higher yields than that (1050 kg/ha) of the best check (ILC-482). Yield data of the top five entries expressed in percent increase over the check is presented in Table 9. Many entries had higher yields than the check and the location mean.

Large differences in yields were caused by the different reactions of the entries to Ascochyta blight diseases and their ability to resist damage caused by heavy rains.

2-3-3. Bristol

SDCSN

Among the 83 entries planted at Bristol, only 15 grew successfully (Table 5).

Five entries had higher yields than 1000 kg/ha. Yields ranged from 367 to 2806 kg/ha. Two entries, SDB-169 and SDB-150, had higher yields than the check (2132 kg/ha).

SDB-169, the highest yielder, exhibited 32% and 145% increases over the check and the location mean, respectively. However, the second highest yielder (SDB-150) had only a 2% increase over the check and a large increase of 89% over the location mean. Six entries had higher yields than the location mean (1146 kg/ha). The lowest yield (367 kg/ha) was recorded for entry SDGI-2 from Spain.

2-3-4. Highmore

CISN-85

Table 8 presents the result of the chickpea international screening nursery at Highmore. The nursery included 36 test entries and three checks, ILC 482 (resistant to Ascochyta blight disease), SDGI-101 (susceptible), and SDGI-6 (local check). The checks were planted at random within a block of every 12 test entries.

The results showed wide ranges for plant stand, Ascochyta blight resistance, and seed yield. Ranges of 0 to 80% for plant height, ratings of 3 to 9 for disease reaction, and 0 to 1767 kg/ha for yield were recorded.

The susceptible check, SDGI-101, and entry SDB-233 were killed by Ascochyta blight disease, hence there was no seed yield recorded for these two entries. Among the 36 test entries, 12 showed a rating of 3 for Ascochyta blight reaction, indicating resistance to the disease. Four of the 12 resistant lines, SDB-285, SDB-284, SDB-231, and SDB-239, had higher yields than the best check entry (SDGI-6).

Top yielding SDB-285 showed an increase of 17% over the yield of the best check and 69% over the location mean. Percentage increases over the best check (SDGI-6) and the location mean for the best five high yielding entries are given in Table 9.

Data for the chickpea international Ascochyta blight screening nursery at Highmore are given in Table 8. The susceptible check, SDGI-101, showed a rating of 9, indicating very high disease infection.

Nine entries, SDGI-50, SDGI-60, SDGI-62, SDGI-140, SDB-108, SDB-129, SDB-132, SDB-136, and SDB-276, with ratings of 3 for Ascochyta blight reaction, were found resistant to the disease. Another eight entries, SDGI-56, SDGI-131, SDGI-138, SDGI-139, SDB-280, SDB-189, SDB-277, and SDB-279, showing ratings of 4, were considered highly promising.

All the entries showing ratings of 5 were disease tolerant and capable of producing very good yields, especially in situations where the disease incidence is mild. Entries with ratings of 6 and above were considered susceptible.

2-4. Conclusions

There was no Ascochyta blight disease at Sidney; therefore, yields of entries in the SDCSN nursery at Sidney were very high, with a location mean of 1841 kg/ha compared to 575 kg/ha and 1146 kg/ha at Watertown and Bristol, respectively.

Most entries at Bristol were destroyed by the disease; only 15 entries were able to grow and produce seed. Although many of the entries survived at Watertown, yields were very low due to damage caused by Ascochyta blight. In addition, heavy rain affected seed yield and quality in the SDCSN nurseries at Watertown and Bristol.

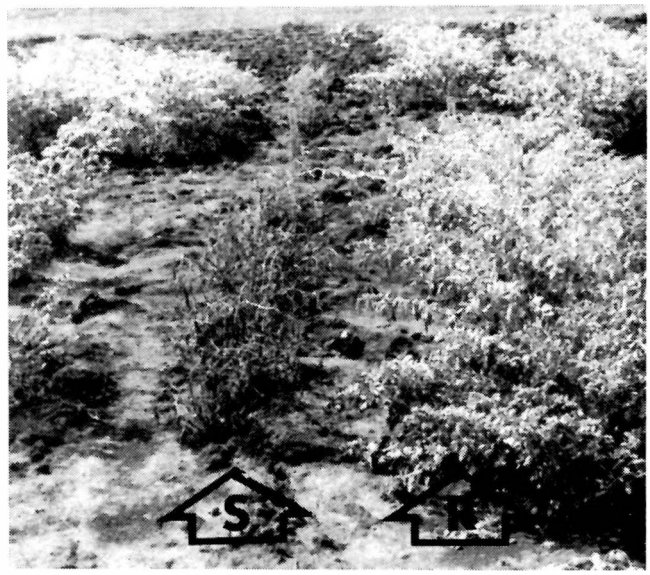
On the basis of overall performance across locations, SDB-169 had the highest yield of 1984 kg/ha. This breeding material was among the best five entries at Bristol and Watertown. Germplasm SDGI-12 originating from Turkey, SDGI-83 and SDGI-84 from Tunisia, and SDGI-13 from Turkey with mean seed yields of 1795, 1672, 1600, and 1536 kg/ha, respectively were the second, third, fourth and fifth highest yielding entries.

The lowest varietal mean of 428 kg/ha was recorded for SDB-159 (breeding material). The check entry SDGI-6 exhibited an overall mean of 1940 kg/ha across locations. SDB-169, with an overall mean of 1984 kg/ha across locations, was the only entry that outyielded the check(1940 kg/ha).

The check (SDGI-6) has also demonstrated superior performance across locations, showing a wide adaptability and reasonably high yield. Yields of 2430, 1237, and 2132 kg/ha at Sidney, Watertown, and Bristol, respectively, were recorded for the check (SDGI-6).

The CISN-84 nursery was very effective for screening entries in both diseases and yield performance. The entries in this nursery were screened for diseases at Watertown and for yield

Ascochyta blight disease screening nursery at Highmore: S=susceptible, R=resistant.



at Sidney. On the basis of yield performances across locations, SDB-201, SDB-220, SDB-225, SDB-200, and SDB-216 showed high yields of 2119, 2066, 2061, 2045, and 2028 kg/ha, respectively.

Table 11 presents yields of 16 entries tested in the Ascochyta blight screening nurseries at Highmore and Sidney.

Nine entries exhibited mean yields above 1500 kg/ha across locations. Among these entries, SDGI-140 and SDB-108 were classified as resistant and high yielding with ratings of 3 for Ascochyta blight reaction at Highmore. Entries SDGI-56 and SDGI-139, each with a 4 rating, and SDGI-137 with a 5 rating were relatively high yielding and moderately resistant.

As a whole, the screening of a large number of chickpea entries at the different locations was very advantageous in examining a wide spectrum of genetic variability for disease resistance and yield.

The relatively high yields at Sidney as compared to those at Watertown, Bristol, and Highmore suggest that chickpeas are a potentially useful pulse crop for the Midwest. However, since this is the first testing of chickpeas in the Nebraska region, caution should be used in giving recommendations.

In addition, the identification of resistant lines to Ascochyta blight disease at Highmore was very beneficial for direct exploitation and/or for a gene source in the hybridization program.

Table 4. Screening Nursery Distribution, 1985.

Nursery	# of Entries/ Nursery	Experimental Sites							
		Bristol	Brookings	Highmore	Redfield	Wall	Watertown	Sidney	Total
SDCSN	83(82+1)	*	*	*	*	*	*	*	7
CISN-84	63(60+3)	-	-	-	-	-	*	*	2
CISN-85	39(36+3)	-	*	*	-	-	-	-	2
CISN-84	71(70+1)	-	-	-	*	-	-	*	2
CIABN-85	41(40+1)	-	*	*	-	-	-	-	2
# Nurseries/ Location		1	3	3	2	1	2	3	15

83(82+1) = 82 test entries plus 1 check
SDCSN = South Dakota Chickpea Screening Nursery
CIABN = Chickpea International Ascochyta Blight Nursery
* = Type of nursery conducted at a site
Total = Total number of nurseries

Table 5. Seed yield (kg/ha) and rank (R) of entries in SDCSN at different locations, 1985.

Entry	Origin/ Source	Sidney kg/ha	R.	Watertown kg/ha	R.	Bristol kg/ha	R.	Mean
SDB -169	ICARDA	1967	27	1178	1	2806	1	1984
SDGI -12	Turkey	2811	4	778	12	--	--	1795
" -83	Tunisia	2694	5	650	20	--	--	1672
" -84	"	2683	6	517	41	--	--	1600
" -13	Turkey	2828	3	244	64	--	--	1536
SDB -167	ICARDA	2022	21	861	9	1600	3	1494
" -150	"	--	--	811	11	2167	2	1489
SDGI -71	Turkey	2344	11	622	23	--	--	1483
" -55	Tunisia	2378	10	583	26	--	--	1481
SDB -163	ICARDA	1817	43	1128	2	--	--	1473
" -162	"	1856	40	972	4	1589	4	1472
" -144	"	1967	28	944	6	--	--	1456
" -93	"	2000	23	833	10	--	--	1417
SDGI -54	Tunisia	2478	8	556	34	1150	6	1395
" -98	India	2167	16	756	13	1256	5	1393
SDB -59	ICARDA	2050	20	722	16	--	--	1386
" -57	"	2128	19	639	21	--	--	1384
SDGI -15	Tunisia	2450	9	267	63	--	--	1359
" -51	Spain	2289	12	--	--	406	13	1348
SDB -145	ICARDA	2011	22	661	19	--	--	1336
" -142	"	1872	39	728	15	--	--	1300
" -87	"	1961	31	617	29	--	--	1289
" -81	"	1972	26	572	27	--	--	1272
SDGI -53	Spain	1900	36	--	--	639	12	1270
SDB -158	"	1994	24	544	38	--	--	1269
" -99	"	1967	29	561	32	--	--	1264
SDGI -65	Turkey	2233	13	289	59	--	--	1261
" -2	Spain	2861	2	550	36	367	14	1259
SDB -157	ICARDA	1833	41	678	18	--	--	1256
SDGI -85	Morocco	2139	18	344	57	--	--	1242
SDB -149	ICARDA	1489	59	972	5	--	--	1231
" 146	"	1883	37	572	28	--	--	1228
SDGI -7	ICRISAT	1922	33	522	40	--	--	1222
" 100	Morocco	1833	42	878	8	906	8	1202
" 142	Turkey	1967	30	411	53	--	--	1189
SDB -75	ICARDA	1972	25	400	55	--	--	1186
SDGI-104	Iran	1917	35	444	47	--	--	1181
SDB -147	ICARDA	1817	44	533	39	--	--	1175
" -170	"	2183	15	272	61	994	7	1150
SDGI -1	Spain	1922	34	711	17	789	9	1141
" -103	Jordan	1961	32	444	68	--	--	1126
" -74	Turkey	1672	53	556	35	--	--	1114
SDB -164	ICARDA	1639	55	550	37	--	--	1095
" -151	"	1717	48	467	44	--	--	1092
SDGI -10	India	1750	47	428	49	--	--	1089
" -8	ICRISAT	1700	50	428	50	--	--	1064
" -141	"	1644	54	450	46	--	--	1047
SDB -95	ICARDA	1556	57	506	42	--	--	1031
" -148	"	1489	60	572	29	--	--	1031
SDGI -3	Spain	1817	45	567	31	667	11	1017
" -165	ICARDA	1411	63	606	25	--	--	1009
SDGI-149	India	1700	51	228	36	--	--	964
" -143	Egypt	1356	66	561	33	--	--	959
SDB -86	ICARDA	1428	62	483	43	--	--	956
" -152	"	1372	64	467	45	--	--	920
" -141	"	1472	61	272	62	--	--	872
SDGI-129	Cyprus	1361	65	217	66	--	--	789
SDB -104	ICARDA	1101	68	406	54	--	--	756
" -154	"	894	70	572	30	--	--	733
" -166	"	--	--	750	14	705	10	728
" -155	"	739	73	633	22	--	--	685
" -153	"	889	71	417	52	--	--	653
" -156	"	983	69	289	60	--	--	636
" -283	"	750	72	389	56	--	--	570
" -159	"	433	75	422	51	--	--	428
SDGI -16	Jordan	2222	14	--	--	--	--	--
" -17	Syria	1756	46	--	--	--	--	--
" -18	Iraq	1689	52	--	--	--	--	--
" -67	Iran	2144	--	--	--	--	--	--
" -14	Turkey	1717	49	--	--	--	--	--
" -101	Syria	1506	58	--	--	--	--	--
" -102	Turkey	1883	[illegible]	--	--	--	--	--
SDB -160	ICARDA	2661	7	--	--	--	--	--
" -161	"	2994	1	--	--	--	--	--
SDGI -11	ICRISAT	1583	[illegible]	--	--	--	--	--
SDB -96	ICARDA	1278	67	--	--	--	--	--
" -106	"	739	74	--	--	--	--	--
SDGI-123	Turkey	--	--	211	67	--	--	--
SDB -158	ICARDA	--	--	917	7	--	--	--
" -168	"	--	--	311	58	--	--	--
" -77	"	--	--	1072	3	--	--	--
SDGI-6 Check		2430		1237			1940	1940
Location Mean		1841		574				

R = Rank

Table 6. Best five high yielding entries in SDCSN at Bristol, Watertown, and Sidney, 1985.

Entry	Bristol (%) Increase Over Check	Bristol (%) Increase Over L. Mean	Entry	Watertown (%) Increase Over Check	Watertown (%) Increase Over L.Mean	Entry	Sidney (%) Increase Over Check	Sidney (%) Increase Over L.Mean
SDB-169	32	145	SDB-169	- 5	105	SDB-161	23	63
" 150	2	89	" -163	- 9	97	SDGI- 2	18	55
" 167	-25	40	" 77	-13	87	" 13	16	54
" 162	-25	39	" 162	-21	69	" 12	16	53
" 98	-41	10	" 149	-21	69	" 83	11	46
SDGI-6 (check)	2132 kg/ha			1237 kg/ha			2430 kg/ha	
L. Mean (Location mean)	1146 kg/ha			574 kg/ha			1841 kg/ha	

Table 7. Seed yield for 63 entries in CISN grown at Watertown and Sidney, 1985.

Entry Name	Watertown (kg/ha)	R	Sidney (kg/ha)	R	Varietal Mean
SDB-201	1194	15	3044	1	2119
" 220	1493	3	2639	9	2066
" 225	1289	11	2833	5	2061
" 200	1100	19	2989	2	2045
" 216	1439	5	2617	11	2028
" 227	1089	22	2828	6	1959
" 210	967	32	2922	3	1945
" 190	1050	27	2806	7	1928
" 187	1528	2	2244	26	1886
" 212	1122	18	2633	10	1878
" 189	861	40	2844	4	1853
" 193	1272	12	2433	19	1853
" 184	1222	14	2467	16	1845
" 211	1244	13	2389	21	1817
" 194	1083	24	2533	12	1808
" 208	1044	28	2517	13	1781
" 218	1483	4	2022	32	1752
" 226	1144	17	2344	23	1744
" 199	1844	1	1644	49	1744
" 176	788	45	2672	8	1730
" 228	939	33	2506	14	1723
" 183	1022	30	2339	24	1681
" 174	1389	7	1961	35	1675
" 192	839	41	2456	18	1648
" 222	1089	23	2206	28	1648
" 214	1156	16	2122	29	1639
" 217	1422	6	1828	43	1625
" 181	1289	10	1922	38	1606
" 134	694	51	2428	20	1561
" 203	833	42	2283	25	1558
" 186	733	46	2367	22	1550
" 198	561	55	2489	15	1525
" 205	928	34	2083	30	1506
" 173	528	57	2461	17	1473
" 188	1306	8	1639	50	1473
SDB-191	906	36	1989	33	1448
" 202	1061	25	1828	43	1445
" 187	639	53	2228	27	1442
" 136	906	37	1944	37	1425
" 213	1056	26	1783	45	1420
" 177	733	47	2061	31	1397
" 209	1089	24	1694	46	1392
" 215	861	38	1883	41	1372
" 178	694	50	1911	39	1303
" 175	628	54	1972	34	1300
" 206	683	52	1906	40	1295
" 182	706	49	1883	42	1295
" 209	917	35	1661	46	1289
" 171	539	56	1956	36	1248
" 221	1294	9	1194	57	1244
" 219	978	31	1494	52	1236
" 196	789	44	1622	51	1206
" 224	861	39	1444	53	1153
" 179	1028	29	1106	58	1067
" 185	1089	23	1039	60	1064
" 197	428	59	1683	45	1056
" 223	800	43	1256	55	1028
" 195	717	48	1061	59	889
" 204	406	60	1344	54	875
" 180	478	58	1250	56	864
SDGI131	932		1625		1279
ILC-482	1050		1794		1422
SDGI-6	970		2207		1589
Location mean	988		2085		

Table 8. Stand (%), Ascochyta blight ratings, and seed yield (kg/ha) of entries in CISN at Highmore, 1985.

Entry	Stand(%)	AB	Yield(kg/ha)
SDB-285	70	3	1767
" 284	70	3	1644
" 239	75	7	1583
" 231	80	3	1550
" 250	70	3	1483
" 249	70	3	1456
" 229	70	3	1383
" 255	60	5	1356
" 235	60	5	1289
" 261	65	3	1278
" 240	60	5	1256
" 237	70	5	1228
" 252	60	3	1183
" 246	75	5	1128
" 259	50	5	1100
" 236	60	3	1067
" 243	60	7	1050
" 256	50	7	961
" 234	30	3	872
" 247	60	5	872
" 260	60	5	794
" 258	60	7	778
" 242	50	3	739
" 257	30	5	706
" 230	70	5	644
" 251	70	5	572
" 248	50	5	533
" 244	60	5	533
" 262	60	5	527
" 238	40	3	472
" 232	40	7	433
" 253	50	5	422
SDGI101	0	9	0
ILC 482	75	4.5	1479
SDGI-6	80	5.0	1510
Location mean	61		1048

AB = Ascochyta blight ratings

Table 9. The five high yielding entries in CISN at various locations, 1985.

Rank	Watertown			Sidney			Highmore		
	Entry	Increase Over		Entry	Increase Over		Entry	Increase Over	
		Check (%)	L.Meqn (%)		Check (%)	L. Mean (%)		Check (%)	L. Mean (%)
1	SDB-199	90	87	SDB-201	38	46	SDB-285	17	69
2	" 187	58	55	SDB-200	35	43	" 284	9	57
3	" 220	54	51	" 210	32	40	" 239	5	51
4	" 218	53	50	" 189	29	36	" 231	3	48
5	" 216	48	46	" 225	28	35	" 250	-2	42
Location Mean		(988/kg/ha)			(2085 kg/ha)			(1048 kg/ha)	
Check-SDGI-6		(970 kg/ha)			(2207 kg/ha)			(1510 kg/ha)	

L.Mean = Location Mean
CISN = Chickpea International Screening Nursery

Table 10. Plant stand and Ascochyta blight reaction rating (AB) for 40 entries in the Ascochyta blight screening nursery at Highmore, 1985.

Entry Name	Origin/ Source	Stand (%)	AB	Entry Name	Origin/ Source	Stand (%)	AB
SDGI-50	Spain	48	3	SDB-184	ICARDA	40	5
" -60	USSR	43	3	" -185	"	50	5
" -62	"	65	3	" -188	"	85	5
" -140	"	53	3	" -137	"	65	5
SDB-108	ICARDA	45	3	" -225	"	18	5
" -129	"	60	3	" -226	"	70	5
" -132	"	65	3	" -210	"	40	5
" -136	"	65	3	" -271	"	60	5
" -276	"	58	3	" -235	"	70	5
SDGI-56	USSR	63	4	" -273	"	45	5
" -131	"	50	4	" -275	"	55	5
" -138	Bulgaria	68	4	" -278	"	50	5
" -139	"	53	4	" -269	"	40	6
SDB-280	ICARDA	68	4	" -272	"	40	6
" -189	"	50	4	" -274	"	30	6
" -277	"	45	4	SDG -63	USSR	43	7
" -279	"	43	4	" -263	"	33	7
SDGI -6	Turkey	55	5	" -115	"	45	7
" -135	Morocco	65	5	" -124	"	25	7
SDB-183	ICARDA	60	5	" 268	"	80	7

Check and/or disease spreader entry (SDGI-101) AB = 9 (dead)

1. AB = Ascochyta blight
2. 3 = Resistant; 4 = Moderately resistant; 5 = Tolerant; 6 = Moderately susceptible; 7 = Susceptible; 9 = Highly susceptible

Table 11. Seed yield for the common entries in the Ascochyta blight nursery at Highmore and Sidney, 1985.

Entry Name	Origin/ Source	kg/ha		
		Highmore	Sidney	Mean
SDGI-140	USSR	1633	2922	2278
" -56	"	1993	2400	2197
SDB -266	ICARDA	2080	2194	2137
SDGI-139	Bulgaria	1697	2100	1899
SDB -108	ICARDA	1400	2111	1756
" -115	"	1510	1850	1680
SDGI -62	USSR	1513	1733	1623
" -135	Morocco	1670	1567	1619
SDB -129	ICARDA	1497	1556	1527
SDGI -63	USSR	1020	1833	1427
" -6	Turkey	1067	1611	1339
" -138	Bulgaria	1387	1083	1235
" -131	USSR	1480	822	1151
" -50	Spain	1347	722	1060
SDB -263	ICARDA	913	972	943
" -124	"	447	572	510

Table 12. Seed yield for entries in the Ascochyta blight screening nursery at Sidney, 1985 (CABN-84).

Entry Name	Origin/Source	Yield (kg/ha)
SDGI-140	USSR	2922
" -29	"	2689
SDB -264	ICARDA	2656
" -135	"	2456
" -82	"	2439
SDGI -56	USSR	2400
" -30	Iraq	2389
" -126	ICARDA	2344
" -34	Iraq	2267
" -146	Morocco	2206
" -23	India	2206
SDB -137	ICARDA	2194
" -119	"	2172
" -108	"	2111
SDGI-139	Bulgaria	2100
" -100	ICARDA	2078
" -33	Iran	2078
" -147	Morocco	2033
SDB -122	ICARDA	2006
SDGI -26	Mexico	1989
SDB -221	ICARDA	1978
SDGI -31	Iran	1956
" -20	ICRISAT	1950
" -32	Iran	1933
SDB -109	ICARDA	1900
" -115	"	1850
" -218	"	1833
SDGI -63	USSR	1833
" -111	USSR	1811
" -19	India	1789
SDB -133	ICARDA	1761
SDGI -62	USSR	1733
" -21	Iran	1722
" -6	Turkey	1611
" -22	Iran	1572
" -135	Morocco	1567
SDB -129	ICARDA	1556
SDGI-148	Morocco	1494
" -59	USSR	1433
SDB -125	ICARDA	1422
SDGI -28	USSR	1328
" -58	"	1317
" -130	Unknown	1278
" -138	Bulgaria	1083
" -144	USSR	1039
SDB -263	ICARDA	972
SDGI -24	--	916
SDGI-119	USSR	878
SDB -120	ICARDA	850
SDGI -57	USSR	844
SDB -116	ICARDA	844
SDGI-131	USSR	822
SDGI -50	Spain	772
" -137	Bulgaria	756
SDB -124	ICARDA	572
SDGI-136	Bulgaria	522
" -132	USSR	450
Location Mean		1679

Project 3: Evaluation of breeding materials and germplasm lines for yield and stability

3-1. Introduction

Increasing yield is the primary aim of most plant breeding and this is also true with chickpeas.

Yield stability is of equal or even greater importance under many agricultural situations. Characteristics such as drought resistance or early maturity may not affect the maximum yield potential of a genotype under very good environmental conditions. However, they may help provide a measure of stability so that under adverse conditions a profitable yield may be obtained.

To breed for stability, it is necessary to grow the nursery either at a number of locations or for several years, but preferably both. Genotypes with consistent performance over environments are called stable genotypes (cultivars,varieties); whereas those with poor performance in some environments and excellent performance in others are called unstable genotypes.

The best variety is the one with a high mean yield over all environments plus a good measure of stability. However, a variety should not be so stable that it can not respond well to improved agronomic practices.

Once a promising line is identified, it should be tested at a number of locations for several years. First, the entry should be evaluated in a preliminary yield trial with a few replicates and locations. If the entry is among the best performers, it is transferred into the advanced yield trial to be evaluated with increased replicates and environments.

Several chickpea breeding materials and germplasm lines were tested for yield and stability performances at one or more locations.

The major objective of these studies was to identify high yielding, disease resistant, and widely adaptable genotypes. Secondary objectives included (a) identification of superior genotypes to specific environments; (b) identification of regions with high productivity; and (c) possible reduction of seasons required for evaluation prior to cultivar release.

3-2. Materials and methods

During the 1985 growing season, six experiments (Appendix VI-XI) were evaluated for adaptability and seed yield at various locations in South Dakota and at Sidney, NE. All the experiments were planted in a randomized complete block design with four-row plots 3 m long with spacings of 30 cm between rows and 10 cm between plants within rows.

SDCYT. This nursery consisted of 17 entries, 9 germplasm collections originating from four countries and seven breeding populations from ICRISAT (International Crops Research Institute for Semi-Arid Tropics) and ICARDA (International Center for Agricultural Research in the Dry Areas). Included in the entries were desi (small-seeded), Kabuli (large-seeded), and intermediate-seeded chickpeas with a wide genetic base.

Half of the entries were selected on the basis of 3 years of yield trials at Highmore, Wall, and Brookings. The trial was designed to study adaptability and stability of entries across locations. The nursery was tested at Brookings, Highmore, Redfield, and Wall.

CIYT-L. A total of 23 test entries and one check (SDGI-6) were tested for yield at Highmore and Wall. All entries in this nursery were derived from germplasm collections which have reasonably large seed sizes but are not large enough to compete with the existing large-seeded commercial varieties. The entries in this trial were susceptible to Ascochyta blight disease at Highmore, so no yield data were recorded for this trial.

CIYT-W. The material for this nursery was composed of 21 test entries and 3 checks. The test entries were identified as resistant to Ascochyta blight disease in Syria. This nursery was planted at Highmore and Brookings for yield and disease evaluations. Due to heavy rain, the trial at Brookings was not harvested; however, several individual plants were selected.

CIF4T. A total of 24 entries - 20 breeding populations (F4) and 4 checks, SDGI-101 (susceptible), SDGI-85 (moderately resistant), ILC 482 (resistant), and SDGI-6 (local check selection) -were evaluated for adaptability and yield at Highmore and Wall. Besides yield, many individual selections were made.

CIF3T. The material for CIF3T was comprised of 21 F3 populations derived from 16 single and 5 three-way crosses. This nursery was planted at Redfield. Individual plant selections were made on the basis of high yield at this location.

CIF3T-STR. Twenty-one test entries and three checks were included in this trial at Sidney, NE. Plants were selected for desirable traits including yield, large seed size, and disease resistance.

3-3. Results and discussion

Evaluation trials for adaptability, yield, and reaction to diseases at several locations in South Dakota and Nebraska were as follows:

3-3-1. Highmore

SDCYT

Four replicated trials (SDCYT, FIF3T, CIYT-W, and CIYT-L) were planted at Highmore. However, data were collected from three trials. No data

were recorded for CIYT-L trial due to poor plant stand caused by Ascochyta blight disease. Data for the remaining three trials are given in Tables 14-16.

In 1985, Ascochyta blight was severe at Highmore, and all susceptible and tolerant entries were attacked and killed by the disease. Only resistant lines to Ascochyta blight were able to grow and produce seed.

Of the 17 entries included in the SDCYT trial, seven were resistant (Table 14). Mean yields were relatively high, ranging from 1075 to 2866 kg/ha. The location mean was 1946 kg/ha.

SDGI-6 produced an average of 2866 kg/ha; this was the highest yield among all entries. Entries SDB-3 and SDB-4, with mean yields of 2364 and 2045 kg/ha, had higher yields than the location mean.

CIF4T

A total of 24 entries - 20 breeding populations (F4 lines) and 4 checks, SDGI-101 (susceptible), SDGI-85 (moderately resistant), ILC 482 (resistant), and SDGI-6 (local check) - were evaluated for adaptability and seed yield. Yield ranged from 0 to 1963 kg/ha (Table 15). SDGI-101, a susceptible check, produced no seeds because it was killed by Ascochyta blight diseases.

Two entries, SDB-49 and SDB-16, gave higher yields than the best check (SDGI-6). Two high yielding entries had yields of 1963 and 1904 kg/ha. The best check had a mean yield of 1730 kg/ha. Eight entries had higher yields than the overall mean yield of 1440 kg/ha.

CIYT-L

Entries in this nursery were very susceptible to Ascochyta blight. All except the local check, SDGI-6, were severely damaged by the disease; no data were recorded at the Highmore nursery.

CIYT-W

This trial had 24 entries (21 test lines and 3 checks) evaluated for seed yield and resistance to Ascochyta blight disease. The check entries included a susceptible, a resistant, and a local South Dakota selection. Yields ranged from 0 to 1862 kg/ha. The susceptible check, SDGI-101, was killed by Ascochyta blight.

Although the local check had the highest yield of 1862 kg/ha, the other four entries (SDB-97, SDB-130, SDB-98, and SDB-118) were classified as promising lines with relatively high yields ranging from 1628 to 1749 kg/ha (Table 16). Eleven entries had higher yields than the overall mean yield of 1334 kg/ha.

3-3-2. Wall

In 1985 three replicated experiments, SDCYT (South Dakota Chickpea Trial), CIYT-L (Chickpea Internationa Large-Seeded Trial), and CIF4T (Chickpea International F4 Yield Trial), were evaluated for adaptability, seed yield, and reaction to diseases at Wall. Results of these nurseries are presented in Tables 17-19.

SDCYT

Table 17 presents results of the South Dakota Yield Trial (SDCYT). A large range of 284 to 2540 kg/ha was obtained for seed yield. Yields of 1459 and 2023 kg/ha were recorded for the location mean and the check (SDCI-6).

Among the 17 entries, UC-5 (a commercial variety grown in California, Washington, Montana, and Saskatchewan, Canada) was most heavily damaged by Ascochyta blight disease.

Eight entries had higher yields than the location mean (1458 kg/ha). Entry SDGI-2 exhibited the highest yield of 2158 kg/ha. The second highest yield was from the check, SDGI-6. Entries SDGI-5, SDB-1, and SDB-4 with mean yields of 1877, 1728, and 1800 kg/ha were among the five high yielding entries.

CIYT-L

The results of the large-seeded yield trial are presented in Table 18. Ranges of 20 to 35 cm, 30 to 90% and 433 to 2237 kg/ha were recorded for plant height, plant stand, and seed yield, respectively.

The location (1303 kg/ha) and check (1276 kg/ha) means were similar. Eleven entries had higher yields than the location mean, and yields of 12 entries exceeded the yield of the check (SDGI-6). The highest yield (1897 kg/ha) was recorded for entry SDGI-14; entries SDGI-85, SDGI-13, SDGI-6, and SDGI-1 had yields of 1661, 1559, 1505, and 1473 kg/ha, respectively.

CIF4T

Twenty entries including breeding populations and four germplasm lines were included in the F4 yield trial at Wall. Data on plant height, plant stand, and seed yield are presented in Table 19.

The range of variation was 20 to 40 cm for plant height, 20 to 80% for plant stand, and 373 to 2003 for seed yield. The highest yield (1711 kg/ha) was recorded for the local check (SDGI-6).

Entries SDB-135, SDGI-85, SDB-50, and SDB-49 had mean yields of 1688, 1402, 1389, and 1319 kg/ha, respectively. Thirteen entries had higher yields than the location mean (1162 kg/ha), but no entry exceeded the yield of the best check (SDGI-6). However, because this trial included

General view of 1985 chickpea nurseries at Brookings.

Close view of a high yielding plot showing high pod setting at Redfield.

breeding populations, there is great potential for selecting well-adapted, high yielding lines.

3-3-3. Redfield

SDCYT and CIF3T nurseries were planted at Redfield. Results of these trials are given in Tables 20 and 21.

SDCYT

Relatively high yields were recorded at this location. The range in yield from 1069 to 4367 kg/ha indicated extensive genetic variability among entries.

Nine entries had larger mean yields than the location mean (2336 kg/ha), indicating superior performance by all. Entries SDGI-6, SDGI-7, SDB-1, SDB-4 and SDB-2 with average yields of 3116, 2957, 2921, 2895, and 2558 kg/ha were the top five high yielding entries in this nursery.

CIF3T

The data on seed yield for 21 test entries and 3 checks are given in Table 21. The location mean was 2494 kg/ha.

Significant differences for yield were observed between populations, with a wide range of 958 to 3733 kg/ha. Three populations, SDB-28, SDB-38 and SDB-54, exceeded the yield (2973 kg/ha) of the best check, SDGI-6. Twelve entries had higher yields than the location mean.

SDB-28 had the highest mean yield of 3478 kg/ha. Entries SDB-38 and SDB-54 were second and third best yielders with 3456 and 3380 kg/ha, respectively.

3-3-4. Sidney

CIF3T-STR

CIF3T-STR consisted of 24 entries and was evaluated at Sidney, NE. Yield data is presented in Table 22.

Relatively high yields were recorded for all entries; the lowest yield of 1394 kg/ha was exhibited by check entry SDGI-131.

Among the 3 checks, the highest yield of 2324 kg/ha was shown by entry ILC 482. The highest mean yield (2737 kg/ha) was recorded for entry SDB-48. Thirteen entries had higher yields than the location mean (2161 kg/ha). Entries SDB-17, SDB-23, SDB-53, and SDB-16 had yields of 2638, 2572, 2504, and 2487 kg/ha, respectively.

3-3-5. Brookings

SDCYT

Table 23 presents yield data for the entries in the SDCYT trial. Data was not recorded for seven entries due to late maturity. Continuous rain in the latter part of the growing season kept the crop vegetative.

The location mean for Brookings was 2367 kg/ha. Early maturing genotypes had the highest yields. The highest yield of 3625 kg/ha was exhibited by SDGI-6.

Small-seeded early maturing entries, SDGI-8 and SDGI-9, had the second and third highest yields of 3442 and 3375 kg/ha. Two other small seeded entries, SDGI-7 and SDGI-10, exhibited very high yields of 3019 and 3033 kg/ha, respectively. Breeding populations of SDB-4 also had a relatively high yield of 3278 kg/ha.

3-4. Conclusions

Summary data for the F4/F3 population trial over three environments and SDCYT over four environments are given in Tables 24 and 25.

In the F4/F5 population trial, only a few genotypes exceeded the yield of the local check; but a large proportion of the entries showed higher yields than the location mean at each site.

There were significant differences among entries within and between locations. The highest population mean yield (2191 kg/ha) was recorded at Sidney. Entry SDB-16 showed the best overall mean of 2027 kg/ha. It also maintained a superior performance by holding highest yielding position among the first five entries at all three locations.

SDGI-6 exhibited an outstanding performance over all locations (Table 25). ANOVA revealed significant differences between entries at Wall and Redfield.

Since many entries were missing in the trials conducted at Highmore and Brookings, analysis of variance was not calculated for entries tested at these two sites.

On the basis of overall performance across locations, SDGI-6 was the highest yielder (2915 kg/ha); entry SDB-4 was the second best with an overall mean yield of 2505 kg/ha.

Entry UC-5 was killed by Ascochyta blight at three out of four locations. This entry (UC-5) had one of the lowest yields (1777 kg/ha) at Redfield.

In general, there was no complete coherence in yield performance of genotypes across locations; however, SDGI-6 and SDB-4 have maintained their superiority by consistently exhibiting high yields, ranking among the best five high yielding entries at all locations.

Relatively high location means of 2351 and 2367 kg/ha were recorded at Redfield and Brookings, respectively. However, seed quality of all the entries at these locations was inferior because of damage caused by continuous rainfall in the latter part of the growing season.

As a whole, yields at all locations were reasonable, considering the time of planting and growing conditions in 1985. Severe drought in central and western South Dakota during the early part of the growing season resulted in reduction of plant stands in most plots. The low overall means for plant stand in the different trials probably was caused by early drought stress.

Table 26 presents location mean yields for different trials at five locations. Relatively high yields were recorded at Brookings and Redfield. The highest location mean (2494 kg/ha) was recorded for populations in CIF3T at Redfield. Trial SDCYT at Brookings and Redfield had the second and third top yields of 2367 and 2351 kg/ha, respectively.

The high yields in eastern South Dakota are associated with availability of abundant moisture. In the west (Wall), the reduction of yield was related to shortage of moisture. In fact, during the 1985 crop season many fields of sorghum and corn were completely abandoned due to shortage of moisture in western South Dakota.

At Highmore, moisture was not as limiting, but diseases and heavy rain at maturity (July) caused heavy pod losses that reduced yields. A high location mean was recorded for Sidney. More research is needed to determine proper cultural practices for growing chickpeas in this region.

Table 13. Chickpea yield trial distribution, 1985.

Trial[1]	# of Entries/ Trial	Experimental Sites					Total[3]
		Brookings	Highmore	Redfield	Wall	Sidney	
SDCYT	17 (16+1)[2]	*	*	*	*	*	4
CIYT-L	24 (23+1)	-	*	-	*	-	2
CIYT-W	24 (23+1)	*	*	-	-	-	2
CIF4T	24 (23+1)		*	-	*	-	2
CIF3T	24 (21+3)	-	-	*	-	-	1
CIF3T-STR	24 (23+1)	-	-	-	-	*	1
# of Trials/ Location		2	4	2	3	1	12

[2] 17 (16+1) = 16 test entries add 1 check

[1] SDCYT = South Dakota Chickpea Yield Trial
CIYT-L = Chickpea International Large-Seeded Yield Trial
CIYT-W = Winter Chickpea International Yield Trial
CIF_4T = Chickpea International F_4 Yield Trial
CIF_3T = Chickpea International F_3 Yield Trial
CIF_3T-STR = Chickpea International F_3 Yield Trial for Semi-Tropical Regions

[3] Total = Total number of trials conducted at a site
* = Type of trial conducted at a site

Table 14. Seed yield for seven entries in SDCYT at Highmore, 1985.

Entry	origin/source	Yield (kg/ha)*
SD BI-3	ICARDA	2364
SD BI-4	"	2045
SD BI-2	"	1851
SD BI-6	"	1222
SD BI-5	"	1699
SD BI-1	"	1075
SD GI-6 (Check)	Turkey	2866
Location mean		1946

No. of entries = 17
Range (kg/ha) = 300-2866

Table 15. Plant stand, plant height, and seed yield for 24 entries in CIF4T at Highmore, 1985.

Name	Stand %	Plant Hgt. cm.	Seed Yield kg/ha
SDB-49	67	29	1963
SDB-16	57	34	1904
SDB-45	65	37	1681
" 23	63	38	1666
" 53	55	33	1582
" 50	48	34	1574
" 31	58	35	1534
" 25	47	34	1520
" 48	57	34	1473
" 47	33	34	1450
" 15	53	35	1429
" 32	40	33	1404
" 27	53	35	1352
" 17	58	38	1319
" 30	35	35	1194
" 46	38	33	1169
" 51	40	36	1054
" 22	50	39	1039
" 135	33	37	979
" 33	40	36	894
SDGI-101	0	0	0
" - 85	65	40	1677
ILC 482	45	31	1525
SDGI-6	50	31	1730
Overall means	50	35	1440
CV	19	7	17
Range	15-75	25-40	783-2200

Table 16. Plant stand, plant height, and seed yield for 24 entries in CIYT-W at Highmore, 1985.

Entry Name	Stand %	Plant Hgt. cm.	Seed Yield kg/ha
SDB- 97	54	31	1749
" 130	70	36	1720
" 98	63	32	1661
" 118	73	31	1628
" 82	54	35	1527
" 120	58	38	1493
" 77	50	35	1481
" 131	64	35	1478
" 100	53	31	1456
" 72	53	34	1353
" 71	53	36	1349
" 132	49	36	1319
" 263	46	35	1287
" 281	61	36	1279
" 73	41	33	1080
" 121	43	35	967
" 81	39	35	953
" 125	58	37	928
" 128	30	36	873
" 124	49	38	866
" 127	44	34	773
SDGI-101	0	0	0
ILC-482	46	30	1596
SDGI-6	63	32	1862
Overall mean	52	34	1334
CV	23	7	19
Range	20-85	25-42	333-2207

Table 17. Seed yield for 17 entries in SDCYT at Wall, 1985.

Entry Name	Origin/Source	Seed Yield (kg/ha)
SDGI-51	Spain	1680
" 2	"	2158
" 3	"	1591
" 1	"	1431
" 5	"	1877
" 9	India	299
" 10	"	1393
" 7	ICRISAT	1393
" 8	"	819
SDB- 1	ICARDA	1728
" 2	"	1033
" 6	"	1285
" 3	"	1348
" 4	"	1800
" 5	"	1481
UC-5	USA	--
SDGI 6	Turkey	2023
Location Mean		1459
CV		19.6
Range		284-2540

Table 18. Plant height, plant stand, and seed yield for 24 large-seeded entries in CIYT-L at Wall, 1985.

Name	Origin	Plant Height(cm)	Plant Stand(%)	Seed Yield (kg/ha)
SDGI-17	Syria	25	53	1264
" 51	Spain	31	68	1325
" 2	"	31	66	1440
" 53	"	29	66	1299
" 3	"	31	68	1374
" 1	"	31	75	1473
" 5	"	32	71	1444
" 54	Tunisia	30	58	1237
" 55	"	28	65	1228
" 13	Turkey	30	69	1559
" 65	"	31	70	1346
" 142	"	29	60	1209
" 14	"	27	83	1897
" 6	"	25	66	1505
" 73	"	30	69	1348
" 84	"	31	56	1077
" 85	"	28	48	1072
" 150	"	32	70	1661
" 101	"	23	48	1127
" 123	"	29	50	887
" 133	"	24	44	908
" 151	"	28	68	1088
" 134	"	31	71	1231
" 6	"	27	55	1276
Location Mean		29	63	1303
CV		7	16	21
Range		20-35	30-90	433-2237

Table 19. Plant height, plant stand, and seed yield for 24 entries in FIF4T at Wall, 1985.

Name	Origin	Plant Height(cm)	Plant Stand (%)	Seed Yield (kg/ha)
SDB-15	ICARDA	30	60	1140
" 16	"	32	70	1688
" 135	"	36	53	1166
" 17	"	32	40	823
" 22	"	37	57	682
" 23	"	37	55	1274
" 25	"	32	55	1273
" 27	"	30	48	872
" 30	"	35	60	906
" 31	"	32	58	1210
" 32	"	26	43	989
" 33	"	33	32	928
" 45	"	34	63	1289
" 46	"	33	53	966
" 47	"	32	58	1072
" 48	"	30	55	1298
" 49	"	28	58	1319
" 50	"	29	57	1389
" 51	"	31	53	1311
ILC-482	Turkey	23	50	1310
SDGI-85	Tunisia	33	60	1402
SDGI-101	Syria	39	65	893
SDGI-6	South Dakota	26	65	1711
Location Mean		31	55	1165
CV		7	20	23
Range		20-40	20-80	373-2003

Table 20. Seed yield for 17 entries in SDCYT at Redfield, 1985.

SN	Entry	Origin/Source	Seed Yield(kg/ha)
1	SDGI-51	Spain	1720
2	" 2	"	2345
3	" 3	"	2188
4	" 1	"	2300
5	" 5	"	1864
6	" 9	India	1573
7	" 10	"	2402
8	" 7	ICRISAT	2957
9	" 8	"	2336
10	SDB - 1	ICARDA	2921
11	" 2	"	2558
12	" 6	"	1954
13	" 3	"	2418
14	" 4	"	2895
15	" 5	"	2390
16	SDGI- 6	SD Selection	3116
17	UC 5	USA	1777
Location mean			2336
CV			17
Range			1069-4367

Table 21. Seed yield for 24 entries in CIF3T at Redfield, 1985.

Entry Name	Origin/Source	Seed Yield(Kg/ha)
SDB- 18	ICARDA	2506
" 19	"	1800
" 20	"	2199
" 21	"	2684
" 24	"	2243
" 26	"	2335
" 28	"	3478
" 29	"	1796
" 35	"	1909
" 36	"	2457
" 37	"	2407
" 38	"	3456
" 39	"	2814
" 40	"	2682
" 41	"	2732
" 42	"	2702
" 43	"	2280
" 44	"	2246
" 52	"	2353
" 54	"	3380
" 55	"	1556
ILC-482	Turkey	2779
SDGI-31	USSR	2075
SDGI-6	South Dakota	2973
Location Mean		2494
CV		29
Range		958-3733

Table 22. Seed yield for 24 entries in FIF3T-STR at Sidney, 1985.

Entry Name	Origin/Source	Seed Yield(kg/ha)
SDB-15	ICARDA	1928
" 16	"	2487
" 135	"	2042
" 17	"	2638
" 282	"	2180
" 23	"	2572
" 25	"	2122
" 27	"	1871
" 30	"	2311
" 31	"	2006
" 32	"	1617
" 33	"	2021
" 34	"	2272
" 45	"	1848
" 46	"	2274
" 47	"	2372
" 48	"	2737
" 49	"	2291
" 50	"	2185
" 51	"	2035
" 53	"	2504
ILC-482	Turkey	2324
SDGI-131	USSR	1394
SDGI-6	South Dakota	1837
Location Mean		2161
CV		26
Range		1044-3305

Table 23. Seed yield for 10 entries in SDCYT at Brookings, 1985.

Name	Origin	Yield(kg/ha)
SDGI-2	Spain	1083
" 3	"	644
" 1	"	953
" 5	"	1217
" 9	India	3375
" 10	"	3033
" 7	ICRISAT	3019
" 8	"	3442
SDB-4	ICARDA	3278
SDGI-6	Turkey	3625
Location Mean		2367

Table 24. Seed yield for 22 F4/F3 entries at Highmore, Wall, and Sidney, 1985.

	Source	Locations							
Entry Name	ICARDA	Highmore	R[1]	Wall	R	Sidney	R	Overall	R
SDB-15	ICARDA	1429	13	1140	13	1928	18	1499	14
SDB-16	"	1904	1	1688	2	2484	1	2027	1
SDB-135	"	982	21	1166	12	2043	14	1397	17
SDB-17	"	1319	16	823	21	2638	2	1593	12
SDB-22	"	1039	20	682	22	2180	12	1300	21
SDB-23	"	1666	6	1274	9	2572	3	1837	2
SDB-25	"	1520	10	1273	10	2122	13	1638	9
SDB-27	"	1352	15	872	20	1871	19	1365	19
SDB-30	"	1194	17	906	19	2311	8	1470	15
SDB-31	"	1534	9	1210	11	2006	17	1583	13
SDB-32	"	1404	14	989	16	1617	22	1337	20
SDB-33	"	894	22	928	18	2021	16	1281	22
SDB-45	"	1681	4	1289	8	1848	20	1606	11
SDB-46	"	1168	18	966	12	2274	10	1469	16
SDB-47	"	1450	12	1072	14	2372	6	1631	10
SDB-48	"	1473	11	1298	7	2737	1	1836	3
SDB-49	"	1797	2	1319	4	2291	9	1802	4
SDB-50	"	1574	8	1389	3	2185	11	1716	8
SDB-51	"	1054	19	1057	15	2035	15	1382	18
SDB-53	"	1582	7	1311	5	2504	4	1799	5
ILC-482	"	1677	5	1310	6	2324	7	1770	6
SDGI-6	"	1730	3	1711	1	1837	21	1759	7
Location Mean		1428(B)*		1167(C)		2191(A)			

* - Means with the same letter are not significantly different
1. R = Ranks within and over all locations

Table 25. Seed yield for 17 entries (SDCYT) at Wall, Redfield, Brookings, and Highmore, 1985.

Entry	Name	Origin	Locations									
			Wall (kg/ha)	R	Redfield kg/ha	R	Brookings (kg/ha)	R	Highmore (kg/ha)	R	Mean	R
SDGI-51		Spain	1680	6	1720	16	-		-		1700	13
SDGI- 2		"	2159	1	2345	9	1083	8	-		1862	8
SDGI- 3		"	1592	7	2188	12	644	10	-		1475	16
SDGI- 1		"	1434	9	2300	11	953	9	-		1562	15
SDGI- 5		"	1877	3	1865	14	1217	7	-		1653	14
SDGI- 6		Turkey	2027	2	3141	1	3625	1	2866		2915	1
SDGI- 9		India	300	16	1573	17	3375	3	-		1749	11
SDGI-10		India	1393	11	2402	7	3033	5	-		2276	4
SDGI- 7		ICRISAT	1395	10	2957	2	3019	6	-		2457	3
SDGI- 8		ICRISAT	857	15	2336	10	3442	2	-		2212	5
SDB- 1		ICARDA	1728	5	2921	3	-		1075	7	1908	7
SDB- 2		"	1050	14	2558	5	-		1851	4	1820	10
SDB- 6		"	1285	13	2176	13	-		1722	5	1728	12
SDB- 3		"	1348	12	2418	6	-		2364	2	2043	6
SDB- 4		"	1800	4	2895	4	3278	4	2045	3	2505	2
SDB- 5		"	1481	8	2391	8	-		1699	6	1857	9
UC- 5		USA	-	17	1777	15	-		-		-	
Location Mean			1462		2351		2367		1946			

Table 26. Mean yields of different trials at different locations, 1985.

Location	Trial	Location Mean kg/ha	R
Highmore	SDCYT	1946	5
"	CIYT-W	1334	8
"	CIF_4T	1428	7
Wall	CIF_4T	1167	10
"	CIYT-L	1303	9
"	SDCYT	1462	6
Redfield	SDCYT	2351	3
"	CIF_3T	2494	1
Sideny	CIF_3T-STR	2191	4
Brookings	SDCYT	2367	2

R = Rank
kg/ha = kilograms per hectare

Project 4:
Cultural practices

The productivity of any crop depends on its genetic composition, the environment, and genotype-environment interactions. Although the ceiling of productivity of a species is set by its genetic composition, the crop environment can be partly regulated by agronomic manipulations to achieve high yields.

Crop improvement demands that agronomic management is considered along with the genetic alteration of plant structure and function. Agronomic studies clarify genotype x environment interactions. They also identify cultural practices that increase crop productivity by optimizing controllable components of the environment.

Chickpeas are a major crop in Middle Eastern and West Asian agriculture. The average productivity has been reported to be 950 kg/ha in the Near East and even lower in the Far East. However, yields as high as 4400 kg/ha have been reported from field experiments in these areas.

The wide gap between potential and actual yield may be attributed to inadequate agronomic management.

Three experiments were conducted in 1985 at Brookings: 1) effect of planting depth on chickpea emergence, 2) effect of seed treatment fungicides on chickpea emergence, and 3) effect of row spacing on yield.

4-1. Effect of planting depth on chickpea emergence

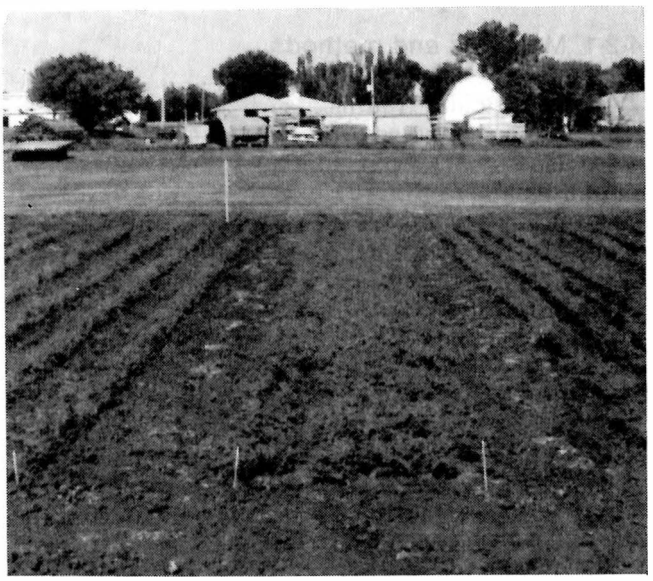
An experiment was planted on June 14, 1985, at the agronomy farm, SDSU, Brookings, to determine the appropriate planting depth for an optimum stand in chickpeas.

4-1-1. Materials and methods

The experiment consisted of three entries: (1) SDGI-6, cream colored, medium seeded, intermediate height, and medium maturing (Kabuli type); (2) SDB-3, cream colored, smooth seeded, tall, and late maturing (Intermediate type); and (3) SDGI-8, brown colored, small seeded, short, and early maturing (Desi type).

The entries were planted in three 15-m-long row plots with spacings of 30 and 10 cm between and within rows, respectively. Four planting depths (10, 15, 20, and 25 cm) were used. Percent emergence was recorded for the middle of each plot on the 8th, 12th, 16th, 20th, and 24th day after planting. Analysis of variance following CATMOD procedure was used to compare and contrast differences between entries and/or treatments. Results of the study are presented in Table 27.

General view of 1985 cultural practices project.



4-1-2. Results and discussion

On the 8th day after planting, SDGI-6, SDGI-8, and SDB-3 exhibited overall plant emergence of 48, 43, and 27%, respectively. Seed had been planted at the 15-cm depth (Table 27).

At the 12th day after planting, overall emergence for SDGI-6, SDB-3, and SDGI-8 increased to 58, 56, and 62%, respectively. This was the only planting date on which entry SDGI-8 exhibited the best emergence.

In the remaining cases, the greatest plant emergence was recorded for entry SDGI-6. No further increase in emergence was observed for the test entries by the 24th day after planting.

Analysis of variance (Table 28) showed significant differences between entries, planting depth, and the variety x days interaction. The chi-square value indicated very high differences between treatments (planting depth).

In general, each entry exhibited the best emergence in plots planted at the 15-cm depth (Figure 2).

Entry SDGI-8, when planted at depths of either 10 or 20 cm, showed comparatively sharp decreases in plant stand. On the other hand, entry SDGI-6 showed relatively little variation between planting depths, indicating this entry has a wider range of adaptability to seed depth.

4-2. Effect of seed treatment fungicides on chickpea emergence

A field investigation was conducted to determine a suitable seed dressing fungicide for establishing good stands of chickpeas.

4-2-1. Materials and methods

Four fungicidal treatments - Benlate, Captan, Apron, and a mixture of Benlate and Captan - were used on SDGI-6 (medium seed, cream colored, Kabuli type) and SDGI-11 (small seeded, brown colored, Desi type) chickpea varieties. Untreated seeds of these two entries also were included as checks. The crop was sown on July 3, 1985, at the Agronomy Farm, SDSU, Brookings, in a randomized complete block design with four replications.

Each plot consisted of three 7-m long rows with 30-cm row spacings and 10 cm between plants within rows. Weeds were removed by hand during early and medium stages of crop development. Percent emergence was recorded on July 19, 16 days after planting. Analysis of variance, using CATMOD procedure, was conducted to compare varieties and treatments.

4-2-2. Results and discussion

Overall, plant emergence was 62 and 50% for varieties SDGI-11 and SDGI-6, respectively. A significant difference of 12% overall in plant emergence was found between the two entries. Significant differences also were observed between fungicide treatments (Table 30).

The treatment involving a mixture of Benlate and Captan fungicides showed the best emergence of 61% (Figure 3).

Captan and Apron fungicide treatments showed similar responses of 59% emergence. Benlate showed 57% emergence, and the check exhibited only 43% emergence. Percent emergence among the chemical treatments was not significantly different; however, when the check was considered along with the chemical treatments, a range of up to 18% difference was observed.

Although the experiment was planted late in the season at a time when soil borne diseases were expected to be less severe, the results clearly demonstrated that seed treatment improved emergence. The results also indicated a mixture of Benlate and Captan fungicides improved the stand. Benlate is a systemic and Captan is a contact fungicide.

Improved emergence by SDGI-11 suggested that soil borne diseases affected the large seeded Kabuli types more than the small seeded Desi types.

4-3. Effect of row spacing on yield of chickpeas

An experiment was conducted at the Agronomy Farm at Brookings to investigate the effect of row spacing on seed yield of chickpeas.

4-3-1. Materials and methods

Two varieties, SDGI-6 and SDB-3, were planted on June 14, 1985, in four 15-m-long row replicated plots with 15, 30, 45, and 60-cm spacings between rows. Spacing within rows was 10 cm. Yield per hectare was calculated using the two middle rows harvested on September 18, 1985. Yield from entry SDB-3 was not determined due to its late maturity.

4-3-2. Results and discussion

Yield data from the row spacing experiment with SDGI-6 are presented in Table 31. There were significant differences between row spacings (Table 32).

In general, yields increased as spacings between rows decreased. The highest yield (2867 kg/ha) was recorded for plots with 15-cm spacing between rows (Table 31). The next highest yield (1837 kg/ha) was obtained in plots with 30-cm spacing between rows, followed by yields from plots with 45- and 60-cm spacing.

The same relationship was obtained in the 1984 row spacing study at Highmore (Figure 4). However, yields obtained from plots with 15-cm spacing between rows were not significantly different from yields of 30-cm spacing plots in the 1984 study.

Usually, plants that compete for nutrients and moisture have reduced plant height, smaller seed size, and earlier maturity. These effects can be beneficial or harmful, depending on your objectives.

If the emphasis is for yield, then narrow spacing (15 cm) between rows with a population of about 650,000 plants per hectare would be the appropriate choice. If seed size, plant height, and other qualities are considered, then wider row spacings that provide less competition among plants should be used for proper development and maturity of the crop.

Compared to earlier studies, relatively high yields were obtained from plots with 30-cm spacing between rows (333,000 plants/ha) without affecting seed size, plant height, and/or any other character.

Consider also that 30-cm row spacings with a proper plant stand bring quick ground coverage by providing vigorous canopy growth. This controls weeds because of the shading effect. This choice of row spacing appears appropriate for SDGI-6

grown in South Dakota. However, additional row spacing experiments are needed and will be conducted at several locations during the 1986 season.

4-4. Conclusions

The planting depth study showed optimum planting depth was 15 cm in Brookings in 1985. However, in dry areas where surface moisture is limited, planting chickpeas in rows up to 20 cm deep would probably be necessary to establish a good plant stand.

In the present experiment, seeds planted 20 cm deep delayed emergence by 8 days, but a good stand with up to 93% emergence was obtained (Table 28) with entry SDGI-6.

In addition, this experiment has shown that chickpeas require at least 15 days before a 75% stand can be observed.

The fungicidal experiment suggested that fungicidal seed treatment is needed to establish optimum chickpea stands.

However, this experiment must be repeated using early planting dates and perhaps more testing sites to acquire dependable information. In the row spacing study, the highest yield was obtained in the 15-cm spacing between rows. Further information is needed on the effect of row spacing on seed quality, ease of planting, and other agronomic characteristics.

Seed increase

Table 33 gives a list of entries, characteristics, and the number of rows planted at various locations during the 1985 growing season. Most entries planted at Brookings and Watertown were not harvested due to damage caused by heavy rains during August and September. However, SDGI-6 planted at all other locations in South Dakota and Nebraska were harvested.

Figure 5 gives yield data for SDGI-6 compared to ILC-482 at different test locations. SDGI-6 had yields of 3625 kg/ha at Brookings and 2132 kg/ha at Bristol. In all other sites SDGI-6 exhibited higher yields than ILC-482. The yield increase ranged from 7% at Redfield to 31% at Wall.

In addition, about 700 lbs of SDGI-6 was harvested from a late increase planted at Highmore.

Table 27. Percent emergence of chickpea lines SDGI-6, SDB-3, and SDBI- at various planting depths and germination intervals, 1985.

Days from Planting	SDGI-6 % Emergence				SDB-3 % Emergence				SDGI-8 % Emergence			
	10cm	15cm	20cm	25cm	10cm	15cm	20cm	25cm	10cm	15cm	20cm	25cm
8	67	71	54	0	41	48	18	0	57	73	40	3
12	75	81	79	5	67	82	73	1	75	87	75	9
16	90	89	90	72	79	91	88	47	81	90	89	32
20	95	93	92	92	93	93	93	69	88	91	91	57
24	95	93	92	92	93	93	93	69	88	91	91	57

Table 28. Analysis of variance.

Source	d.f.	Chi-square
Varieties	2	8.32*
Depths	3	139.62***
Varieties x Days	6	21.06**
Varieties x Depths	6	8.79
Days x Depths	6	156.01**
Varieties x Depths x Days	18	25.71

Table 29. Effect of seed treatment on emergence.

Treatment	Percent Emergence
Benlate	57
Captan	59
Apron	59
Benlate + Captan	61
Check	43

Table 30. Analysis of Variance.

Source	dif	Chi. square
Variety	1	61.89***
Treatment	4	65.52***
Variety X Treatment	4	10.82**
Variety X Treatment X Reps.	12	40.09**

Table 31. Seed yield for SDGI-6 at various row spacings, Brookings, 1985.

Row width	Yield (kg/ha)
15 cm	2867
30 cm	1837
45 cm	1100
60 cm	676

Table 32. Analysis of variance.

Source	d.f.	MS
Rep	1	185441
Treatment	3	1841938*
Error	3	232597

* significant at 0.1 level

Table 33. Seed increase of intermediate and small seeded lines.

Entry	Pedigree	Origin	Seed Type	Seed Size	Locations **						TOTAL*
					Bristl	Bkgs	Hghm	Redf	Watr	Sidn	
SDGI-12	ILC	Turkey	K	M	—	4	—	—	—	—	4
SDGI-6	ILC	Turkey	K	M	14	60	10	40	6	20	150
SDGI-2	X81TH-101	ICARDA	I	M	—	4	—	—	—	—	4
SDGI-3	X81TH-111	ICARDA	I	M	2	16	—	—	1	—	19
SDGI-9	ICC-4948	INDIA	D	S	—	4	—	—	—	—	4
SDGI-11	ICC-10136	ICRISAT	D	M	—	12	—	—	1	—	13
SDGI-8	ICC-11529	ICRISAT	D	S	—	4	—	—	—	—	4
SDGI-7	ICC-50003	ICRISAT	D	M	—	—	—	—	2	—	2
—	UC-5	U.S. Cal.	K	L	—	4	—	—	1	5	10
—	Souratato	Mexico	K	L	—	4	—	—	—	—	4

* = Number of 15-M long single row plots
K = Rough-shaped, light-colored, large-seeded chickpeas
I = Smooth-shaped, light or dark colored chickpeas
D = Shriveled-shape, dark-colored, small-seeded chickpeas
M,S,L = Medium, small and large
** = Bristl (Bristol), Bkgs (Brookings), Hghm (Highmore), Redf (Redfield), Watr (Watertown) and Sidn (Sidney)

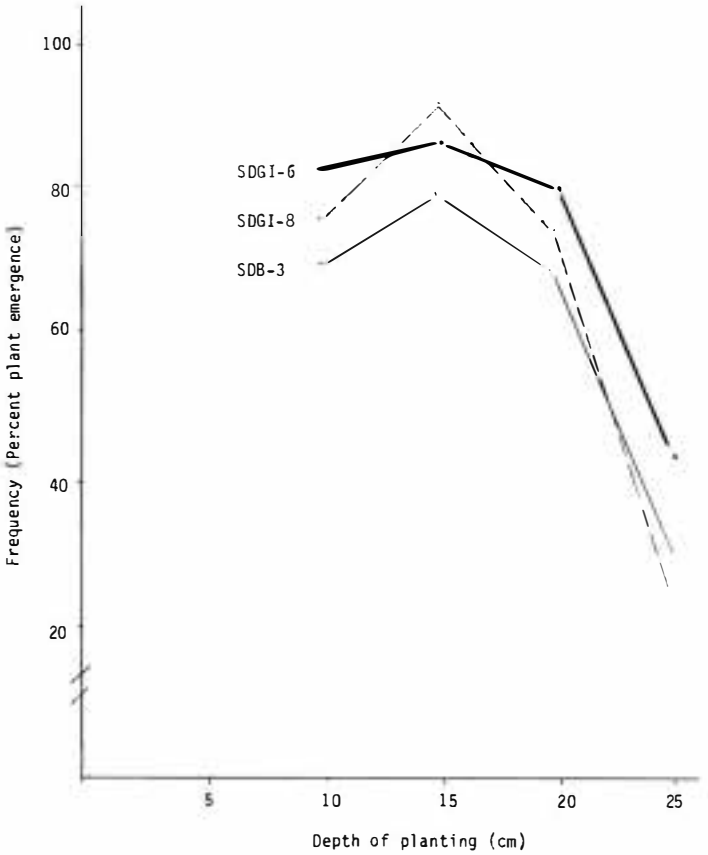


Fig 2. Percent emergence of varieties at various planting depths.

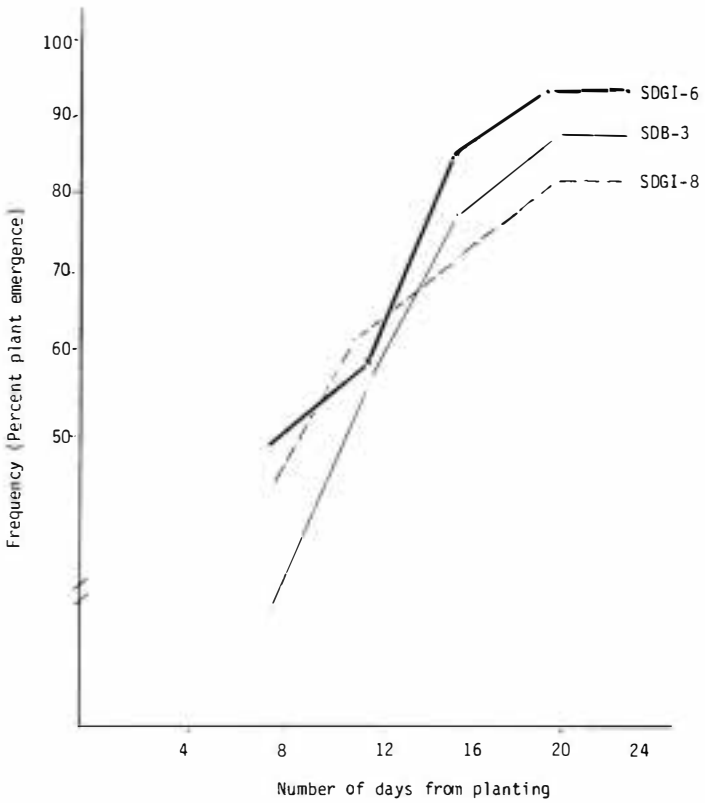


Fig 3. Percent plant emergence of varieties at various days from planting.

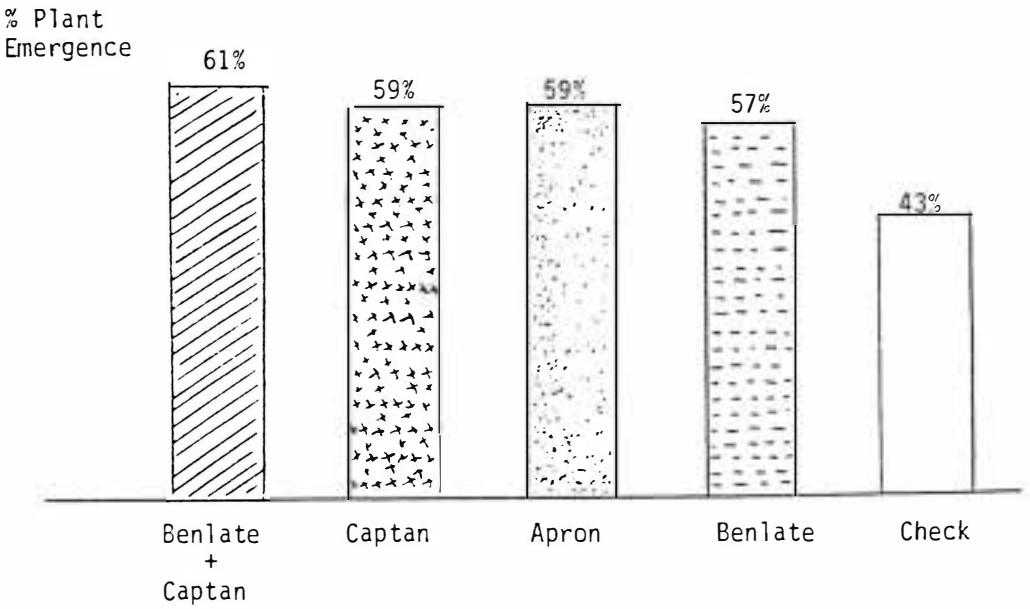


Fig 4. Effect of seed treatment on percent emergence of field-grown chickpeas.

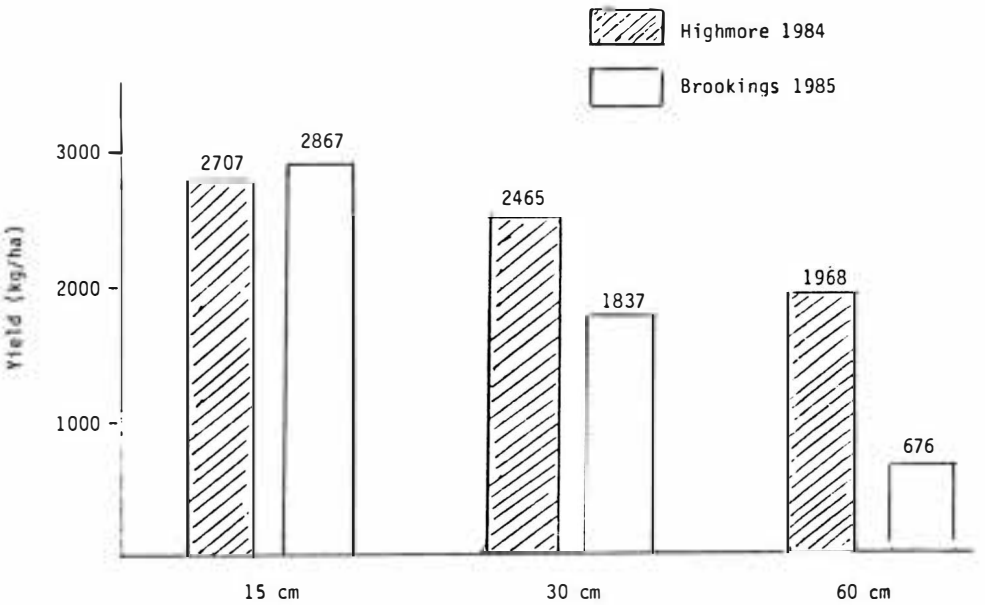


Fig 5. Effect of row spacing on yield of SDGI-6 chickpea at Highmore (1984) and Brookings (1985).

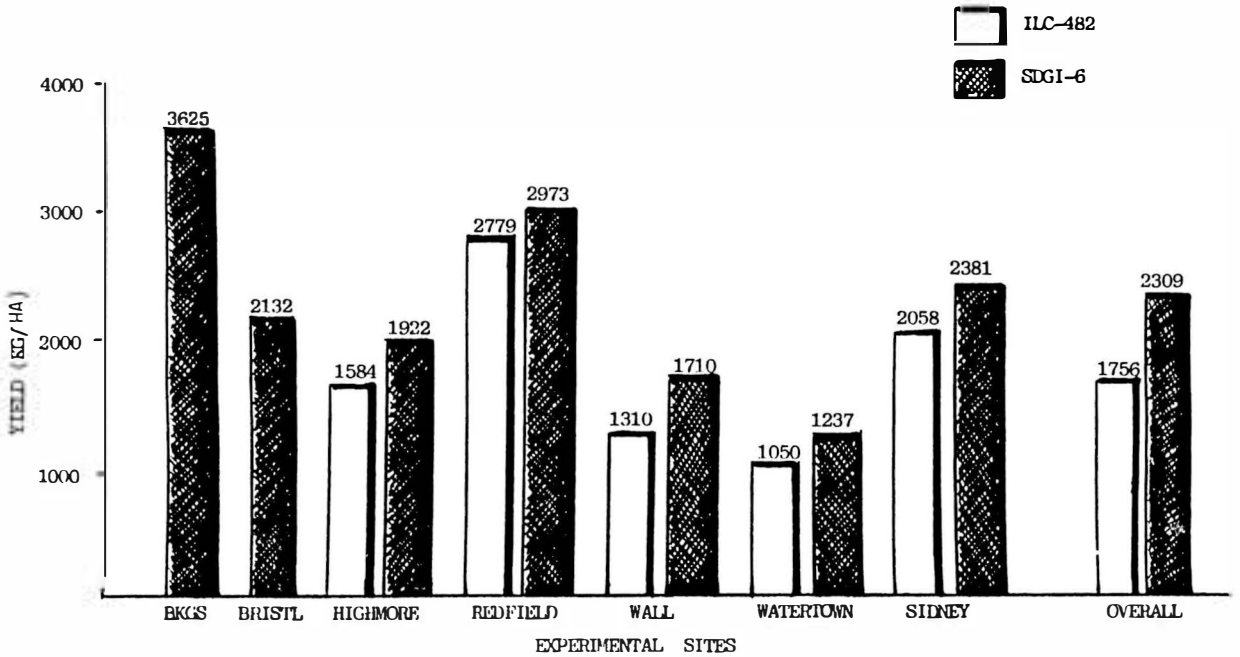


Fig 6. Performance of chickpea SDGI-6 (South Dakota selection) against ILC 482, 1985.

Appendix

Appendix I: South Dakota Chickpea Screening Nursery (SDCSN-85)

SN	Entry	Origin/source	Pedigree
1	SDGI -16	Jordan	ILC -4
2	" 17	Syria	" 35
3	" 18	Iraq	" 66
4	" 51	Spain	" 76
5	" 2	"	" 83
6	" 53	"	" 116
7	" 3	"	" 132
8	" 1	"	" 134
9	" 5	"	" 135
10	" 54	Tunisia	" 136
11	" 55	"	" 165
12	" 13	Turkey	" 171
13	" 65	"	" 254
14	" 142	"	" 263
15	" 67	Iran	" 295
16	" 14	Turkey	" 451
17	" 71	"	" 464
18	" 12	"	" 480
19	" 6	"	" 482
20	" 74	"	" 493
21	" 143	Egypt	" 519
22	" 83	Tunisia	" 610

Appendix I: (SDCSN-85)cont.

SN	Entry		Origin/source	Pedigree	
23	"	84	"	"	613
24	"	85	Morocco	"	620
25	"	15	Tunisia	"	629
26	"	98	India	"	1919
27	"	100	Morocco	"	1922
28	"	101	Syria	"	1929
29	"	102	Turkey	"	1931
30	"	103	Jordan	"	1932
31	"	104	Iran	"	1934
32	"	123	Turkey	"	2587
33	"	129	Cyprus	"	3256
34	"	9	India	ICC	4198
35	"	10	India	"	4948
36	"	11	ICRISAT	"	10136
37	"	141	"	"	11524
38	"	8	"	"	11529
39	"	7	"	"	5003
40	SDB	140	ICARDA	FLIP	11- 64
41	"	141	"	"	75 -02
42	"	142	"	"	75 -03
43	"	143	"	"	75 -06
44	"	144	"	"	75 -08
45	"	145	"	"	75 -09
46	"	146	"	"	75 -10
47	"	147	"	"	75 -11
48	"	148	"	"	75 -15

Appendix I: (SDCSN-85)cont.

SN	Entry	Origin/source	Pedigree
49	" 149	"	" 75 -16
50	" 150	"	" 75 -17
51	" 151	"	" 75 -18
52	" 152	"	" 75 -19
53	" 153	"	" 75 -20
54	" 154	"	" 75 -21
55	" 155	"	" 75 -23
56	" 156	"	" 75 -25
57	" 157	"	" 75 -26
58	" 158	"	" 75 -28
59	" 159	"	" 75 -31
60	" 160	"	" 75 -33
61	" 161	"	" 75 -35
62	" 162	"	" 75 -38
63	" 163	"	" 75 -46
64	" 164	"	" 75 -53
65	" 165	"	" 75 -55
66	" 166	"	" 75 -58
67	" 167	"	" 75 -63
68	" 168	"	" 75 -69
69	" 169	"	" 75 -76
70	" 170	"	" 75 -79
71	" 56	"	FLIP 80 -01
72	" 57	"	" 80 -02
73	" 59	"	" 80 -05
74	" 75	"	FLIP 81 -32

Appendix I: (SDCSN-85)cont.

SN	Entry	Origin/source	Pedigree
75	" 77	"	" 81 -34
76	" 81	"	" 81 -40
77	" 86	"	" 81 -45
78	" 87	"	" 81 -46
79	" 93	"	" 81 -52
80	" 95	"	" 81 -54
81	" 99	"	" 81 -58
82	" 104	"	" 81 -63
83	" 106	"	" 81 -65

Appendix II: Chickpea International Screening Nursery (CISN-84)

SN	Entry	Origin/Source	Pedigree
1	-----	Turkey	ILC -482
2	SDGI-131	USSR	" 3279
3	"	SD selection	Local Check
4	SDB -171	ICARDA	FLIP-82 -96c
5	" 172	"	" 82 -97c
6	" 173	"	" 82 -98c
7	" 134	"	" 82-100c
8	" 174	"	" 82-101c
9	" 136	"	" 82-104c
10	" 175	"	" 82-112c
11	" 176	"	" 82-113c
12	" 177	"	" 82-115c
13	" 178	"	" 82-117c
14	" 179	"	" 82-118c
15	" 180	"	" 82-119c
16	" 181	"	" 82-121c
17	" 182	"	" 82-126c
18	" 183	"	" 82-127c
19	" 184	"	" 82-128c
20	" 185	"	" 82-130c
21	" 186	"	" 82-133c
22	" 187	"	" 82-138c

Appendix II: (CISN-84) cont.

SN	Entry	Origin/Source	Pedigree
23	" 188	"	" 82-144c
24	" 189	"	" 82-150c
25	" 190	"	" 82-152c
26	" 228	"	" 82-154c
27	" 191	"	" 82-160c
28	" 192	"	" 82-161c
29	" 193	"	" 82-164c
30	" 194	"	" 82-167c
31	" 195	"	" 82-169c
32	" 196	"	" 82-175c
33	" 197	"	" 82-180c
34	" 198	"	" 82-181c
35	" 199	"	" 82-182c
36	" 200	"	" 82-186c
37	" 201	"	" 82-188c
38	" 202	"	" 82-189c
39	" 203	"	" 82-193c
40	" 204	"	" 82-194c
41	" 205	"	" 82-195c
42	" 206	"	" 82-196c
43	" 207	"	" 82-197c
44	" 208	"	" 82-199c
45	" 209	"	" 82-203c
46	" 210	"	" 82-205c
47	" 211	"	" 82-208c
48	" 212	"	" 82-219c

Appendix II: (CISN-84) cont.

SN	Entry	Origin/Source	Pedigree
49	" 213	"	" 82-225c
50	" 214	"	" 82-228c
51	" 215	"	" 82-232c
52	" 216	"	" 82-234c
53	" 217	"	" 82-236c
54	" 218	"	" 82-239c
55	" 219	"	" 82-241c
56	" 220	"	" 82-245c
57	" 221	"	" 82-246c
58	" 222	"	" 82-251c
59	" 223	"	" 82-254c
60	" 224	"	" 82-255c
61	" 225	"	" 82-258c
62	" 226	"	" 82-259c
63	" 227	"	" 82-261c

Appendix III: Chickpea International Screening Nursery, (CISN-85)

SN	Entry	Origin/Source	Pedigree
1	" 229	"	" 82-172
2	" 230	"	" 82-174
3	" 231	"	" 82-221
4	" 232	"	" 83- 9c
5	" 233	"	" 83- 10c
6	" 234	"	" 83- 11c
7	" 235	"	" 83- 21c
8	" 236	"	" 83- 26c
9	" 237	"	" 83- 30c
10	" 238	"	" 83- 32c
11	" 239	"	" 83- 33c
12	" 240	"	" 83- 34c
13	" 241	"	" 83- 37c
14	" 242	"	" 83- 40c
15	" 243	"	" 83- 41c
16	" 244	"	" 83- 42c
17	" 245	"	" 83- 43c
18	" 246	"	" 83- 52c
19	" 284	"	" 83- 53c
20	" 247	"	" 83- 62c
21	" 248	"	" 83- 63c
22	" 249	"	" 83- 69c

Appendix III: (CISN-85)cont.

SN	Entry	Origin/Source	Pedigree
23	" 250	"	" 83- 77c
24	" 251	"	" 83- 78c
25	" 252	"	" 83- 85c
26	" 253	"	" 83- 86c
27	" 254	"	" 83- 88c
28	" 255	"	" 83- 91c
29	" 256	"	" 83- 96c
30	" 257	"	" 83- 99c
31	" 258	"	" 83-101c
32	" 259	"	" 83-102c
33	" 260	"	" 83-103c
34	" 261	"	" 83-104c
35	" 262	"	" 83-107c
36	" 285	"	" 83-111c
37	-------	Turkey	ILC- 482
38	SDGI-101	Syria	ILC-1929
39	SDGI- 6	SD selection	Local Check

Appendix IV: Chickpea International Ascochyta Blight Nursery, (CIABN-84)

SN	Entry	Origin/Source	Pedigree
1	SDGI -50	Spain	ILC - 72
2	" 56	USSR	" - 182
3	" 57	"	" - 187
4	" 58	"	" - 195
5	" 59	"	" - 196
6	" 60	"	" - 200
7	" 61	"	" - 201
8	" 62	"	" - 202
9	" 63	"	" - 215
10	" 6	Turkey	" - 482
11	" 111	USSR	" -2380
12	" 119	"	" -2506
13	" 144	"	" -2956
14	" 130	Unknown	" -3274
15	" 131	"	" -3279
16	" 132	"	" -3346
17	" 135	Morocco	" -3856
18	" 136	Bulgaria	" -3864
19	" 137	"	" -3866
20	" 138	"	" -3868
21	" 139	"	" -3870
22	" 140	USSR	" -4421

Appendix IV: (CIABN-84)cont.

SN	Entry		Origin/Source	Pedigree
23	"	19	India	ICC - 641
24	"	20	ICRISAT	" -2160
25	"	21	Iran	" -3932
26	"	22	"	" -4256
27	"	23	India	" -5035
28	"	24	-	" -5124
29	"	25	Unknown	" -5127
30	"	26	Mexico	" -5566
31	"	28	USSR	" -6304
32	"	29	"	" -6306
33	"	30	India	" -6336
34	"	31	Iran	" -6373
35	"	32	"	" -6945
36	"	33	"	" -6981
37	"	34	"	" -6988
38	"	35	"	" -6989
39	"	36	"	" -7028
40	"	145	USSR	NEC 138- 2
41	"	146	Morocco	Pch - 15
42	"	147	"	" - 70
43	"	148	"	" - 124
44	"	101	Syria	ILC - 1929
45	SDB	82	ICARDA	FLIP-81- 41
46	"	100	"	" -81- 59
47	"	108	"	" -81- 70
48	"	109	"	" -81- 71

Appendix IV: (CIABN-84)cont.

SN	Entry	Origin/Source	Pedigree
49	" 110	"	" -81- 75
50	" 263	"	" -81-293
51	" 115	"	" -82- 1c
52	" 116	"	" -82- 2c
53	" 117	"	" -82- 3c
54	" 119	"	" -82- 26c
55	" 120	"	" -82-40c
56	" 122	"	" -82- 59c
57	" 123	"	" -82- 61c
58	" 124	"	" -82- 64c
59	" 125	"	" -82- 65c
60	" 126	"	" -82- 68c
61	" 129	"	" -82- 74c
62	" 131	"	" -82- 91c
63	" 133	"	" -82- 99c
64	" 134	"	" -82-100c
65	" 264	"	" -82-129c
66	" 265	"	" -82-178c
67	" 266	"	" -82-191c
68	" 267	"	" -82-222c
69	" 218	"	" -82-239c
70	" 221	"	" -82-246c
71	" 226	"	" -82-259c

Appendix V: Chickpea International Ascochyta Blight Nursery, (CIABN-85)

SN	Entry	Origin/Source	Pedigree
1	SDGI- 50	Spain	ILC - 72
2	" 56	USSR	" - 182
3	" 60	"	" - 200
4	" 62	"	" - 202
5	" 63	"	" - 215
6	" 6	Turkey	" - 482
7	" 131	USSR	" -3279
8	" 135	Morocco	" -3856
9	" 138	Bulgaria	" -3868
10	" 139	Bulgaria	" -3870
11	" 140	USSR	" -4421
12	SDB -108	ICARDA	FLIP-81- 70
13	" 263	"	" - 293
14	" 115	"	" 82- 1c
15	" 280	"	" - 52c
16	" 124	"	" - 64c
17	" 129	"	" - 74c
18	" 132	"	" - 93c
19	" 136	"	" 82- 104c
20	" 183	"	" 82-127c
21	" 184	"	" 82-128c
22	" 185	"	" 82-130c

Appendix V: (CIABN-85)cont.

SN	Entry	Origin/Source	Pedigree
23	" 188	"	" 82-144c
24	" 189	"	" 82-150c
25	" 137	"	" 82-191c
26	" 268	"	" 82-243c
27	" 225	"	" 82-258c
28	" 226	"	" 82-259c
29	" 269	"	FLIP-83- 7c
30	" 270	"	" -83- 12c
31	" 271	"	" -83- 13c
32	" 272	"	" -83- 15c
33	" 235	"	" -83- 21c
34	" 273	"	" -83- 22c
35	" 274	"	" -83- 23c
36	" 275	"	" -83- 31c
37	" 276	"	" -83- 46c
38	" 277	"	" -83- 47c
39	" 278	"	" -83- 48c
40	" 279	"	" -83- 60c
41	SDGI- 101	Syria	ILC -1929

Appendix VI: South Dakota Chickpea Yield Trial, (SDCYT-85)

SN	Entry	Origin/Source	Pedigree
1	SDGI-51	Spain	ILC - 76
2	" 2	"	" - 83
3	" 3	"	" - 132
4	" 1	"	" - 134
5	" 5	"	" - 135
6	" 9	India	ICC - 4918
7	" 10	"	" - 4948
8	" 7	ICRISAT	" - 5003
9	" 8	"	" -11529
10	SDB - 1	ICARDA	XTH81- 85
11	" 2	"	" - 101
12	" 6	"	" - 105
13	" 3	"	" - 111
14	" 4	"	" - 112
15	" 5	"	" - 126
16	------	USA	UC - 5
17	SDGI- 6	SD Selection	Local Check

Appendix VII: Chickpea Large Seeded Yield Trial (CIYT-L-85)

SN	Entry	Origin/Source	Pedigree
1	SDGI- 17	Syria	ILC - 35
2	" 51	Iraq	" - 76
3	" 2	"	" - 83
4	" 53	"	" - 116
5	" 3	"	" - 132
6	" 1	"	" - 134
7	" 5	"	" - 135
8	" 54	"	" - 136
9	" 55	Tunisia	" - 165
10	" 13	"	" - 171
11	" 65	Turkey	" - 254
12	" 142	"	" - 263
13	" 14	"	" - 451
14	" 75	"	" - 496
15	" 84	Tunisia	" - 613
16	" 85	"	" - 620
17	" 15	"	" - 629
18	" 123	Turkey	" - 2587
19	" 133	Mexico	" - 3395
20	" 150	"	" - 3396
21	" 134	France	" - 3749
22	-------	Turkey	" - 482
23	" 101	Syria	" - 1929
24	" 6	SD Selection	Local Check

Appendix VIII: Chickpea Yield Trial-Winter, (CIYT-W-85)

SN	Entry	Origin/Source	Pedigree
1	SDB - 72	ICARDA	FLIP 81- 26
2	" 73	"	" 81- 29
3	" 77	"	" 81- 34w
4	" 81	"	" 81- 40w
5	" 82	"	" 81- 41w
6	" 97	"	" 81- 56w
7	" 98	"	" 81- 57w
8	" 100	"	" 81- 59w
9	" 281	"	" 81- 269
10	" 263	"	" 82- 293
11	" 286	"	" 82- 5c
12	" 118	"	" 82- 13c
13	" 120	"	" 82- 40c
14	" 121	"	" 82- 43c
15	" 124	"	" 82- 64c
16	" 125	"	" 82- 65c
17	" 127	"	" 82- 72c
18	" 128	"	" 82- 73c
19	" 130	"	" 82- 79c
20	" 131	"	" 82- 91c
21	" 132	"	" 82- 93c
22	-------	Turkey	ILC - 482
23	SDGI-101	Syria	" -1929
24	SDGI- 6	SD Selction	Local Check

Appendix IX: Chickpea International F4 Trial, (CIF4T-85)

SN	Entry	Origin/Source	Pedigree
1	SDB-15	ICARDA/ICRISAT	X82TH- 2
2	" 16	"	" 13
3	" 135	"	" 61
4	" 17	"	" 65
5	" 22	"	" 77
6	" 23	"	" 78
7	" 25	"	" 81
8	" 27	"	" 86
9	" 30	"	" 91
10	" 31	"	" 92
11	" 32	"	" 98
12	" 33	"	" 99
13	" 45	"	" 137
14	" 46	"	" 146
15	" 47	"	" 149
16	" 48	"	" 152
17	" 49	"	" 156
18	" 50	"	" 158
19	" 51	"	" 160
20	" 53	"	" 165
21	SDGI-85	Tunisia	ILC- 620
22	-------	Turkey	" 482
23	SDGI-101	Syria	" 1929
24	SDGI- 6	SD Selection	Local Check

Appendix X: Chickpea International F3 Trial, (CIF3T-84)

SN	Entry	Origin/Source	Pedigree
1	SDB-18	ICARDA/ICRISAT	X82TH- 67
2	" 19	"	" 68
3	" 20	"	" 70
4	" 21	"	" 76
5	" 24	"	" 80
6	" 26	"	" 82
7	" 28	"	" 87
8	" 29	"	" 88
9	" 35	"	" 102
10	" 36	"	" 105
11	" 37	"	" 110
12	" 38	"	" 111
13	" 39	"	" 121
14	" 40	"	" 125
15	" 41	"	" 127
16	" 42	"	" 128
17	" 43	"	" 134
18	" 44	"	" 136
19	" 52	"	" 164
20	" 54	"	" 168
21	" 55	"	" 169
22	-------	Turkey	" 482
23	SDGI-131	USSR	" 3279
24	SDGI- 6	SD Selection	Local Check

Appendix XI: Chickpea International F3 Trial, (CIF3T-STR-84)

SN	Entry	Origin/Source	Pedigree
1	SDB-15	ICARDA/ICRISAT	X82TH- 2
2	" 16	"	" 13
3	" 135	"	" 61
4	" 17	"	" 65
5	" 22	"	" 77
6	" 23	"	" 78
7	" 25	"	" 81
8	" 27	"	" 86
9	" 30	"	" 91
10	" 31	"	" 92
11	" 32	"	" 98
12	" 33	"	" 99
13	" 34	"	" 100
14	" 45	"	" 137
15	" 46	"	" 146
16	" 47	"	" 149
17	" 48	"	" 152
18	" 49	"	" 156
19	" 50	"	" 158
20	" 51	"	" 160
21	" 53	"	" 165
22	-------	Turkey	" 482
23	SDGI-131	USSR	" 3279
24	SDGI- 6	SD Selection	Local Check

Published in accordance with an act passed in 1881 by the 14th Legislative Assembly, Dakota Territory, establishing the Dakota Agricultural College and with the act of reorganization passed in 1887 by the 17th Legislative Assembly, which established the Agricultural Experiment Station at South Dakota State University.

AX 098

HORIZONS AGRICULTURAL EXPERIMENT STATION
CENTENNIAL 1887-1987