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Results of Chickpea Research in Southwestern Colorado from 1994 to 2003

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General Introduction

Chickpea (*Cicer arietinum* L.) commonly called garbanzo bean in the U.S. is an important source of protein in human diets. Chickpea seeds are commonly found in salad bars in the U.S. and are used in a variety of dishes throughout the world. Most of the chickpea produced in the world is of the *Desi* (small-seeded) type while the bulk of the chickpea produced in the U.S. is of the *Kabuli* (large-seeded) type. Chickpea production in the US averaged 22,275 harvested hectares (ha) and 1524 kg ha^{-1} in 1994-2003 (http://www.nass.usda.gov/) (verified 15 Oct. 2004). Production dropped from a high of 60,345 planted hectares 2001 to 17,618 hectares in 2003. Yield was highest in 1995 (1852 kg ha^{-1}) and lowest in 2002 (1,301 kg ha^{-1}). Until 1998, most of the chickpea production was concentrated in California and the Palouse Region of Idaho, Oregon, and Washington. Other chickpea-producing states are Montana, North Dakota, South Dakota, and Nebraska.

Interest in chickpea production in southwestern Colorado was prompted by the need for alternative crops. Testing was done at the Southwestern Colorado Research Center in the early 1980s but was discontinued after a few years, for unknown reasons. Nonetheless, the testing proved that chickpea could be grown successfully in southwestern Colorado, utilizing the same farming practices used to grow dry bean (unpublished data). Dry bean, mostly pintos, is a major crop in southwestern Colorado, along with alfalfa and winter wheat.

The release of Ascochyta blight-resistant varieties and the continuous need for alternative crops to replace less economically viable crops, or to intensify cropping systems, led to renewed interest in chickpeas in the 1990's. The acreage of dry bean in southwestern Colorado had been declining because some of the cropland was converted to the Conservation Reserve Program (CRP) or seeded to alfalfa. Another reason for the decline in bean acreage was low prices combined with generally poor yields—most of the bean acreage in southwestern Colorado is dry land. Bean prices went up sharply in 2004[1].

Chickpea has several apparent advantages compared to dry bean. Chickpea prices were consistently higher than those of pinto beans in the 1990's (not true anymore, except for organic chickpea). Chickpea is more frost tolerant than dry bean and thus, can be planted earlier. Dry bean is usually planted in early to mid-June in southwestern Colorado. Chickpea can be planted four to six weeks earlier than dry bean (Berrada et al., 1999). Early chickpea varieties mature by mid- to late August, which should leave adequate time to plant winter wheat in rotation with chickpea. Hammon et al. (1999) reported a significant decline in dryland winter wheat yield when planting is delayed past the third or fourth week of September. Winter wheat after dry bean is usually not planted until October in southwestern Colorado (Berrada et al., 1995).

Another advantage of chickpea over dry bean is the fact that several chickpea varieties have an upright architecture and can be combined directly. Dry bean is usually cut by mid-September, raked, and left to dry in the field for a couple weeks before threshing it. Direct combining can save time and money over the multi-step method commonly used to harvest dry bean.

Chickpea seed yields at Yellow Jacket were generally similar to dry bean yields under irrigated conditions and superior under dryland conditions[2]. However, as will be discussed later in this report, achieving good seed quality is a bigger challenge with chickpea than with dry bean.

Chickpea studies at the Southwestern Colorado Research Center included variety yield trials, planting date trials, the response to irrigation and N fertilization, and the evaluation of drought tolerance of a chickpea core collection. Some of the results of the studies conducted prior to 1999 were published in various publications (Brick et al., 1998; Berrada et al., 1999). This bulletin contains more complete results of past and recent studies.

All the studies reported herein were conducted at the Southwestern Colorado Research Center in Yellow Jacket, Colorado. The predominant soil series at the research center is Wetherill loam (fine-silty, mixed, superactive, mesic, Aridic Haplustalf). The elevation is 2,128 m. The number of days with minimum temperature > -2.2 ^{o}C is 143 in 8 out of 10 years (http://www.wrcc.dri.edu/index.html) (verified 15 Oct. 2004). The average annual precipitation is 404 mm of which approximately 40% comes from snow. Monthly average precipitation ranges from 15 to 48 mm, with June being the driest month (Table 1).

[1] Pinto bean dealer price was around $32.00/cwt on 23 November 2004, compared to $22.00/cwt or less a year ago (http://www.ams.usda.gov/LSMNpubs/pdf_weekly/bean.pdf, verified 11/29/04).

[2] This was deduced from comparing chickpea and dry bean yields at the Southwestern Colorado Research Center over several years. The results of this comparison have not been published.

Table 1. Monthly precipitation at Yellow Jacket, CO in 1999-2003

Month	1971-2000	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	---------- mm ----------										
January	30.5	0.0	32.5	10.4	55.4	22.4	4.8	30.0	18.3	0.3	5.6
February	33.0	0.0	17.0	9.9	29.5	50.3	13.0	15.5	24.1	1.0	51.6
March	34.8	23.1	83.3	13.2	0.5	55.6	0.8	39.4	2.3	13.0	42.2
April	23.4	54.4	21.3	5.3	45.0	22.4	68.6	8.9	26.9	5.8	4.8
May	33.5	23.1	32.0	3.6	40.1	9.7	42.2	9.9	12.4	2.3	17.3
June	15.0	7.1	19.3	35.8	6.4	1.5	27.4	3.0	5.1	0.0	1.3
July	38.9	12.2	46.7	28.4	53.8	54.9	42.7	14.0	29.7	3.3	15.0
August	41.9	20.6	35.1	5.3	56.9	11.4	63.8	59.4	71.6	20.1	29.5
September	39.1	33.5	0.0	33.5	50.8	21.3	23.9	19.3	4.8	68.1	55.1
October	49.5	28.4	10.4	83.3	34.0	86.4	0.3	49.8	14.0	45.0	30.2
November	38.9	31.0	2.0	36.1	29.2	58.4	1.5	18.8	13.7	32.5	21.3
December	26.4	21.8	2.0	31.8	20.3	2.8	2.8	9.9	21.6	14.2	8.4
Total	404.9	255.3	301.8	296.7	421.9	397.0	291.6	277.9	244.6	205.5	282.2
% Normal	**100.0**	**63.0**	**74.5**	**73.3**	**104.2**	**98.1**	**72.0**	**68.6**	**60.4**	**50.8**	**69.7**
Oct.-Sept.*	404.9	255.3	301.8	296.7	421.9	397.0	291.6	204.0	273.8	163.1	313.9
% Normal	**100.0**	**63.0**	**74.5**	**73.3**	**104.2**	**98.1**	**72.0**	**50.4**	**67.6**	**40.3**	**77.5**
May-Aug.	129.3	63.0	133.1	73.2	157.2	77.5	176.0	86.4	118.9	25.7	63.0
% Normal	**100.0**	**48.7**	**102.9**	**56.6**	**121.6**	**59.9**	**136.1**	**66.8**	**91.9**	**19.8**	**48.7**

*Cumulative precipitation from October of Year “n-1” to September of Year “n”.

Part I

Results of the Chickpea Variety Trials at Yellow Jacket, CO in 1999-2003

Abdel Berrada

Introduction

Chickpea (*Cicer arietinum* L.) variety trials were conducted at the Southwestern Colorado Research Center in Yellow Jacket from 1999 through 2003 under dryland conditions. The objectives of these trials were to evaluate the yield potential of several chickpea varieties and experimental lines, and to assess their adaptability to the climatic conditions of southwestern Colorado. This was part of a larger effort to assess the agronomic feasibility of chickpea as an alternative to dry bean (Berrada et al., 1999).

Materials and Methods

Table 2 shows the entries tested, their origin, and selected properties. All the entries were of the *Kabuli* type (large seeds), except 'Myles' which is a *Desi* type (small seeds). The 2002 trial was not harvested due to the extremely dry conditions that prevailed prior to and during most of the chickpea growth period (Table 1). All the trials were planted with a Monosem planter at approximately 6.6 seeds m^{-1} of row in 76.2-cm spaced rows. Plot size was 3.0 x 12.2 m in 1999 and 2003, 3.0 x 15.2 m in 2000, and 3.0 x 9.1 m in 2001. A randomized complete block design with four replications (two in Variety Trial No. 1 in 1999) was used. The entries were assigned at random to four complete blocks (2 in Variety Trial No. 1 in 1999). The plot area (different field each year) was in winter wheat in 1998 and in summer fallow prior to the 2000, 2001, and 2003 trials. Dual (S-Metolachlor) at 2.34 L ha^{-1} in 2000 and Treflan (alpha, alpha, alpha-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine) at 1.75 L ha^{-1} in 2001 were sprayed and incorporated in the top 5 to 10 cm of soil prior to planting. No pesticide was used in 1999 or 2003. One or two cultivations were performed each year to control weeds between the rows. Hoeing was done when needed. The two middle rows were harvested by hand at pod maturity and later threshed with a Hege plot combine and weighed. The seeds were cleaned with an electric fan and by hand to eliminate plant and soil debris and weighed. They were then screened with a 7.94 mm (20/64 inch) mesh screen. Approximately 60 grams of seeds that did not pass the screen were separated into “acceptable” and "odd" seeds, counted and weighed. Odd seeds were mostly immature (green) seeds and those damaged (stained) by rain. One hundred seeds from the “acceptable” seed lot were weighed and the result converted to “number of seeds per once”, sometimes referred to as “can test”. The approximate dates of 50% flowering and 80% pod maturity were recorded.

Table 2. Chickpea entries tested at Yellow Jacket, CO in 1999-2003 and their characteristics

Entry (release date)	Origin	Crosses and/or charactersitics
Dwelley (1994)	Released by USDA-ARS in collaboration with the Washington State and Idaho State Experiment Stations.	FLIP 85-58 x 'Surutato-77'. Resistance to Ascochyta blight & fusarium wilt. Unifoliate structure. Indeterminate flowering habit. Light-cream colored seeds.
Evans (1997)		FLIP 85-58 x 'Surutato-77'. Resistance to Ascochyta blight & fusarium wilt. Unifoliate leaf structure. Indeterminate flowering habit. Light-cream colored seeds. Earlier maturity than 'Sanford' or 'Dwelley'.
Sanford (1994)		FLIP 85-58 x 'Surutato-77'. Resistance to Ascochyta blight & fusarium wilt. Unifoliate leaf structure. Indeterminate flowering habit. Light-cream colored seeds.
Myles (1994) Desi type		(BDN 9-3 x K 1184) x ICP87440. Resistance to Ascochyta blight. Fern leaf structure. Indeterminate flowering habit.
UC27 (1988)	Released by the University of California, Davis	UC5 x 'Sonora'. Susceptible to Ascochyta blight. Resistance to fusarium wilt. Upright plant type. Fern leaf structure. Seed appearance & canning characteristics are excellent.
L5	Mexico	Bushy-like, good pod set.
HS9	Private?	Early maturing, zone-ascochyta blight resistance, mid-size seeds, short stature, pods come off easily.
CT8737	Developed by Helm Bean and Seed Warehouse in Kerman, CA. (ConAgra subsidiary)	Tall, erect, cold tolerant, ascochyta blight resistance, fern leaf structure.
HB14		Tall, upright, heat tolerant, ascochyta blight resistance, fern leaf structure. Leaves stay green even after most pods are mature.
HB19		Ascochyta blight resistance, fern leaf structure. Large seeds (2001). Shorter than HB14 but mature quicker and more uniformly.
CA1888359	USDA-ARS breeding program in Pullman, WA	
CA188587		
CA9990B1514C		
CA9990B1579C		
CA99901895C		
CA9783072C		
CA9783152C		Released as 'Sierra' in 2001?
CA9783163C		Released as 'Evans' in 1997
CA9901861W		
CA99901875W		
CA9890169W		
CA9890233W		
CA9890239W		
CA9783007W		

Table 2 (Continued)

Entry (release date)	Origin	Crosses and/or charactersitics
FLIP 97-129	ICRISAT-ICARDA*	X94TH12/FLIP90-132XS91347. Upright, fern leaf structure, good pod set.
FLIP 97-130	ICRISAT-ICARDA	X94TH12/FLIP90-132XS91347. Similar to FLIP 97-129
FLIP 97-217	ICRISAT-ICARDA	X94TH11/FLIP90-132XS91345. Similar to FLIP 97-129
FLIP 97-43	ICRISAT-ICARDA	X94TH12/FLIP90-132XS91347. Fern leaf structure. Bushy-like. Pods close to ground
FLIP 97-85	ICRISAT-ICARDA	X94TH12/FLIP90-132XS91347. Fern leaf structure. Late maturity.
ICCV 95-333	ICRISAT	[(ICCC 32 x ICCV 88507) x ICCC 32] x II GAC 83-4-85-M-2-M

*ICRISAT: International Crops Research Institute for the Semi-Arid Tropics. ICARDA: International Center for Agricultural Research in the Dry Areas.

Results

Year 1999:

The ICRISAT-ICARDA entries FLIP 97-217, FLIP 97-130, and FLIP 97-129 produced the highest seed yield but had a high percentage of odd seeds and a low 100-seed weight (Table 3). FLIP 97-43 had the highest 100-seed weight and a high percentage of odd seeds. The ICRISAT entry ICCV 95333 had the lowest seed yield. CA188587 produced 2238 kg ha^{-1} and had above average seed weight and below average percentage of odd seeds (Table 4). Among the public and commercial varieties, 'Dwelley' had the highest percentage of odd seeds. 'Evans' and 'HS9' had the lowest seed yield. Myles is a *Desi* type chickpea and, therefore had the lowest seed weight, but its seed yield was similar to that of the *Kabuli* type varieties (Table 4). Fifty percent flowering occurred during the first half of July 1999. 'UC27', 'HB14', and Evans were the earliest flowering entries (Tables 3 & 4).

Year 2000:

Chickpea seed yields were about half as much as recorded in 1999 (Table 5). Even though total precipitation was similar in 1999 and 2000, season (May-Sept.) precipitation was much higher in 1999 than in 2000 (Table 1). There was also above average precipitation in April 1999. The experimental lines from USDA-ARS averaged 576 to 778 kg ha^{-1} in 2000, with the exception of CA188587 (1164 kg ha^{-1}), which is an earlier maturing entry. The ICRISAT-ICARDA entries were again among the top producers but had a high percentage of odd seeds (Table 5).

Table 3. Results of chickpea variety trial no. 1 at Yellow Jacket, CO in 1999*

Entry	Seed Yield kg/ha	100-seed wt. g	Can Test Seeds/oz	Green & Stained (% by wt.)	Date 50% Bloom
FLIP 97-217	2775	44.5	63.8	16.9	10-July
FLIP 97-130	2766	44.2	64.3	14.6	10-July
FLIP 97-129	2590	43.3	65.6	27.7	12-July
FLIP 97-85	2322	50.5	56.2	19.2	12-July
Dwelley	2215	52.1	54.5	19.4	14-July
Sanford	2272	49.3	57.6	5.3	14-July
FLIP 97-43	1972	56.1	50.6	22.8	8-July
ICCV 95-333	938	46.9	60.5	18.7	6-July
Average	2219	48.4	59.1	18.0	
$LSD_{.05}$	270	3.9	6.0	NS[1]	

*There were only enough seeds of the experimental lines to plant two blocks.
Planting: 25-May Harvest: 15-Sept. Previous crop: Winter wheat
[1] Not significant at $\alpha \leq 0.05$

Table 4. Results of chickpea variety trial no. 2 at Yellow Jacket, CO in 1999

Entry	Seed Yield kg/ha	100-seed wt. g	Can Test Seeds/oz	Green & Stained (% by wt.)	Date 50% Bloom
L5	2452	52.8	51.3	3.1	8-July
HB14	2380	50.6	56.1	3.7	4-July
CT8737	2343	45.8	61.9	5.4	6-July
CA188587	2238	54.3	52.3	4.1	6-July
Myles	2221	20.2	140.7	5.5	6-July
UC27	2150	55.6	51.3	8.5	4-July
Sanford	2156	50.7	56.0	11.1	12-July
Dwelley	2152	50.8	55.8	13.2	12-July
Evans	1765	49.7	57.0	8.1	4-July
HS9	1543	44.0	64.5	9.9	6-July
Average	2140	50.5[2]	56.2[2]	7.3	
$LSD_{.05}$	291	3.3	2.4	4.7	

Planting: 25-May Harvest: 13-Sept. except CA188587 and L5 (late Sept.)
Previous crop: Winter wheat
[2] Averages of 100-seed wt. and can test do not include Myles.

Table 5. Results of the chickpea variety trial at Yellow Jacket, CO in 2000

Entry	Seed Yield kg/ha	100-seed wt. g	Can Test Seeds/oz	Green & Stained (% by wt.)	Date 50% Bloom	Date 80% Pod Maturity	Harvest Date
FLIP 97-129	1285	51.6	66.8	17.1	10-July	By 15 Aug.	20-Aug.
Myles	1276	20.1	145.1	2.9	1-July	By 15 Aug.	18-Aug.
CT8737	1275	47.1	63.8	5.5	5-July	By 15 Aug.	18-Aug.
FLIP 97-130	1269	51.8	67.5	18.8	10-July	By 15 Aug.	20-Aug.
HB14	1266	45.8	62.1	0.4	5-July	By 20 Aug.	1-Sept.
FLIP 97-217	1250	54.2	67.4	22.2	10-July	By 15 Aug.	20-Aug.
UC27	1180	54.5	55.2	5.6	2-July	By 15 Aug.	18-Aug.
CA188587	1164	50.4	58.0	2.9	4-July	By 15 Aug.	25-Aug.
FLIP 97-43	1146	59.9	57.9	18.2	4-July	By 18 Aug.	20-Aug.
Sanford	1092	46.5	62.9	2.9	9-July	By 20 Aug.	25-Aug.
HS9	1029	48.9	64.1	9.2	1-July	By 15 Aug.	18-Aug.
FLIP 97-85	1024	49.0	59.2	2.2	Late	By 25 Aug.	1-Sept.
L5	992	47.5	60.0	0.5	5-July	By 20 Aug.	1-Sept.
Evans	905	43.3	65.6	0.2	6-July	By 20 Aug.	1-Sept.
Dwelley	888	47.0	61.8	2.2	10-July	By 20 Aug.	1-Sept.
CA9783007W*	778	55.1	59.2	9.9	10-July	By 30 Aug.	1-Sept.
CA9783072C*	739	45.6	62.6	0.7	10-July	By 25 Aug.	1-Sept.
CA9783163C*	609	58.8	53.2	9.1	Late	By 25 Aug.	1-Sept.
CA9783152C*	576	48.4	59.4	1.3	Late	By 30 Aug.	1-Sept.
Average	1039	50.3**	61.5**	6.9			
$LSD_{.05}$	374	5.4	4.8	6.5			

Planting: 26-May, Previous crop: Fallow

* Two Replications

** Averages of 100-seed wt. and can test do not include Myles.

Year 2001:

Seed yield averaged 767 kg ha^{-1} (456 to 1040 kg ha^{-1}) in 2001, which was also a dry year. 'HB19' had the highest seed yield followed by CA188587 (Table 6). HB14 and CA9783163C had the lowest yields (Table 6). As in 1999 and 2000, the ICRISAT-ICARDA entries had a high percentage of odd seeds. HB14 had the highest percentage of odd seeds (18.3%), in sharp contrast with 2000 (0.4%). HB14 reached 80% pod maturity at about the same time (3rd week of August) in 2000 and 2001, but was harvested much earlier in 2000. The earlier seed maturation could explain the low percentage of odd seeds in 2000.

Year 2003:

Several of the entries from the 2003 Western Regional Chickpea Trials did poorly at Yellow Jacket (Table 7). All entries beginning with ”CA” and ending with ”W” and CA978163C produced less than 700 kg ha^{-1}. They matured late and had a poor pod set. The top five entries produced around 1100 kg ha^{-1}. CA99901895C had the best appearance in the field (upright

architecture, good pod set) and could easily be harvested and threshed in one operation (direct combining). It also had a lower incidence of odd seeds than HB19 and the other top performers (ICRISAT-ICARDA entries) (Table 7).

Table 6. Results of the chickpea variety trial at Yellow Jacket, CO in 2001

Entry	Seed Yield kg/ha	100-seed wt. g	Can Test Seeds/oz	Green & Stained (% by wt.)	Date 50% Bloom	Date 80% Pod Maturity	Harvest Date
HB19	1040	56.9	49.9	4.0	30-June	21-Aug.	8/30
CA188587	955	53.1	53.5	1.7	27-June	20-Aug.	9/11,10/18
HS9	901	45.3	62.7	0.3	25-June	21-Aug.	8/29
Myles	896	20.0	142.0	0.5	27-June	17-Aug.	8/28
FLIP 97-43	849	50.5	56.2	13.8	27-June	21-Aug.	8/29
CT8737	828	47.4	60.0	3.0	27-June	19-Aug.	8/29
FLIP 97-129	786	45.7	62.1	11.6	2-July	19-Aug.	8/28
Sanford	785	48.1	59.0	6.3	3-July	27-Aug.	8/30,10/18
FLIP 97-217	775	43.2	65.7	3.6	1-July	18-Aug.	8/28
CA9783152C	747	51.9	54.7	3.8	29-June	10-Sept.	10/18
FLIP 97-130	741	43.7	65.1	5.9	3-July	18-Aug.	8/28
UC27	731	55.5	51.2	1.3	25-June	18-Aug.	8/28
Dwelley	682	53.5	53.1	3.7	6-July	6-Sept.	10/18
Evans	665	47.5	59.8	5.3	28-June	26-Aug.	8/30,10/18
FLIP 97-85	651	47.7	59.5	6.8	3-July	27-Aug.	9/11,10/18
HB14	556	48.4	58.7	18.3	25-June	20-Aug.	10/18
CA9783163C	456	57.5	49.4	1.7	5-July	11-Sept.	9/11,10/18
Average	767	49.7*	57.5*	5.4			
$LSD_{.05}$	183	1.7	2.0	5.7			

Planting: 11-May, Previous crop: Fallow

* Averages of 100-seed wt. and can test do not include Myles.

1999-2001 Averages:

Averaging the trials from 1999 through 2001, FLIP 97-217, FLIP 97-129, FLIP 97-130, and CT8737 had the highest seed yield and Dwelley, HS9, and Evans the lowest seed yield (Table 8). The top ICRISAT-ICARDA lines exhibited good disease resistance, plant architecture (upright), and productivity but had a high percentage of odd seeds compared to CT8737. All four entries had a similar seed count of 60 to 61 seeds/oz. They all reached 80% pod maturity by mid-August, but CT8737 matured more uniformly and exhibited a somewhat less indeterminate growth habit than the top ICRISAT-ICARDA lines. These lines may be less adapted to the climatic conditions in southwestern Colorado than CT8737 based on their geographic origin (Middle East).

Beside CT8737, another promising entry is CA188587. It averaged 1449 kg ha^{-1} over three years, had a low percentage of odd seeds, low seed count (54 seeds/oz), and cream color. Its low

seed count and creamy color makes it suitable for canning. It also performed well in the 2003 variety trial (Table 7). Desirable qualities for canning include medium seed size (54 to 56 seeds/oz.), pale cream color, rough texture, high water intake, and a seed coat that does not fracture easily (Brick et al., 1988). One disadvantage of CA188587 compared to CT8737 is its 'bushy' architecture (less erect than CT8737 and pods are closer to the ground), which makes it less suitable for direct harvesting.

HB19 was a top seed producer in 2001 and 2003 but had a high percentage of odd seeds in 2003. Both CT8737 and HB19 are privately owned varieties and may only be available for commercial production in California under contract.

Table 7. Results of the chickpea variety trial at Yellow Jacket, CO in 2003

Entry	Seed Yield kg/ha	100-seed wt. g	Can Test Seeds/oz	Green & Stained (% by wt.)	Date 50% Bloom	Date 80% Pod Maturity	Harvest Date
HB19	1231	58.3	48.7	17.4	9-July	20-Aug.	20-Aug.
F97129	1117	44.1	64.3	19.6	5-July	20-Aug.	22-Aug.
F97217	1077	44.3	64.0	18.4	5-July	20-Aug.	22-Aug.
F97130	1076	43.7	64.9	15.9	5-July	20-Aug.	20-Aug.
CA188587	1072	51.8	54.8	6.5	7-July	15-Sept.	15-Sept.
CA99901895C	1044	45.2	62.7	2.3	8-July	10-Sept.	15-Sept.
UC27	1008	51.2	55.4	3.5	7-July	20-Aug.	20-Aug.
CT8737	1006	44.6	63.5	3.7	6-July	15-Aug.	20-Aug.
CA9990B1579C	955	49.5	57.3	1.6	14-July	20-Sept.	18-Sept.
CA99901604C	946	57.7	49.1	2.8	7-July	2-Sept.	3-Sept.
Sanford	930	46.8	60.6	11.5	9-July	17-Sept.	15-Sept.
CA1888359	850	51.1	55.5	2.5	6-July	15-Sept.	18-Sept.
CA9783152C	844	48.6	58.3	2.5	6-July	16-Sept.	15-Sept.
CA9990B1514C	813	49.5	57.3	1.8	5-July	16-Sept.	18-Sept.
CA99901861W	661	56.0	50.7	4.4	7-July	19-Sept.	25-Sept.
CA9890169W	613	57.7	49.2	2.9	10-July	20-Sept.	25-Sept.
CA9783163C	397	55.6	51.0	3.6	9-July	Late	25-Sept.
CA9890233W	367	57.6	49.3	8.2	6-July	22-Sept.	25-Sept.
CA99901875W	253	57.0	49.7	6.8	6-July	Late	25-Sept.
CA9890239W	217	55.6	51.1	3.6	8-July	24-Sept.	25-Sept.
Average	824	51.3	55.9	7.0			
$LSD_{.05}$	186	2.3	2.3	4.2			

Planting: 22-May, Harvest: 20-Aug. to 25-Sept.
Previous crop: Fallow

Table 8. Chickpea variety trial results at Yellow Jacket, CO. 1999-2001 averages

Entry	Plant Height[1] Cm	Seed yield kg/ha	100-seed wt. g	Can test Seeds/oz	Green & Stained (%)
FLIP 97-217	32.0	1616	47.7	65.2	12.0
FLIP 97-130	31.5	1608	46.9	65.1	12.8
FLIP 97-129	29.7	1569	47.2	64.4	24.0?
CT8737	28.7	1482	46.8	61.9	4.6
Myles	26.7	1464	20.1	142.6	2.9
CA188587	31.5	1449	52.6	54.6	2.9
HB14	36.1	1400	48.3	59.0	7.5
Sanford	35.6	1352	48.4	59.3	6.1
FLIP 97-85	31.5	1344	49.3	58.0	9.3
UC27	28.7	1343	55.2	52.6	5.1
FLIP 97-43	28.7	1337	55.8	54.5	15.2
Dwelley	32.8	1252	50.7	56.6	6.2
HS9	27.4	1157	46.1	63.8	6.5
Evans	36.1	1111	46.8	60.8	4.6
Average	31.2	1392	51.8[2]	56.0[2]	8.5
$LSD_{.05}$	-	152	1.5	1.4	4.2

[1] Average of 2000 and 2001 measurements
[2] Averages of 100-seed wt. and can test do no include 'Myles'.

Conclusion

Chickpea yields were exceptionally high in 1999, nil in 2002, and average in 2000, 2001, and 2003. Cumulative precipitation from May through August was above average in 1999 and below average in 2000 through 2003 (Table 1). The period from September 2001 through August 2002 was extremely dry, which explains the failure of the chickpea crop in 2002. Production in 2000, 2001, and 2003 was helped by the long fallow period—19 months—that preceded chickpea (winter wheat-fallow-chickpea). More soil moisture was available at planting than if chickpea followed winter wheat (winter wheat-chickpea).

Among the top entries, only two were consistent in terms of both seed yield and quality: CT8737 and CA188587. CA99901895C showed promise but was tested in 2003 only. Producing chickpea with acceptable seed quality could be a challenge in southwestern Colorado due to the short growing season and late summer rains, which tend to trigger new growth and delay seed maturity. Ideally, a breeding program should be conducted to develop chickpea varieties that are adapted to the unique environment of southwestern Colorado.

Part II

Evaluation of Chickpea Planting Date

Abdel Berrada

Introduction

Chickpea is more frost tolerant than dry bean and could be planted earlier e.g., prior to 25 May when the probability of a killing frost is over 50%. No studies have been done to determine the optimum planting date of chickpea in SW Colorado or a similar climate. It is recommended that chickpea be planted when soil temperature is above 5.6 ^{o}C, although "some varieties can tolerate temperatures as low as -9.4 ^{o}C in early stages or under snow cover" (Muehlbauer and Tullu, 1997). In Mediterranean type climates, chickpea is generally planted in November through February. Chickpea is a quantitative long-day plant but flowers in every photoperiod (Smithson et al., 1985).

The objective of this study was to determine the effects of planting date on seed yield, dry matter (DM) yield, and seed quality of four chickpea varieties.

Materials and Methods

The chickpea varieties used in this experiment were Dwelley, Evans, Sanford, and UC27. Dwelley, Evans, and Sanford were developed by the USDA-ARS in cooperation with Washington State University, the University of Idaho, and Oregon State University and released in 1994 and 1997 (Evans) (Muehlbauer et al., 1998a; Muehlbauer et al., 1998b; Muehlbauer and Kaiser, 2002). UC27 was released by the University of California-Davis in 1988 (Helms et al., 1992). The order of maturity (early-to-late) of these varieties is: UC27 ≥ Evans > Sanford ≥ Dwelley. Dwelley, Evans, and Sanford have good resistance to Ascochyta blight [caused by by *Ascochyta rabiei* (Pass.)] while UC27 does not. Ascochyta blight is a common and serious disease of chickpea. It spreads rapidly under cool moist conditions and is difficult to control (Wiese et al., 1995).

The four varieties were planted with a Monosem planter at approximately 6.6 seeds m^{-1} in 76.2-cm spaced rows on 22 April, 6 May, 20 May, 2 June and 16 June in 1997 and on 1 May, 5 May, 22 May, 3 June, and 16 June in 1998. Planting dates are denoted D1 (early), D2, D3, D4, and D5 (late). The original intend was to allow a two-week interval between plantings, which was realized in 1997 but not in 1998 due to rain or other unforeseen circumstances. Planting dates were assigned to the main plots and varieties to the subplots, in a split-plot design, in four randomized complete blocks. Subplot size was 3.0 x 12.2 m. The experiment was moved to a different area of the same field each year. The preceding crop was winter wheat in both years. Cicer-specific rhizobium inoculant was broadcast by hand prior to each planting at approximately 33.6 kg ha^{-1}. No fertilizer was applied in 1997 or 1998. Chickpea plots were

cultivated once or twice during the growing season and hoed when needed. Dual (S-Metolachlor) was applied at 2.34 Lha^{-1} on 30 April 1998 and incorporated to the soil with a field cultivator to control weeds.

Flowering date and pod maturity were monitored on a regular basis. At pod maturity, chickpea plants from the middle two 3.0-m rows in each plot were cut at ground level, placed in burlap sacs, and left to dry in an open shed for several weeks. After drying, they were then weighed and threshed with a Hege plot combine. The seeds were cleaned with an electric fan and by hand to eliminate plant and soil debris, weighed, and separated into "acceptable" and "odd" (green and stained) seeds and weighed again. One hundred seeds were selected at random from the "acceptable" lot seed and weighed separately. Pods were counted in 10 plants per plot in 1997. The data was analyzed using the SAS MIXED procedure (SAS Institue Inc., Cary, NC, 2000).

Climatic Conditions and Phenology

April precipitation was above normal in 1997 and near normal in 1998 (Table 1). Cumulative precipitation from May through September was 208 mm in 1997 (124% of normal) and 99 mm in 1998 (59% of normal). Temperatures were generally lower in April and May and higher in June through September in 1998 than in 1997 (http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?coyell) (verified 15 Oct. 2004).

The number of days from planting to 50% emergence was approximately 19 (D1), 15 (D2 & D3), and 9 days (D4 & D5) in 1997 and 17 (D1), 15 (D2), 11 (D3), and 9 days (D4 & D5) in 1998. Chickpea plant emergence occurred faster as planting was delayed, due to warmer conditions. Fifty percent flowering occurred from mid-June to late July of 1997, in the order (first to last): D1>D2> D3≥D4>D5 and from late June to early August of 1998, in the order: D1≥D2> D3>D4>D5. Generally, UC27 bloomed first, followed closely by Evans, then Sanford, and later Dwelley.

It took approximately two months after 50% flowering to reach 80 to 90% pod maturity. Above normal precipitation late in the season—probably in conjunction with cooler temperatures--delayed maturity and triggered new growth, as was clearly the case in 1997. Chickpea planted on 22 April 1997 (D1) was harvested on 18 August (UC27, Evans, and Sanford) or 25 August (Dwelley). All other chickpeas were harvested on 10-15 October after a hard freeze, with the exception of UC27 and Evans at D2, which were harvested on 18 August and 25 August, respectively. In 1998, chickpea was harvested on 28 September (D1-D4) and 8 October (D5).

Results

Year 1997:

On average, chickpea produced significantly lower seed yield when planted on 22 April or 5 May than when it was planted on or after 20 May. In contrast, the percentage of odd seeds generally increased as planting was delayed (Table 9). Evans and UC27 produced poor seed

quality (high % of odd seeds) when planted on or after 20 May. Dwelley and Sanford produced poor seed quality when planted in May or on 16 June, and produced acceptable seed quality when planted on 22 April or 2 June. One hundred seed weight generally increased as planting was delayed from 22 April to 20 May and either decreased or remained about the same (UC27) thereafter. Dwelley had the highest 100-seed weight followed by UC27. Sanford and Evans produced much lower 100-seed weight than Dwelley and UC27. Dwelley and UC27 produced seeds of canning quality (≤58 seeds/oz) regardless of the planting date.

Above-ground total dry matter (DM) production generally increased as planting was delayed (D3 and D4 produced about the same biomass). With the exception of D1 (all varieties) and D2 (UC27 and Evans), chickpea was harvested after a hard freeze in October. There were more pods per plant when chickpea was planted on or after 5 May, depending on the variety. The percentage of odd seeds was highest at D5 as was DM. Plant height averaged 28 to 46 cm with Sanford = Evans > Dwelley > UC27.

Year 1998:

Chickpea produced significantly higher seed yield when planted on or after 22 May than when it was planted on 1 May (Table 10). UC27 had the highest seed yield, 1544 kg ha^{-1}, compared to around 1100 to 1180 kg ha^{-1} for the other varieties. It also had the highest percentage of odd seeds, on average. The least percentage of odd seeds was achieved when chickpea was planted on 22 May (Dwelley, Evans, and Sanford) or 3 June (all four varieties). Dry matter production averaged 2580 kg ha^{-1} with no significant differences among varieties or planting dates. Dry matter production at D5 was not measured in 1998. Seed count was highest with Evans and lowest with Dwelley.

Conclusions

Chickpea produced more seeds and DM, by weigh, in 1997 than in 1998, due to more favorable moisture conditions in 1997. Seed yield generally increased as planting was delayed past early May. The least percentage of odd seeds was achieved when chickpea was planted on 22 April (all four varieties) or 5 May (Evans) in 1997 and 3 June in 1998. Seed lots with a high percentage of stained or green seeds may be rejected or sold as animal feed. There were fewer odd seeds in 1998 than in 1997 due to the drier conditions in 1998. When seed maturity is delayed due to untimely precipitation, chickpeas should be swathed and left to dry in the field for several days before they are threshed (Muehlbauer et al., 1982). Desiccants such as Paraquat dichloride (1,1'-dimethyl-4,4'-bipyridinium dichloride) could be used to hasten maturity.

Table 9. 1997 chickpea variety by planting date results

	Seed Yield (kg/ha)				
Date	Dwelley	Evans	Sanford	UC-27	Mean
22-Apr	900	681	842	830	813
5-May	1017	730	1006	884	909
20-May	1460	1404	1479	1893	1559
2-Jun	1668	1502	1254	2224	1662
16-Jun	2123	1527	1841	2591	2021
Mean	1434	1169	1284	1684	

Statistics			
Effect	DF	F Value	Pr>F
Date	4	21.81	<.0001
Variety	3	18.49	<.0001
D x V	12	3.79	0.0005
DLSM*	422		

	DM Yield (Stover + Seed, kg/ha)				
Date	Dwelley	Evans	Sanford	UC-27	Mean
22-Apr	2275	1587	1884	1633	1845
5-May	3423	2009	3358	1705	2624
20-May	4104	3666	3628	4672	4017
2-Jun	4080	4150	3504	4799	4133
16-Jun	6221	4769	5018	5220	5307
Mean	4021	3236	3479	3606	

Statistics			
Effect	DF	F Value	Pr>F
Date	4	61.58	<.0001
Variety	3	7.26	0.0005
D x V	12	4.02	0.0003
DLSM	837		

	100-seed wt. (g)				
Date	Dwelley	Evans	Sanford	UC-27	Mean
22-Apr	54.8	45.0	46.8	50.5	49.3
5-May	59.2	46.6	50.0	51.2	51.8
20-May	57.1	53.0	53.5	56.0	54.9
2-Jun	55.5	51.4	49.0	54.9	52.7
16-Jun	54.1	49.7	47.5	56.2	51.9
Mean	56.1	49.1	49.4	53.8	

Statistics			
Effect	DF	F Value	Pr>F
Date	4	11	0.0006
Variety	3	77.51	<.0001
D x V	12	5.79	<.0001
DLSM	2.5		

	Seeds/oz				
Date	Dwelley	Evans	Sanford	UC-27	Mean
22-Apr	51.8	63.1	60.8	56.2	58.0
5-May	47.9	60.8	56.9	55.4	55.3
20-May	49.7	53.6	53.0	50.6	51.7
2-Jun	51.2	55.2	58.0	51.7	54.0
16-Jun	52.5	57.1	59.8	50.4	54.9
Mean	50.6	57.9	57.7	52.9	

Statistics			
Effect	DF	F Value	Pr>F
Date	4	11.02	0.0005
Variety	3	67.13	<.0001
D x V	12	5.17	<.0001
DLSM	3.1		

	Odd Seeds (%)				
Date	Dwelley	Evans	Sanford	UC-27	Mean
22-Apr	0.8	0.5	0.7	0.9	0.7
5-May	35.7	0.2	35.0	2.2	18.3
20-May	30.5	36.3	29.9	32.5	32.3
2-Jun	8.6	21.4	7.1	30.5	16.9
16-Jun	73.1	48.1	34.8	39.7	48.9
Mean	29.7	21.3	21.5	21.2	

Statistics			
Effect	DF	F Value	Pr>F
Date	4	43.69	<.0001
Variety	3	4.41	0.0084
D x V	12	9	<.0001
DLSM	13.5		

Table 9 (Continued)

	Total pods/plant				
Date	Dwelley	Evans	Sanford	UC-27	Mean
22-Apr	13.5	14.1	13.8	18.3	14.9
5-May	39.3	13.8	30.5	19.4	25.7
20-May	27.8	46.7	28.3	69.0	42.9
2-Jun	28.0	31.6	18.3	50.1	32.0
16-Jun	41.4	31.5	34.3	69.3	44.1
Mean	30.0	27.5	25.0	45.2	

Statistics			
Effect	DF	F Value	Pr>F
Date	4	16.24	<.0001
Variety	3	22.6	<.0001
D x V	12	7.9	<.0001
DLSM	13.50		

	Height (cm)				
Date	Dwelley	Evans	Sanford	UC-27	Mean
22-Apr	13.9	14.5	14.7	12.1	13.8
5-May	15.3	15.0	17.8	10.9	14.7
20-May	13.2	16.1	15.3	14.0	14.7
2-Jun	14.1	15.7	15.8	12.3	14.5
16-Jun	15.3	18.1	17.0	13.3	15.9
Mean	14.4	15.9	16.1	12.5	

Statistics			
Effect	DF	F Value	Pr>F
Date	4	7.24	0.0033
Variety	3	41.73	<.0001
D x V	12	3.38	0.0015
DLSM	3.2		

* DLSM: Difference of Least Square Means

Table 10. 1998 chickpea variety by planting date results

	Seed Yield (kg/ha)				
Date	Dwelley	Evans	Sanford	UC-27	Mean
1-May	997	1027	1156	1138	1079
8-May	981	1069	1074	1368	1123
22-May	1344	1032	1110	1766	1313
3-Jun	1395	1195	1323	1582	1374
16-Jun	1135	1189	1242	1864	1357
Mean	1170	1102	1181	1544	

Statistics			
Effect	DF	F Value	Pr>F
Date	4	4.97	0.0135
Variety	3	16.29	<.0001
D x V	12	1.79	0.0797
DLSM*			
Date	192		
Variety	306		

	DM Yield (Stover + Grain, kg/ha)				
	Dwelley	Evans	Sanford	UC-27	Mean
1-May	2414	2383	2601	2259	2414
8-May	2207	2478	2357	2646	2422
22-May	2682	2488	2425	3141	2684
3-Jun	2898	2784	2813	2705	2800
16-Jun	-	-	-	-	-
Mean	2550	2533	2549	2688	

Statistics			
Effect	DF	F Value	Pr>F
Date	3	2.48	0.1271
Variety	3	0.66	0.5834
D x V	9	1.52	0.1771

	100-seed wt				
	Dwelley	Evans	Sanford	UC-27	Mean
1-May	56.1	46.3	49.3	49.3	50.3
8-May	56.4	48.0	50.5	51.1	51.5
22-May	54.7	48.4	49.1	53.7	51.5
3-Jun	53.5	46.9	48.5	52.1	50.3
16-Jun	57.3	47.5	47.8	54.9	51.9
Mean	55.6	47.4	49.0	52.2	

Statistics			
Effect	DF	F Value	Pr>F
Date	4	5.93	0.0072
Variety	3	193.43	<.0001
D x V	12	6.40	<.0001
DLSM	1.7		

	Seeds/oz				
Date	Dwelley	Evans	Sanford	UC-27	Mean
1-May	50.6	61.4	57.6	57.6	56.8
8-May	50.4	59.2	56.3	55.6	55.4
22-May	52.0	58.7	57.8	53.0	55.4
3-Jun	53.2	60.6	58.6	54.5	56.7
16-Jun	49.6	59.9	59.5	51.7	55.2
Mean	51.1	60.0	58.0	54.5	

Statistics			
Effect	DF	F Value	Pr>F
Date	4	6.19	0.0061
Variety	3	202.74	<.0001
D x V	12	6.43	<.0001
DLSM	1.8		

	Odd Seeds (%)				
	Dwelley	Evans	Sanford	UC-27	Mean
1-May	14.3	22.3	14.0	42.0	23.2
8-May	11.0	21.8	10.8	32.0	18.9
22-May	2.4	9.0	5.5	20.5	9.4
3-Jun	2.0	5.0	1.6	2.6	2.8
16-Jun	27.5	13.8	9.3	14.3	16.2
Mean	7.4	14.5	8.0	24.3	

Statistics			
Effect	DF	F Value	Pr>F
Date	4	10.55	0.0007
Variety	3	16.07	<.0001
D x V	12	4.93	<.0001
DLSM	10.9		

* DLSM: Difference of Least Square Means

Part III

Chickpea Response to N fertilization and Irrigation

Abdel Berrada

Introduction

Published estimates of N_2 fixation in chickpea range from 0 to 176 kg N ha^{-1} depending on environmental conditions, variety, and presence of appropriate strain of rhizobia (Beck, 1992). Nitrogen fixed by chickpea in New South Wales in Australia averaged 73 kg N ha^{-1} (range: 4 to 116 kg ha^{-1}). The portion of N derived from N_2 fixation averaged 57% (range: 4 to 79%) (Marcellos et al., 1998). In a two-year study, Horn et al (1996) reported a low amount of N_2 fixation, 15 to 32 kg N ha^{-1}, due to high initial soil nitrate levels and low total biomass caused by low rainfall.

Information on the response of chickpea to N fertilization is scarce. In general, it is believed that well nodulated and actively N_2 fixing chickpeas do not require N fertilizer for optimum growth. Moreover, high soil N levels may inhibit nodulation and N_2 fixation (Horn et al., 1996) and cause excessive vegetative growth. Saxena (1980) reported a positive response to N fertilization in soils with poor nodulation or low organic matter. A small amount (10 to 15 N kg ha^{-1}) of starter N fertilizer is sometimes recommended since nodules take six to eight weeks to form. Seed reserves of N tend to run out before that time, which can lead to N deficiency during early growth (Loss et al., 1998).

Chickpea is mostly produced under rainfed conditions but will respond positively to irrigation. Applying one or two irrigations at flowering or pod-filling increased chickpea seed yield by 92% in northern Syria (Zhang et al., 2000). The increase was smaller in the wet years than in the dry years. Chickpea seed yield increased linearly with the amount of water applied [kg ha^{-1} = 5.14 (mm - 106.8), r^2 = 0.73].

Nielson (2001) found a strong correlation between *Kabuli* chickpea seed yield and water use [kg ha^{-1} = 10.6 (mm-147.2), r^2 = 0.81] at Akron, CO. Chickpea yield ranged from 600 to 3500 kg ha^{-1} with 220 to 420 mm of water use. Nielson (2001) also summarized the response to water use reported by various authors. Miller et al. (2001) reported chickpea water use efficiencies (WUE) of 2.5 to 13.6 kg $mm^{-1}ha^{-1}$ (mean of 6.2 kg $mm^{-1}ha^{-1}$) in the northern Great Plains. Grewal et al. (1984) reported WUEs of 4.3 to 4.7 kg $mm^{-1}ha^{-1}$ in a high rainfall area and 5.3 to 6.2 kg $mm^{-1}ha^{-1}$ in a low rainfall area. Water use efficiency was highest when there was no irrigation.

Few studies have looked at chickpea response to N under varying irrigation depths. Furthermore, research information is generally lacking on chickpea adaptability and agronomic feasibility in marginal chickpea production areas such as the high plains of the southwestern U.S.

The main objective of this study was to determine the response of two chickpea varieties to gradient irrigation, with or without N fertilization.

Materials and Methods

Water was applied with a line-source sprinkler irrigation system similar to the one described by Hanks et al. (1976). The irrigation pipes were laid out perpendicular to the chickpea rows. Row length was 18.3 m on each side of the irrigation line. Water pressure at the inlet manifold was maintained at approximately 0.28 MPa (40 psi) throughout the irrigation season, except in 1999 when water pressures as low as 0.14 MPa (20 psi) were recorded. Water was applied once or twice a week under calm conditions (wind speed $\leq$3.2 km hr^{-1}). Irrigation was usually stopped when water started to run off the soil surface. Irrigation depth was measured at 1.8, 5.5, 9.1, 12.8, and 16.5 m from the sprinkler line in two replications. Total water applied decreased linearly as the distance from the sprinkler line increased, except in 1999 due to variations in water pressure (Fig. 1). Nine irrigation levels (ilevel) were distinguished for harvest purposes as shown in Fig. 2. Soil moisture content was monitored with a neutron probe on a weekly basis, starting in mid- to late June of each year. Measurement depths were 0.0 to 30.5 cm, 30.5 to 61.0 cm, 61.0 to 91.5 cm, and 91.5 to 122.0 cm. The access tubes for the neutron probe were placed next to the plastic cups (mounted on a metal rod) used to measure irrigation depth.

Two N fertilizer rates were tested each year, a check and 56 to 78 kg N ha^{-1}. The higher rate was used in 1999 due to an error in adjusting the fertilizer spreader. Urea (1994) or ammonium nitrate was broadcast by hand (1994-1996) or with a fertilizer spreader (1999) one to two weeks before planting chickpea and incorporated in the soil with a field cultivator. Approximately 19.6 kg P ha^{-1} was applied uniformly to the whole plot area each year, except in 1999 when no P was added. Soil pH averaged 7.1 to 7.6 and organic matter 0.7 to 1.0%. Soil test NO_3-N levels in the 0- to 30.5 cm depth averaged 3, 1, 4, and 9 mg kg^{-1} in 1994, 1995, 1996, and 1999, respectively.

In 1994, two separate but identical experiments were conducted; one was planted to Dwelley and the other to Sanford. In each experiment, N fertilizer (Check and 56 kg N ha^{-1}) was applied at random in each of three blocks that ran across the irrigation line. Both experiments were located on the same field and managed the same way. Soil water content was monitored in the Sanford trial only.

A similar experiment was conducted in 1995 and 1996 using Sanford only. The number of replications was four in 1995 and six (three on each side of the irrigation line) in 1996. In 1999, chickpea variety (Sanford or Dwelley) was assigned to the main plots and N rate to the subplots (split-plot design) in three replicates on each side of the irrigation line.

Individual plot (irrigation level x chickpea variety x N rate) size was 3.0 x 1.8 m in 1994 to 1996 and 4.6 x 1.8 m in 1999. Plot location varied each year but soil type remained the same: Wetherill loam (fine-silty, mixed, superactive, mesic, Aridic Haplustalf).

Kabuli chickpea varieties Dwelley and Sanford were used in the study because of their resistance to Ascochyta blight (Muehlbauer et al., 1998a and 1998b). Ascochyta blight [caused by *Ascochyta rabiei* (Pass)] is a serious chickpea disease that spreads rapidly under cool moist conditions and is difficult to control (Wiese et al., 1995). Dwelley is a few days later than Sanford and produces larger seeds (Muehlbauer et al., 1998a and 1998b).

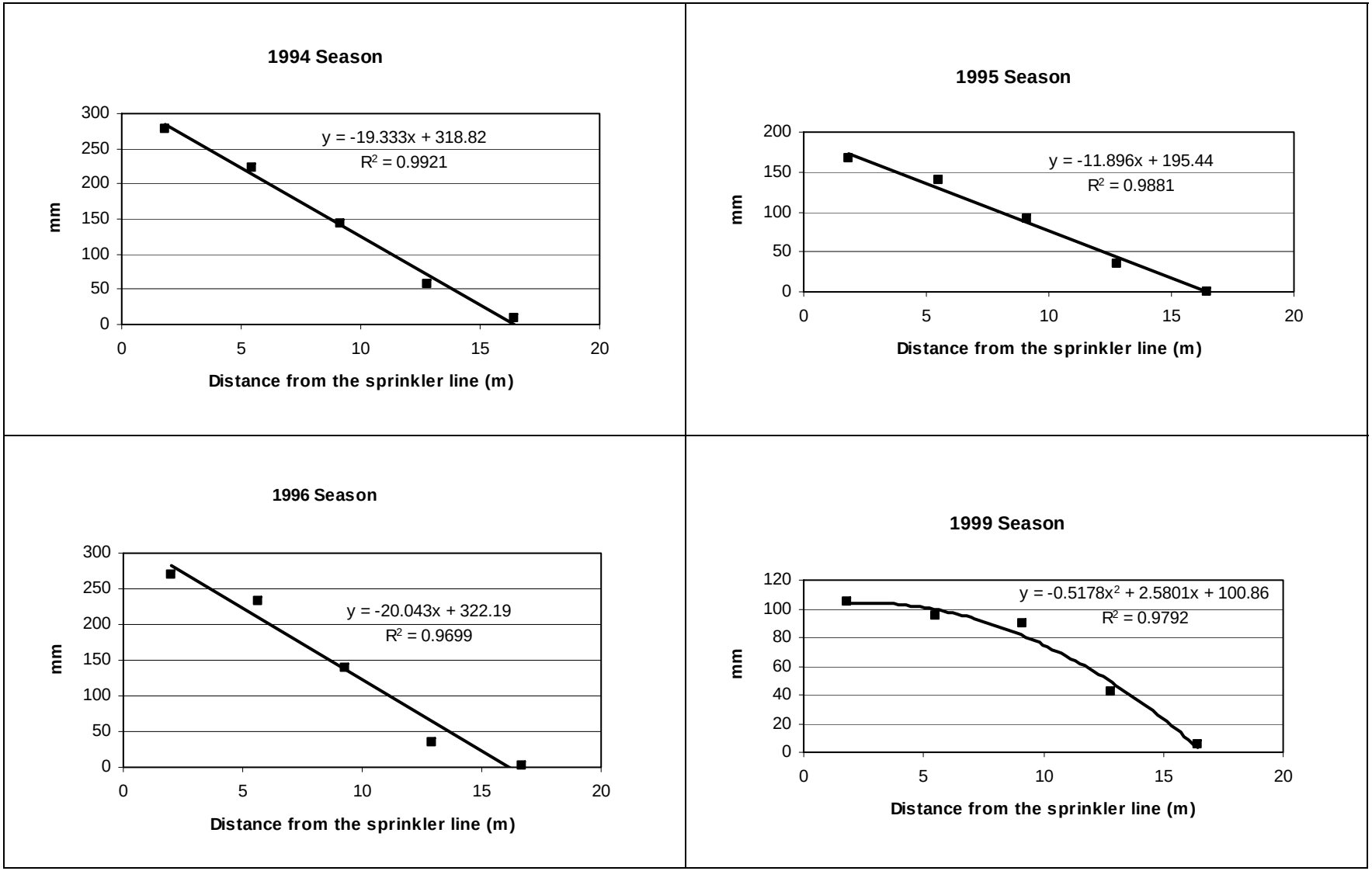
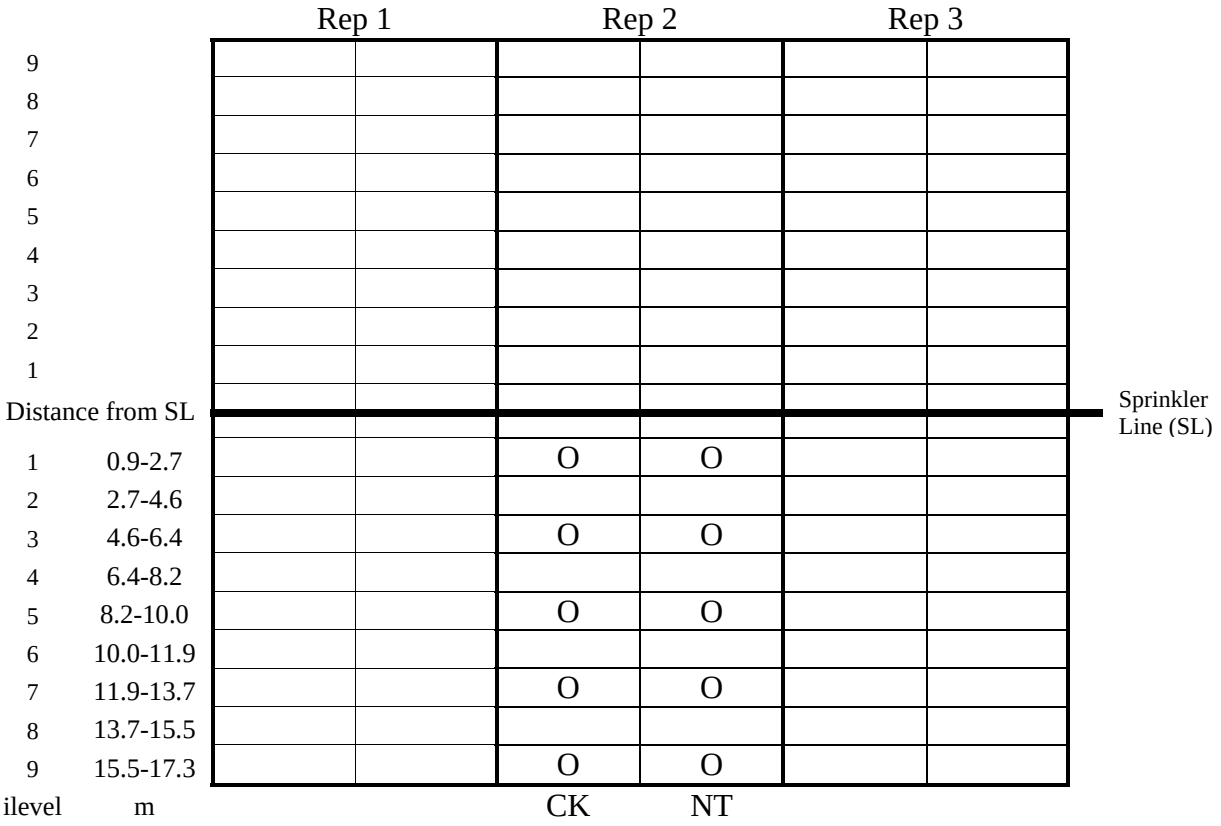


Figure 1. Irrigation amount (mm) as a function of the distance (m) from the sprinkler line



ilevel: Irrigation level
CK: Check NT: Nitrogen Treatment
O: Soil moisture and precipitation measurement location

Figure 2. Plot diagram

Chickpea was planted with a 4-row White Air Planter in 1994, 1995, and 1996 and with a 4-row Monosem Planter in 1999 in 76.2-cm spaced rows. Seeding rate was approximately 9.8 seeds m^{-1} of row in 1994 and 1995 and 13.1 seeds m^{-1} of row in 1996 and 1999. Planting occurred on 2 June, 5 May, 21 May, and 25 May in 1994, 1995, 1996, and 1999, respectively. Weeds were controlled mechanically (row cultivation) and by hand. In addition, Dual (S-Metolachlor) was applied pre-plant at 2.2 to 2.8 kg $a.i.ha^{-1}$ and incorporated with a field cultivator to control pigweeds and night shade.

At pod maturity, all the chickpea plants in the middle two rows of each plot were cut at ground level, placed in burlap sacs, and left to dry for several weeks before being weighed and threshed with a Hege plot combine. The seeds were cleaned with an electric fan and by hand to eliminate plant and soil debris and weighed. One-hundred whole seeds from ilevels 1, 3, 5, 7, and 9 were also weighed.

Water used by chickpea was calculated by subtracting the change in available soil moisture from the total amount of precipitation (irrigation plus rain) for the period in consideration. Water use from planting to the first neutron probe reading was estimated from precipitation and ET data. Water use efficiency is: total above-ground biomass or seed yield per mm of water used and is expressed in kg $mm^{-1}ha^{-1}$.

Analyses of variance and differences of least square means were performed using PROC MIXED (SAS Institue Inc., Cary, NC, 2000). The irrigation response data was fitted using SigmaPlot 8.0 (SPSS Inc., Chicago, IL, 2002).

Results

Year 1994:

Dwelley seed yield averaged 900 kg ha^{-1} in the check (CK) and 1963 kg/ha in the N treatment (NT) (Table 11). Differences among irrigation levels were not significant in CK. In NT, Dwelley seed yield increased significantly as precipitation amount (PP) increased. It reached a plateau of about 2400 kg ha^{-1} at PP=210 to 316 mm and dropped to 2050 kg ha^{-1} at PP=352 mm (Fig. 3). There was a similar drop in DM yield in NT (Fig. 4). Dwelley DM yield increased linearly with precipitation amount in CK. A quadratic (seed) or cubic (DM) function provided the best fit in NT (Table 12).

Dry matter and seed yield of Sanford increased significantly with increasing amount of precipitation (PP) in both CK and NT (Table 13). Sanford seed yield was greater than that of Dwelley in CK and about the same, on average, in NT. As would be expected, precipitation use efficiencies (PUEs) exceeded water use efficiencies (WUEs)--since PP<Water Use (WU)--in the order: DM PUE>Seed PUE>DM WUE>Seed WUE (Table 13). In CK, PUEs and WUEs generally decreased as PP or water use increased. Precipitation use efficiencies followed a similar pattern in NT, while WUEs increased as PP increased, up to 210 mm and declined thereafter.

Assuming that Sanford used similar amounts of water in CK and NT (PP was the same); greater PUEs and WUEs were achieved in NT than in CK, except in the two driest treatments where there were fewer differences between CK and NT. The yield response to water use was linear (CK) or sigmoidal (NT) as shown in Table 12 and figures 5 and 6.

As with DM and seed yield, the 100-seed weight of Dwelley and Sanford was impacted by N fertilization, ilevel, and N x ilevel (Tables 11 and 13). Nitrogen fertilization caused a significant increase in 100-seed weight. The increase was larger in Dwelley than in Sanford. In CK, the 100-seed weight of Dwelley decreased as PP increased, up to 210 mm. In NT, 100-seed weight averaged 58.3 g at PP≤210 mm, 52 g at PP=281 mm, and 47 g at PP=352 mm. The 100-seed weight of Sanford was highest at PP≤140 mm in CK, at PP=140 to 175 mm in NT, and lowest at PP≥281 mm in both CK and NT.

Year 1995:

In 1995, DM and seed yield of Sanford increased significantly with increasing precipitation amount (Table 14). There were no significant differences in DM or seed yield between CK and NT (same ilevel comparison), except at the highest ilevel of 317 mm of precipitation for which NT>CK. One hundred seed weight was in the order: ilevel 5=7=9>3>1 when averaged over N rate. Seed WUE averaged 4.9 kg $mm^{-1}ha^{-1}$ and DM WUE averaged 10.7 kg $mm^{-1}ha^{-1}$ with minor differences among N rate or ilevels. In contrast, PUEs generally decreased as precipitation amount increased. Seed and DM yields were closely correlated to water use (Table 12 and Fig. 7-8).

Year 1996:

Nitrogen fertilization, ilevel, and N x ilevel had a significant impact on seed yield, DM yield, and 100-seed weight in 1996. Greater DM and seed yields were achieved in NT than in CK, except at the driest treatment (Table 15). Seed yield increased with increasing precipitation amount, up to approximately 1100 kg/ha in CK (PP=250 mm) and 1700 kg ha^{-1} in NT (PP=287 mm). Dry matter yield followed a similar trend.

Precipitation and WUEs were much lower in 1996 than in 1994 or 1995 due to lower seed and DM yields in 1996. Seed WUE averaged 3.6 kg $mm^{-1}ha^{-1}$ at ilevels 1 and 6, 3.4 kg $mm^{-1}ha^{-1}$ at ilevel 7, and 3.1 to 3.2 kg $mm^{-1}ha^{-1}$ at the other irrigation levels. Dry matter WUE averaged 8.5 kg $mm^{-1}ha^{-1}$ (ilevels 1 and 6) to 7.5 kg $mm^{-1}ha^{-1}$ (all other levels). Precipitation use efficiencies generally decreased with increasing precipitation amounts. Nitrogen fertilization increased WUE and PUE, on average, compared to the check with no N added. Dry matter and seed yields increased linearly with increasing water use in CK and closely matched a sigmoidal pattern in NT (Table 12 and Fig. 9-10).

Year 1999:

Chickpea variety did not have a significant impact on any of the response variables; therefore, the results were averaged over the two varieties, Dwelley and Sanford (Table 16). Nitrogen fertilization enhanced seed and DM yields significantly, though not as much as ilevel. The effect of N x ilevel on seed or DM yield was not significant at α=0.05. Seed and DM yields increased in a linear fashion with increasing precipitation amount, up to PP=232 mm (DM) or PP=246 mm (seed), leveled off thereafter, except for DM yield, which increased sharply at PP=260 mm. The increase in DM yield from ilevel 8 to ilevel 9 was not matched by a corresponding increase in PP and WU.

One hundred seed weight generally decreased as PP increased (Table 16). Similarly, the percentage of large seeds decreased as PP increased (data not shown). Although not measured, it can be deduced from biomass production and visual observations that more pods and seeds were produced per plant as PP increased, which more than compensated from the lower seed weight. The percentage of immature seeds averaged 4.8% in the driest treatment and 8 to 10% in the other treatments (data not shown).

Precipitation and water use efficiencies were high in 1999 compared to previous years due to favorable climatic conditions and record yields (Table 16). Seed WUE averaged 8.5 to 10.2 kg $mm^{-1}ha^{-1}$ and DM WUE averaged 18 to 26 kg $mm^{-1}ha^{-1}$. The seed yield response to water use was sigmoidal (Fig. 11) and that of DM was linear (Fig. 12).

Conclusion

As would be expected in this semi-arid environment, chickpea seed and DM yields increased significantly with increasing amounts of precipitation every year of the study. The amount of water it took to reach the maximum production varied from year to year. Water use efficiency was highest in 1999 and lowest in 1996 due to drought. Chickpea produced the maximum seed yield (3783 kg ha^{-1}) in 1999 with approximately 380 mm of water use—this amount does not include possible water extraction below 120 cm of soil depth. It took as much water in 1996 to produce half the seed yield in the N treatment.

The application of 56 to 78 kg N ha^{-1} increased seed and DM yields every year, except in 1995, in spite of a low N soil test level. The effect of N by irrigation level on seed and DM yield was significant every year of the study, except in 1999. It took 22 to 37 mm more precipitation in the control than in the N treatment to produce the maximum seed yield in 1994, 1995, and 1996.

Seed water use efficiency varied from a low of 2.5 kg $mm^{-1}ha^{-1}$ in 1996 to a high of 10.2 kg $mm^{-1}ha^{-1}$ in 1999, which was within the range of values reported by Nielson (2001), Miller et al. (2001), and Grewal et al. (1984). Seed and DM water use efficiencies were generally enhanced with N fertilization. However, N fertilization did not increase seed yield in 1995 or 1999.

As with DM and seed yields, 100-seed weight of Dwelley and Sanford was highly impacted by precipitation amount every year of the study. In 1994 (CK only) and 1999, seed weight generally decreased as precipitation increased. In 1995, seed weight was lowest in the driest treatment (PP=129 mm) and highest at PP≥171 mm in CK and PP≥215 mm in NT with no significant increase thereafter. A similar trend was observed in 1996, although the seed weight in NT reached a maximum of 47.8 g at PP=213 mm then declined to 45.5 g at PP=362 mm. In general, chickpea plants in the drier treatments were smaller and had fewer pods and seeds than those in the wetter treatments. With fewer seeds (less competition) one would expect seeds to weigh more in the drier than in the wetter treatments, although other conditions (drought severity, temperature, season length, variety, etc.) could alter this trend.

As would be expected, the seeds of Dwelley weighed distinctly more than those of Sanford, especially when N was added. This was not the case in 1999 as there were no significant differences in 100-seed weight between Dwelley and Sanford. Dwelley matures three to four days later than Sanford, has larger seeds, and usually only one seed per pod, whereas Sanford may have two seeds per pod and generally greater seed yield, as was the case in 1994. Chickpea seeds in 1999 were not certified, hence the possibility that the seeds of Dwelley and Sanford were intermingled at the warehouse where they were bought.

This study indicates a high chickpea yield potential in southwestern Colorado with limited irrigation—around 400 mm of water use (15 to 16 inches) would maximize seed production. It would be useful to determine the optimum irrigation scheduling that would produce the maximum yield while minimizing the percentage of immature (green) seeds. Late irrigations are likely to prolong chickpea growth and increase the percentage of immature seeds but this hypothesis needs to be tested. Similarly, the effects of N application on chickpea seed yield and quality should be studied in conjunction with rhizobium inoculation to assess the real need (or lack of it) for N fertilization.

Table 11. 1994 Dwelley seed and dry matter yield as influenced by precipitation amount and N fertilization

N rate: 0 (CK)					N rate: 56 kg N/ha (NT)		
Irrigation level	Total Precip.*	Seed yield	DM yield	100-seed weight	Seed yield	DM yield	100-seed weight
	mm	kg/ha	kg/ha	g	kg/ha	kg/ha	g
1	69	893	2329	48.4a**	1042	2678	56.6b**
2	104	858	2363		1267	3135	
3	140	981	2729	46.1b	1739	4255	59.8a
4	175	894	2817		1984	4625	
5	210	804	2833	39.6c	2344	5525	58.5ab
6	246	909	3315		2396	6207	
7	281	894	3184	38.2c	2469	6846	52.4c
8	316	916	3323		2369	7004	
9	352	950	3668	38.5c	2053	6393	46.6d
Average	**210**	**900**	**2951**	**42.2**	**1963**	**5185**	**54.8**
$LSD_{.05}$		NS	454		212	445	

*Rain+Irrigation
**Means followed by the same letter are not significantly different at α≤5%
Planting: 3-June
Harvest: 23-Sept., 26-Sept., and 3-Oct.
Season rainfall: 65.5 mm

Table 12. Regression equations for yield versus precipitation (PP) or water use (WU)

Year	Variety	Trt.	x (mm)	Y (kg/ha)	Regression equation, Y =f (x)	Adj. Rsq.
1994	Dwelley	NT	PP*	Seed	-286.86+20.00*x-0.04*x^2	0.960
1994	Dwelley	CK	PP	DM	1994.81+4.55*x	0.929
1994	Dwelley	NT	PP	DM	2791.26-14.78*x+0.23*x^2-0.0004*x^3	0.986
1994	Sanford	CK	WU	Seed	721.44 + 2.16*x	0.944
1994	Sanford	NT	WU	Seed	782.56+1736.54/(1+exp(-(x-218.65)/26.67))	0.999
1994	Sanford	CK	WU	DM	845.53+10.18*x	0.961
1994	Sanford	NT	WU	DM	2153.08+5915.51*exp(-exp(-(x-236.55)/68.90))	0.992
1995	Sanford	Avg.	WU	Seed	68.38+4.69*x	0.981
1995	Sanford	Avg.	WU	DM	132.70+10.58*x	0.983
1996	Sanford	CK	WU	Seed	151.79+2.18*x	0.948
1996	Sanford	NT	WU	Seed	624.51+1174.15/(1+exp(-(x-301.54)/40.94))	0.996
1996	Sanford	CK	WU	DM	269.65+5.62*x	0.965
1996	Sanford	NT	WU	DM	1591.42+2428.18/(1+exp(-(x-302.36)/40.47))	0.991
1999	Sanford	Avg.	WU	Seed	2578.83+1114.01/(1+exp(-(x-339.95)/13.80))	0.967
1999	Sanford	Avg.	WU¶	DM	-4593.59+33.78*x	0.972

*No WU data was available for Dwelley in 1994.
¶The highest WU amount (ilevel #9) was not included in the regression analysis.

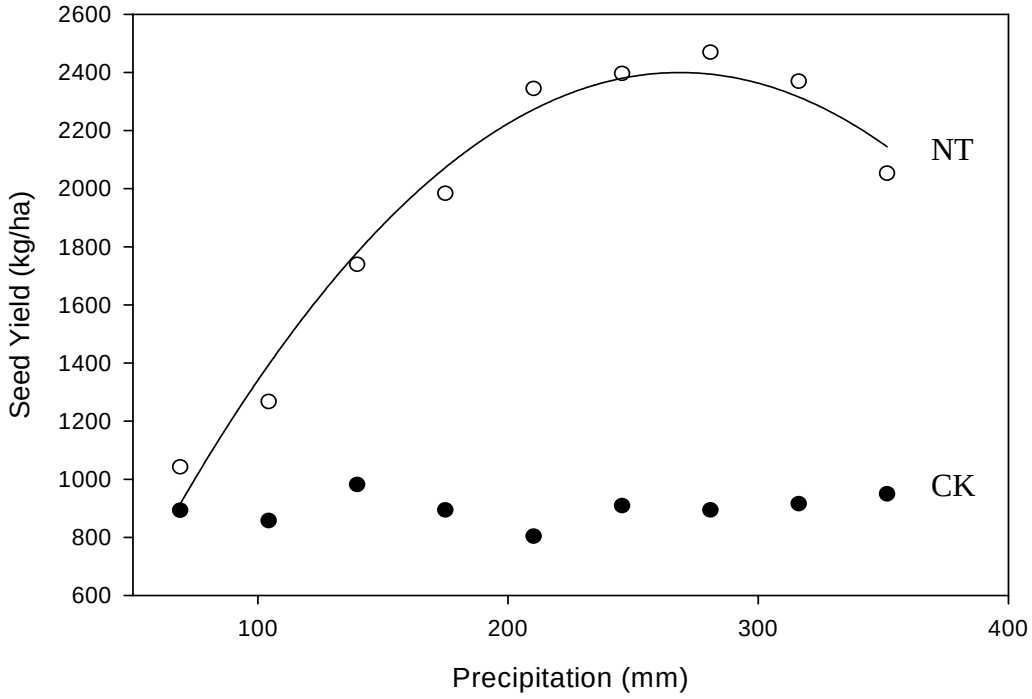


Figure 3. 1994 Dwelley seed yield as affected by precipitation amount

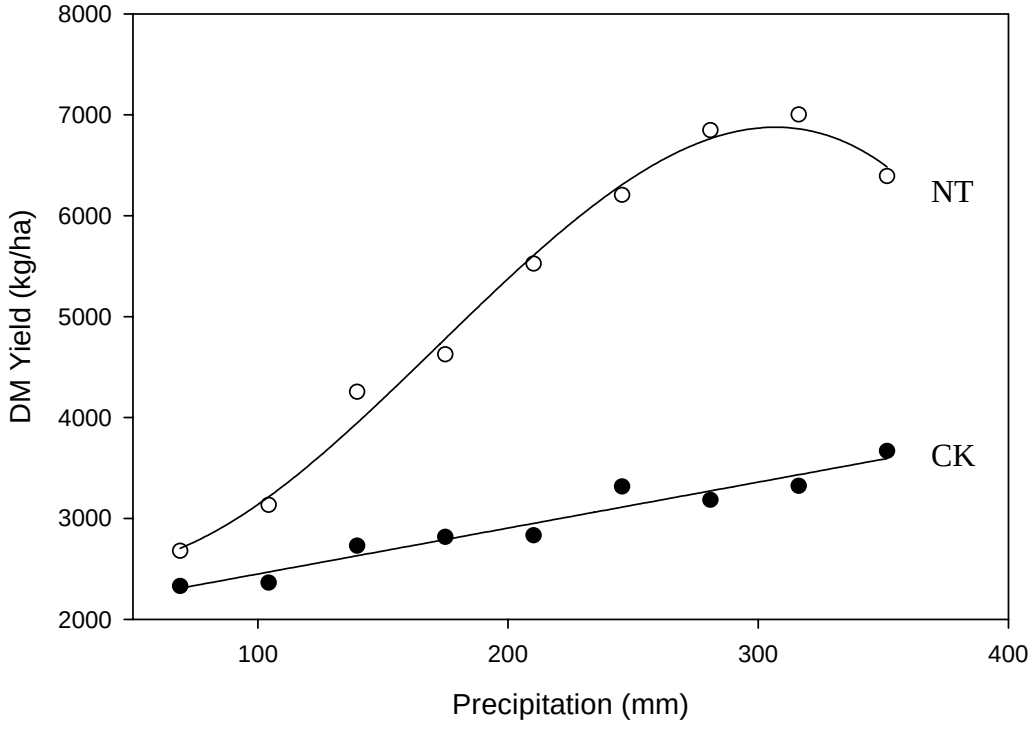


Figure 4. 1994 Dwelley DM yield as affected by precipitation amount

Table 13. 1994 Sanford yield and water use efficiency as influenced by precipitation amount and N fertilization

N rate: 0 (CK)						Water Use Efficiency		Precipitation Use Efficiency	
Irrigation level	Total Precip.*	Water used	Seed yield	DM yield	100-seed weight	Seed WUE	DM WUE	Seed WUE	DM WUE
		mm	kg/ha	kg/ha	g	kg/mm.ha	kg/mm.ha	kg/mm.ha	kg/mm.ha
1	69	148	992	2337	45.6a**	6.7	15.7	14.4	33.9
2	104	176	1088	2634		6.2	15.0	10.4	25.3
3	140	205	1148	2621	45.2a	5.6	12.8	8.2	18.8
4	175	236	1339	3545		5.7	15.0	7.7	20.3
5	210	268	1296	3612	39.8b	4.8	13.5	6.2	17.2
6	246	302	1377	4089		4.6	13.6	5.6	16.6
7	281	337	1447	4150	37.3c	4.3	12.3	5.2	14.8
8	316	374	1521	4670		4.1	12.5	4.8	14.8
9	352	412	1583	4962	36.0c	3.8	12.0	4.5	14.1
Average	**210**	**273**	**1310**	**3624**	**40.8**	**5.1**	**13.6**	**7.4**	**19.5**
$LSD_{.05}$			205	524					
N rate: 56 kg N/ha (NT)									
1	69	148	882	2281	44.8b**	5.9	15.4	12.8	33.1
2	104	176	1099	2757		6.2	15.7	10.5	26.4
3	140	205	1435	3375	48.3a	7.0	16.5	10.3	24.2
4	175	236	1894	4114		8.0	17.5	10.8	23.5
5	210	268	2294	5554	48.9a	8.6	20.7	10.9	26.4
6	246	302	2478	6050		8.2	20.1	10.1	24.6
7	281	337	2493	6739	42.4c	7.4	20.0	8.9	24.0
8	316	374	2502	7452		6.7	19.9	7.9	23.6
9	352	412	2505	7579	37.2d	6.1	18.4	7.1	21.6
Average	**210**	**273**	**1954**	**5100**	**44.3**	**7.1**	**18.2**	**9.9**	**25.3**
$LSD_{.05}$			198	469					

*Rain+Irrigation Season rainfall: 65.5 mm Planting: 2-June Harvest: 20-Sept.

**Means followed by the same letter are not significantly different at $\alpha \leq 5\%$.

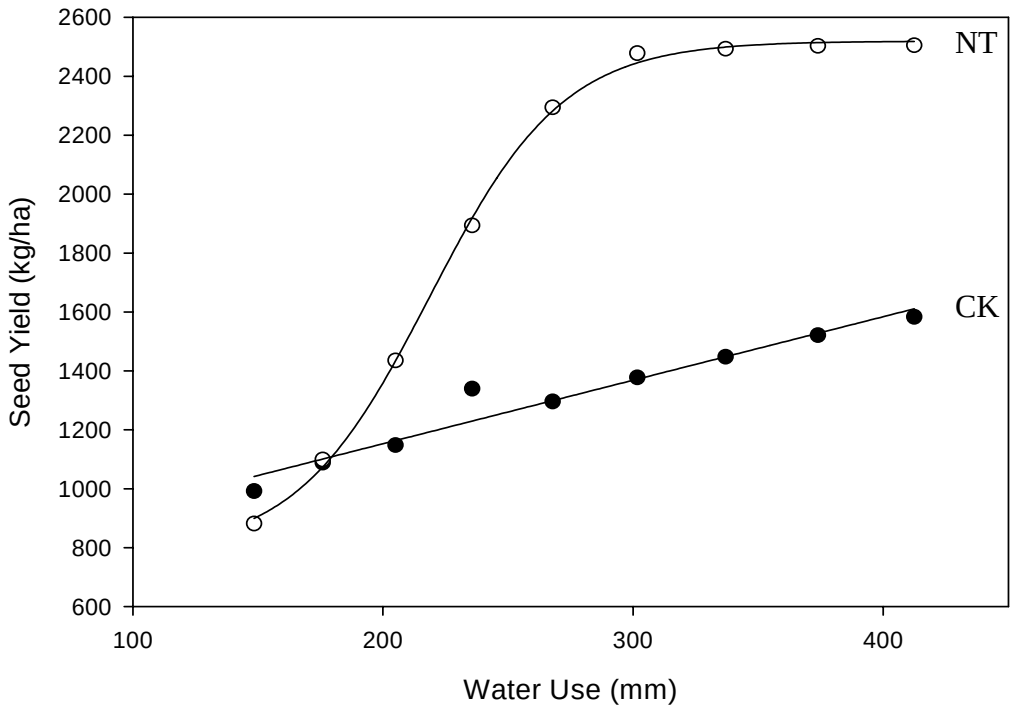


Figure 5. 1994 Sanford seed yield as affected by water use

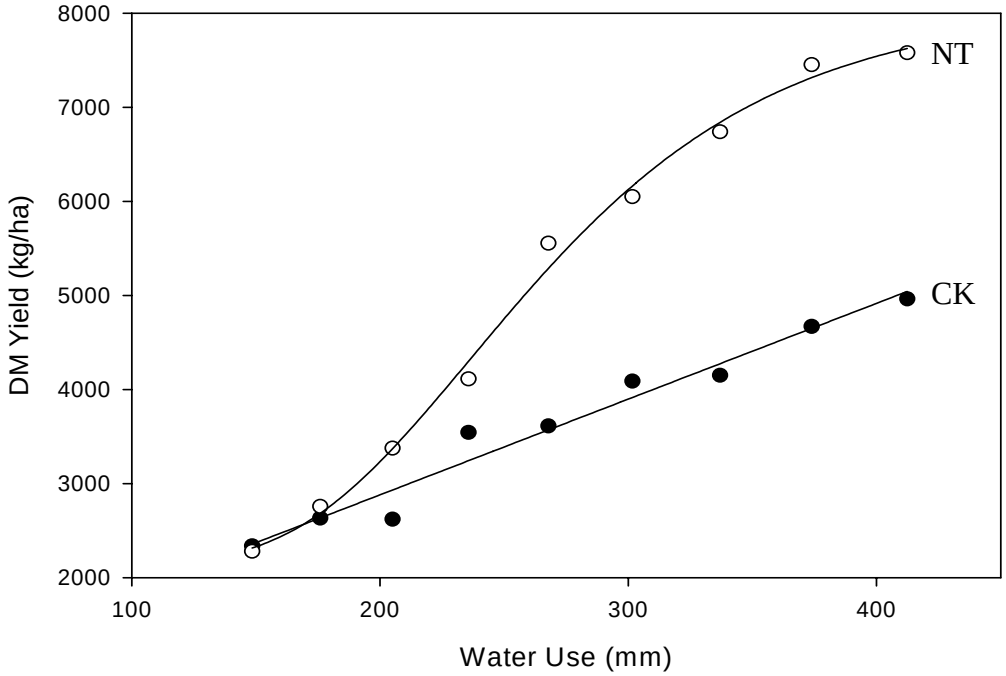


Figure 6. 1994 Sanford DM yield as affected by water use

Table 14. 1995 Sanford yield and water use efficiency as affected by precipitation amount and N fertilization

N rate: 0 (CK)						Water Use Efficiency		Precip. Use Efficiency			
Irrigation level	Total Precip.*	Water used	Seed yield	DM yield	100-seed weight	Seed WUE	DM WUE	Seed WUE	DM WUE		
	mm	mm	kg/ha	kg/ha	g	kg/mm.ha	kg/mm.ha	kg/mm.ha	kg/mm.ha		
1	129	240	1236	2728	46.6	5.1	11.4	9.6	21.1		
2	149	263	1274	2771		4.8	10.5	8.6	18.6		
3	171	285	1447	3144	48.5	5.1	11.0	8.5	18.4		
4	191	307	1539	3319		5.0	10.8	8.1	17.4		
5	215	329	1568	3451	49.3	4.8	10.5	7.3	16.1		
6	252	365	1814	3977		5.0	10.9	7.2	15.8		
7	274	386	1820	4067	49.3	4.7	10.5	6.6	14.8		
8	296	406	2050	4435		5.0	10.9	6.9	15.0		
9	317	426	1934	4251	48.6	4.5	10.0	6.1	13.4		
Average	**222**	**334**	**1631**	**3571**	**48.5**	**4.9**	**10.7**	**7.6**	**16.7**		
$LSD_{.05}$				493							
										Average	
										Seed Yield	100-seed
N rate: 56 kg N/ha (NT)										kg/ha	wt (g)
1	129	246	1264	2992	46.7	5.1	12.2	9.8	23.2	1250	46.6c**
2	149	266	1225	2809		4.6	10.6	8.2	18.9	1249	
3	171	287	1348	3064	47.2	4.7	10.7	7.9	17.9	1397	47.8b
4	191	309	1591	3508		5.1	11.4	8.3	18.4	1565	
5	215	332	1606	3722	49.0	4.8	11.2	7.5	17.3	1587	49.2a
6	252	370	1751	4152		4.7	11.2	6.9	16.5	1783	
7	274	393	1923	4380	48.4	4.9	11.1	7.0	16.0	1872	48.8a
8	296	418	2064	4724		4.9	11.3	7.0	16.0	2057	
9	317	443	2221	5110	48.9	5.0	11.5	7.0	16.1	2078	48.7a
Average	**222**	**340**	**1666**	**3829**	**48.0**	**4.9**	**11.2**	**7.7**	**17.8**	**1649**	**48.3**
$LSD_{.05}$				361						126	

*Rain+Irrigation Season rainfall: 129 mm Planting: 4-May Harvest: 24-Aug. and 31-Aug.

**Means followed by the same letter are not significantly different at $\alpha \leq 5\%$.

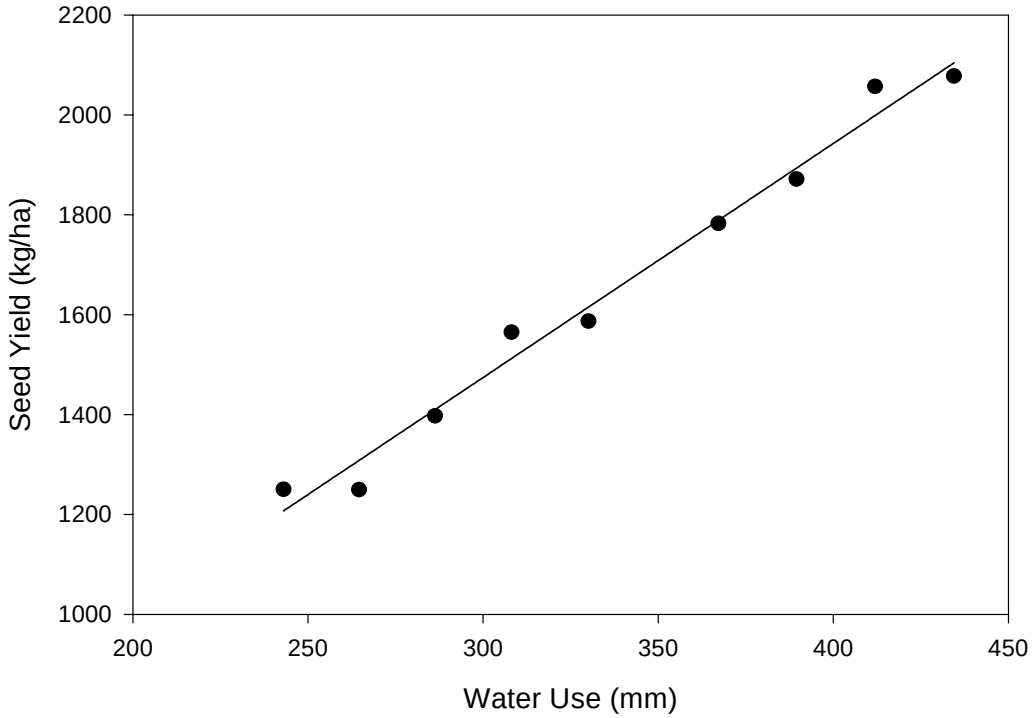


Figure 7. 1995 Sanford seed yield as affected by water use—Average of CK and NT

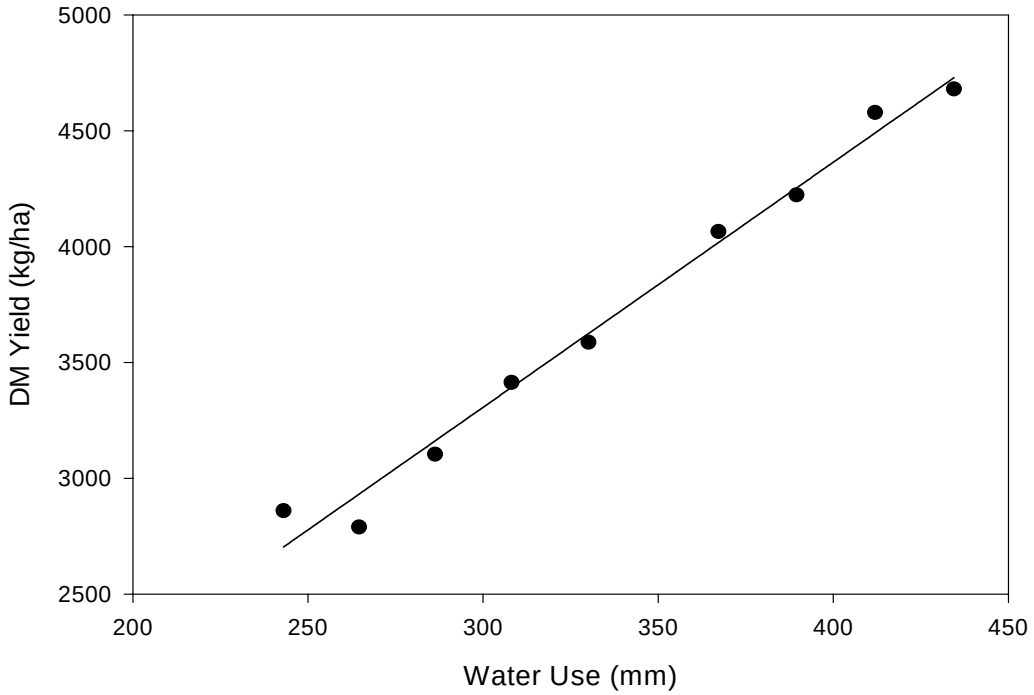


Figure 8. 1995 Sanford DM yield as affected by water use--Average of Ck and NT

Table 15. 1996 Sanford yield and water use efficiency as influenced by precipitation amount and N fertilization

N rate: 0 (CK)						Water Use Efficiency		Precipitation Use Efficiency	
Irrigation level	Total Precip.*	Water used	Seed yield	DM yield	100-seed weight	Seed WUE	DM WUE	Seed WUE	DM WUE
	mm	mm	kg/ha	kg/ha	g	kg/mm.ha	kg/mm.ha	kg/mm.ha	kg/mm.ha
1	68	174	598	1392	42.5b**	3.4	8.0	8.8	20.5
2	97	215	567	1386		2.6	6.4	5.9	14.3
3	134	254	680	1664	44.0a	2.7	6.5	5.1	12.4
4	176	305	799	1948		2.6	6.4	4.5	11.1
5	213	343	849	2036	44.2a	2.5	5.9	4.0	9.6
6	250	379	1076	2552		2.8	6.7	4.3	10.2
7	287	413	1067	2635	43.8ab	2.6	6.4	3.7	9.2
8	324	454	1128	2742		2.5	6.0	3.5	8.5
9	362	482	1190	3035	44.6a	2.5	6.3	3.3	8.4
Average	**212**	**335**	**884**	**2154**	**43.8**	**2.7**	**6.5**	**4.8**	**11.6**
$LSD_{.05}$			134	280					
N rate: 50 lb/acre (NT)									
1	68	186	681	1667	43.0d**	3.7	8.9	10.0	24.5
2	97	214	744	1851		3.5	8.6	7.7	19.1
3	134	242	869	2137	44.3c	3.6	8.8	6.5	16.0
4	176	286	1113	2514		3.9	8.8	6.3	14.3
5	213	320	1299	2997	47.8a	4.1	9.4	6.1	14.1
6	250	354	1574	3614		4.4	10.2	6.3	14.5
7	287	389	1682	3728	46.2b	4.3	9.6	5.9	13.0
8	324	433	1763	3922		4.1	9.1	5.4	12.1
9	362	468	1758	3970	45.5bc	3.8	8.5	4.9	11.0
Average	**212**	**321**	**1276**	**2933**	**45.4**	**3.9**	**9.1**	**6.6**	**15.4**
$LSD_{.05}$			124	300					

*Rain+Irrigation Season rainfall: 68 to 73 mm Planting: 21-May Harvest: 28-Aug., 4-Sept., and 10-Sept.

**Means followed by the same letter are not significantly different at $\alpha \leq 5\%$.

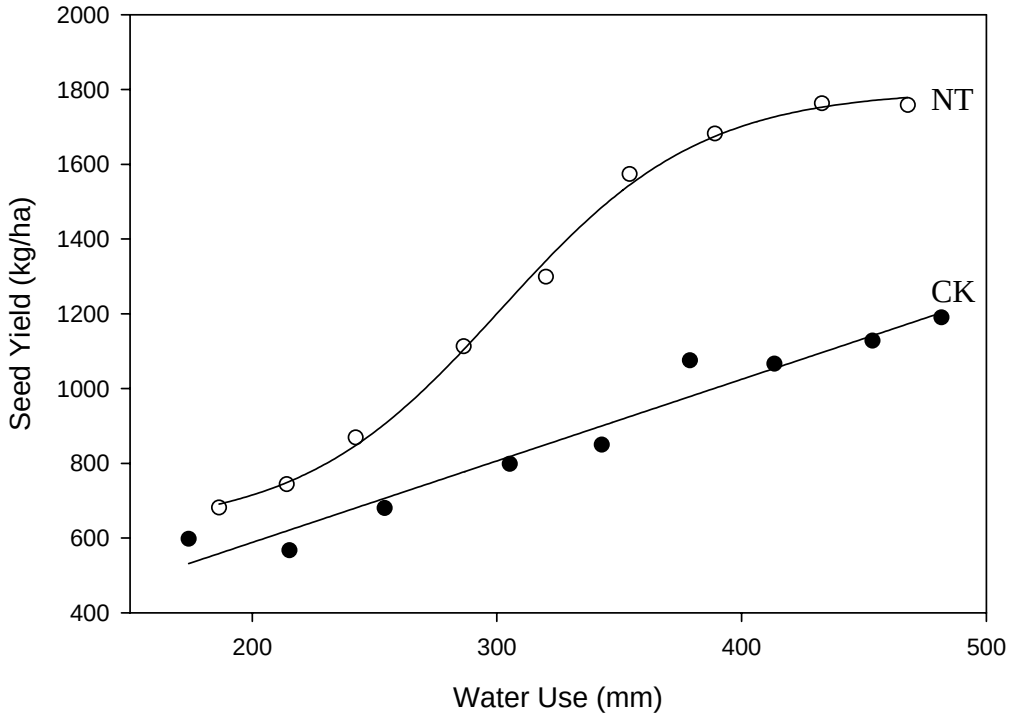


Figure 9. 1996 Sanford seed yield as affected by water use

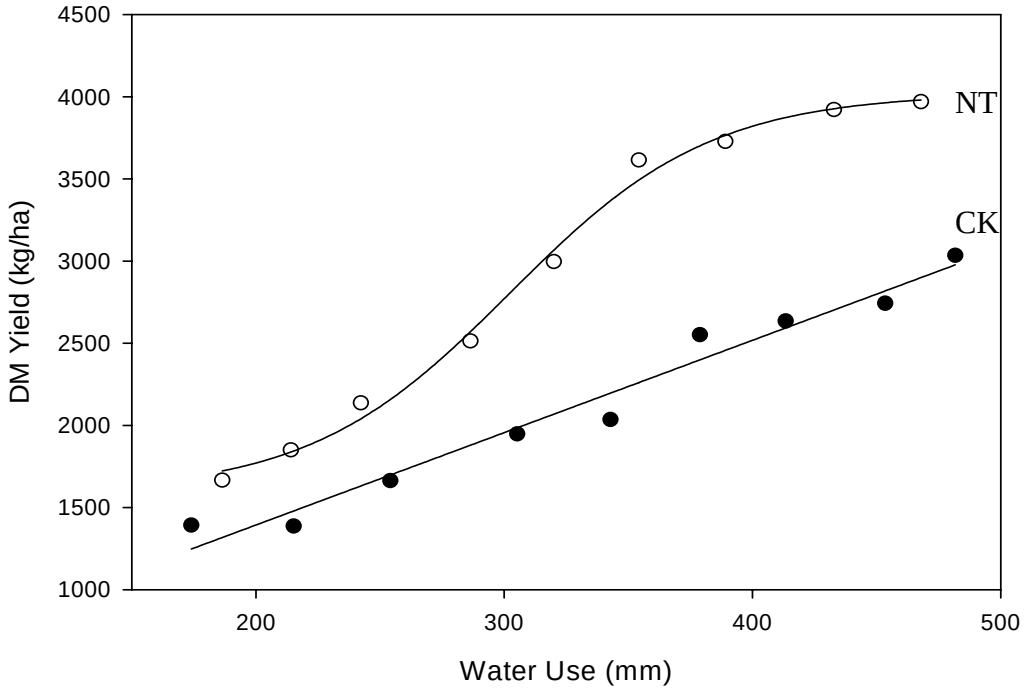


Figure 10. 1996 Sanford DM yield as affected by water use

Table 16. 1999 chickpea yield and water use efficiency as influenced by precipitation amount and N fertilization

N rate: 0 (CK)						Water Use Efficiency		Precip. Use Efficiency			
Irrigation level	Total Precip	Water used	Seed yield	DM yield	100-seed weight	Seed WUE	DM WUE	Seed WUE	DM WUE		
	mm	mm	kg/ha	kg/ha	g	kg/mm.ha	kg/mm.ha	kg/mm.ha	kg/mm.ha		
1	156	293	2488	5265	48.6a**	8.5	18.0	15.9	33.7		
2	177	316	2677	5758		8.5	18.2	15.1	32.5		
3	196	336	2860	6184	46.5b	8.5	18.4	14.6	31.6		
4	218	357	3257	7036		9.1	19.7	15.0	32.3		
5	232	371	3458	7923	45.8bc	9.3	21.4	14.9	34.1		
6	246	382	3667	7924		9.6	20.8	14.9	32.2		
7	253	389	3569	8062	45.1c	9.2	20.7	14.1	31.8		
8	258	394	3565	8382		9.0	21.3	13.8	32.5		
9	260	395	3645	8901	43.5c	9.2	22.5	14.0	34.2		
Average	**222**	**359**	**3243**	**7271**	**45.9**	**9.0**	**20.1**	**14.7**	**32.8**	Average	
N rate: 70 lb/acre (NT)										Seed Yield kg/ha	DM Yield kg/ha
1	156	289	2690	5606	49.1a**	9.3	19.4	17.2	35.9	2589	5436
2	177	314	2864	6082		9.1	19.4	16.2	34.3	2770	5920
3	196	336	3216	6887	47.9b	9.6	20.5	16.4	35.2	3038	6536
4	218	358	3570	7633		10.0	21.3	16.4	35.0	3413	7334
5	232	373	3762	8716	45.4c	10.1	23.4	16.2	37.5	3610	8320
6	246	384	3898	8818		10.2	23.0	15.8	35.8	3783	8371
7	253	391	3695	8799	44.0d	9.4	22.5	14.6	34.7	3632	8430
8	258	395	3601	9195		9.1	23.3	14.0	35.6	3583	8789
9	260	396	3694	10287	41.8e	9.3	26.0	14.2	39.6	3670	9594
Average	**222**	**360**	**3443**	**8003**	**45.6**	**9.6**	**22.1**	**15.7**	**36.0**	**3343**	**7637**
$LSD_{.05}$										158	441

*Rain+Irrigation Season rainfall: 146 to 158 mm Planting: 25-May Harvest: 17-, 20-, 24-, and 29-Sept. and 2-Oct.

**Means followed by the same letter are not significantly different at $\alpha \leq 5\%$.

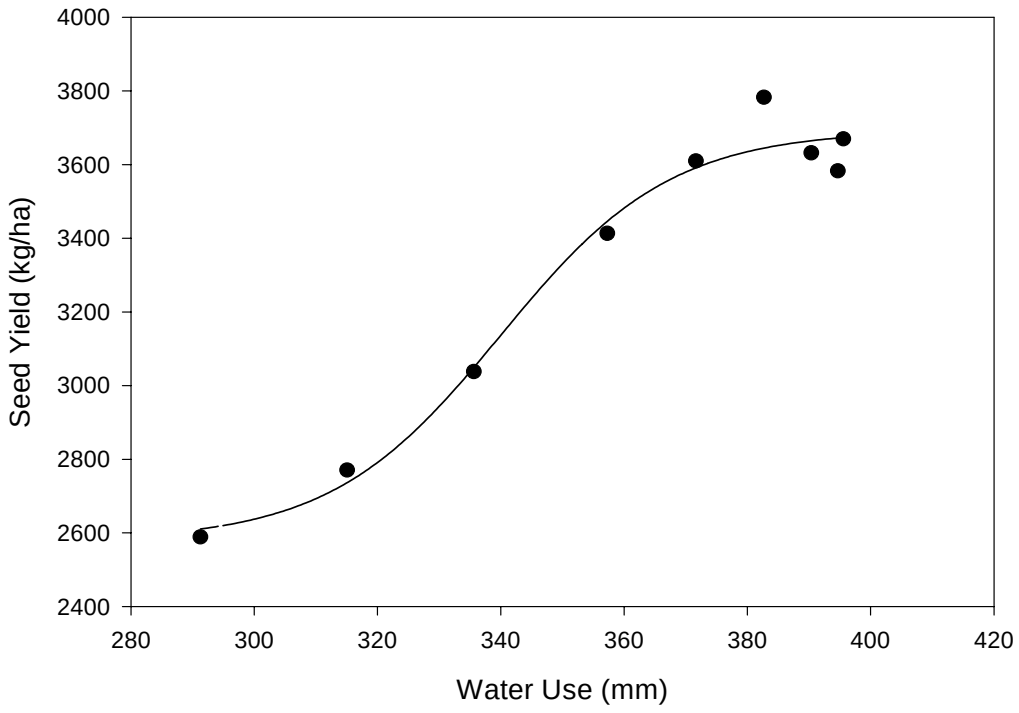


Figure 11. 1999 average chickpea seed yield as affected by water use

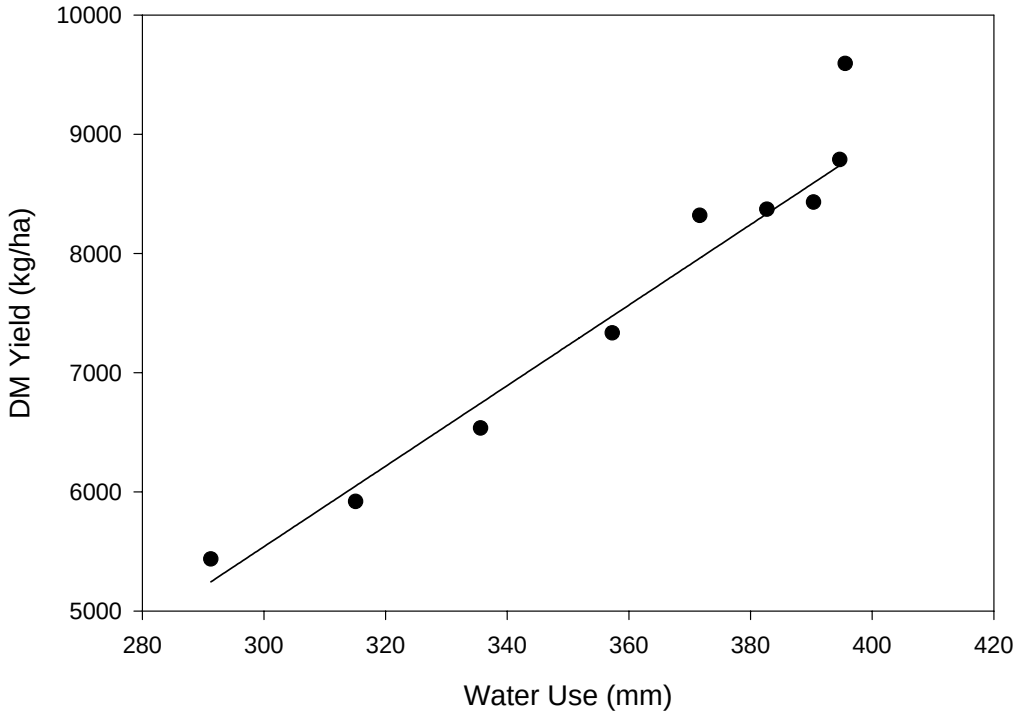


Figure 12. 1999 average chickpea DM yield as affected by water use

Part IV

Evaluation of the Chickpea Core Collection for Drought Tolerance

Abdel Berrada Thomas M. Hooten[1]

Introduction

Desirable characteristics of chickpea in southwestern Colorado include:

- Good yield potential
- Early maturity/drought tolerance
- Good disease and insect resistance
- Good seed size and color
- Upright architecture

The objective of this study was to evaluate the core National Plant Germplasm System (NPGS) chickpea collection for drought tolerance. This was identified as a priority by the Cool Season Food Legume Crop Germplasm Committee at its annual meeting on November 7, 2000 in Minneapolis, MN. Promising accessions could be used in future breeding programs in Colorado and elsewhere.

Materials and Methods

A total of 477 accessions were evaluated in 2002 (238 accessions) and 2003 (239 accessions) at the Southwestern Colorado Research Center in Yellow Jacket, CO. They were planted in 76.2-cm rows and 9.5-cm seed spacing with a Monosem Planter on 24 May in 2002 and 23 May in 2003. Each accession was planted in an 18.3-m single row with no replication. The plot area was irrigated with a line-source sprinkler system similar to the one described by Hanks et al. (1976). The amount of irrigation water decreased with the distance away from the sprinkler line. For practical purposes, we only distinguished two irrigation levels, wet and dry (Table 17). Total precipitation from May to August was 25 mm in 2002 and 119 mm in 2003 compared to a 30-year average of 130 mm (Table 1). There was good soil moisture at planting in both years. Chickpea accessions were planted on fallow ground in 2002 and 2003 (different field each year).

The following observations and measurements were made in 2002 and 2003:

- Precipitation amount (rain and irrigation)

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- Drought tolerance: 1=susceptible … 5=tolerant.
  Drought tolerance was assessed by comparing the same chickpea entry at physiological maturity in the wet and dry treatments. A tolerant variety (5) was one that had similar growth in both treatments. A susceptible (1) entry had a drastic difference in growth. Evaluations 2, 3, and 4 were graded in between.

- Days to first bloom: Day of the year when flowering begins.
- Days to flower: Actual number of days from seed sowing to first flower.
- Pod maturity: Number of days to 80% of the pods at harvestable maturity.

Results

The results of this evaluation are shown in Tables 18 (2002) and 19 (2003). They are also available on http://www.ars-grin.gov/cgi-bin/npgs/html/desc.pl?54032 (verified 15 Oct. 2004) Days to first flower averaged 37.5 in 2002 with a range of 31 to 59 days. Days to 80% pod maturity averaged 89.4 days (73-116) in the dry treatment and 99.3 days (91-116) in the wet treatment. In 2003, days to first flower averaged 38.5 (33-62). Days to 80% pod maturity averaged 90.4 days (70-125) in the dry treatment and 99.1 days (79-125) in the wet treatment (Table 18). No major pest infestation or damage was observed in 2002 or 2003. Several entries showed good drought tolerance. Information from this evaluation can be used in breeding programs to develop chickpea varieties adapted to a particular environment.

Table 17. Precipitation amount during the growing season.

Precipitation amount (mm)	Dry treatment		Wet treatment	
	2002	2003	2002	2003
Irrigation only	22.9	20.3	228.6	182.9
Including pre-irrigation	83.8	0.0	289.6	0.0
Including rainfall 5/24 to 8/6	88.9	38.1	294.6	200.7
Including rainfall 5/24 to 8/20	88.9	45.7	294.6	208.3
Including rainfall 5/24 to 8/30	106.7	66.0	315.0	228.6

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Table 18. Chickpea drought evaluation—2002 results

item no.	accession no.	50% emergence	first flower	days to 1st flower	80% pod maturity dry cond.	80% pod maturity wet cond.	days to pod maturity dry cond.	days to pod maturity wet cond.	drought tolerance**
1	450786	6/10/02	6/30/02	37	8/5/02	8/27/02	73	95	4
2	451054	6/10/02	6/27/02	34	*	8/30/02	*	98	5
3	451378	6/10/02	7/1/02	38	8/5/02	8/25/02	73	93	4
4	360470	6/10/02	6/30/02	37	8/5/02	8/25/02	73	93	4
5	503008	6/10/02	7/9/02	46	9/6/02	9/9/02	105	108	5
6	451220	6/10/02	7/1/02	38	9/3/02	9/3/02	102	102	3
7	451095	6/10/02	7/8/02	45	9/6/02	9/3/02	105	102	4
8	360674	6/10/02	6/30/02	37	8/9/02	8/25/02	77	93	3
9	360090	6/10/02	7/1/02	38	8/26/02	8/30/02	94	98	4
10	379220	6/10/02	6/30/02	37	8/26/02	8/30/02	94	98	3
11	439801	6/10/02	6/30/02	37	8/15/02	8/30/02	83	98	3
12	223433	6/10/02	6/24/02	31	8/20/02	8/30/02	88	98	4
13	439858	6/10/02	7/1/02	38	8/23/02	8/30/02	91	98	3
14	426556	6/10/02	7/1/02	38	8/9/02	8/30/02	77	98	4
15	426591	6/10/02	7/1/02	38	8/9/02	8/27/02	77	95	2
16	222774	6/10/02	7/1/02	38	8/13/02	8/30/02	81	98	2
17	339223	6/10/02	6/30/02	37	8/20/02	9/3/02	88	102	2
18	450575	6/10/02	6/28/02	35	8/13/02	8/30/02	81	98	3
19	450585	6/10/02	7/1/02	38	8/13/02	8/30/02	81	98	2
20	450603	6/10/02	6/27/02	34	8/13/02	8/30/02	81	98	3
21	450684	6/10/02	7/2/02	39	8/23/02	8/30/02	91	98	4
22	359228	6/10/02	7/1/02	38	8/26/02	8/30/02	94	98	3
23	450738	6/10/02	6/27/02	34	8/23/02	8/30/02	91	98	3
24	450740	6/10/02	7/1/02	38	8/20/02	8/30/02	88	98	3
25	359374	6/10/02	7/1/02	38	8/9/02	8/27/02	77	95	3
26	450778	6/10/02	7/1/02	38	*	8/30/02	*	98	3
27	450825	6/10/02	6/30/02	37	8/9/02	8/30/02	77	98	2
28	450876	6/10/02	6/30/02	37	8/9/02	8/30/02	77	98	2
29	450902	6/10/02	7/13/02	50	9/9/02	9/6/02	108	105	4
30	359555	6/10/02	7/2/02	39	8/20/02	8/30/02	88	98	2
31	450977	6/10/02	7/8/02	45	8/30/02	8/30/02	98	98	2
32	359899	6/10/02	6/30/02	37	8/20/02	8/30/02	88	98	3

* Did not mature by 17 Sept.

** 1=susceptible, 2=somewhat susceptible, 3=neither susceptible nor tolerant, 4=somewhat tolerant, 5=tolerant

Table 18 (Continue)

item no.	accession no.	50% emergence	first flower	days to 1st flower	80% pod maturity dry cond.	80% pod maturity wet cond.	days to pod maturity dry cond.	days to pod maturity wet cond.	drought tolerance**
33	451175	6/10/02	7/7/02	44	*	8/30/02	*	98	4
34	451285	6/10/02	7/7/02	44	8/23/02	8/30/02	91	98	2
35	451358	6/10/02	7/1/02	38	8/20/02	8/30/02	88	98	3
36	451390	6/10/02	7/1/02	38	8/20/02	8/30/02	88	98	3
37	360063	6/10/02	7/1/02	38	8/13/02	8/30/02	81	98	3
38	451445	6/10/02	6/28/02	35	8/9/02	8/30/02	77	98	4
39	451567	6/10/02	6/30/02	37	*	9/6/02	*	105	3
40	451654	6/10/02	7/4/02	41	9/3/02	9/17/02	102	116	5
41	462019	6/10/02	7/9/02	46	9/3/02	9/3/02	102	102	3
42	462022	6/10/02	7/6/02	43	9/3/02	9/3/02	102	102	3
43	360253	6/10/02	6/30/02	37	8/26/02	8/30/02	94	98	4
44	468936	6/10/02	6/30/02	37	8/26/02	8/30/02	94	98	3
45	499407	6/10/02	7/15/02	52	9/3/02	9/17/02	102	116	5
46	543061	6/10/02	6/28/02	35	8/9/02	8/30/02	77	98	2
47	360348	6/10/02	6/28/02	35	8/23/02	8/30/02	91	98	2
48	360434	6/10/02	6/26/02	33	8/9/02	8/30/02	77	98	3
49	360456	6/10/02	6/25/02	32	8/9/02	9/3/02	77	102	2
50	360696	6/10/02	6/27/02	34	8/15/02	9/3/02	83	102	4
51	426561	6/10/02	6/27/02	34	8/20/02	8/30/02	88	98	3
52	450693	6/10/02	6/30/02	37	8/9/02	8/30/02	77	98	2
53	450832	6/10/02	7/2/02	39	9/3/02	8/30/02	102	98	3
54	450975	6/10/02	7/3/02	40	8/26/02	8/30/02	94	98	3
55	451299	6/10/02	6/30/02	37	8/26/02	8/30/02	94	98	4
56	451346	6/10/02	6/27/02	34	8/18/02	8/30/02	86	98	4
57	451449	6/10/02	7/1/02	38	8/30/02	9/3/02	98	102	3
58	451594	6/10/02	7/22/02	59	*	*	*	*	3
59	468945	6/10/02	7/1/02	38	8/20/02	9/13/02	88	112	3
60	193480	6/10/02	6/30/02	37	8/15/02	8/30/02	83	98	5
61	343015	6/10/02	6/30/02	37	8/26/02	8/30/02	94	98	2
62	439756	6/10/02	7/1/02	38	8/26/02	9/3/02	94	102	3
63	462200	6/10/02	7/13/02	50	9/17/02	9/3/02	116	102	4
64	251781	6/17/02	7/19/02	56	*	9/3/02	*	102	5

* Did not mature by 17 Sept.

** 1=susceptible, 2=somewhat susceptible, 3=neither susceptible nor tolerant, 4=somewhat tolerant, 5=tolerant

Table 18 (Continue)

item no.	accession no.	50% emergence	first flower	days to 1st flower	80% pod maturity dry cond.	80% pod maturity wet cond.	days to pod maturity dry cond.	days to pod maturity wet cond.	drought tolerance**
65	359219	6/10/02	7/1/02	38	8/23/02	8/30/02	91	98	3
66	359498	6/10/02	6/30/02	37	8/18/02	8/30/02	86	98	2
67	359738	6/10/02	7/1/02	38	8/20/02	8/30/02	88	98	2
68	360011	6/10/02	7/1/02	38	8/23/02	9/3/02	91	102	2
69	360292	6/10/02	6/30/02	37	8/18/02	9/3/02	86	102	3
70	360472	6/10/02	6/27/02	34	8/9/02	8/27/02	77	95	3
71	360664	6/10/02	7/1/02	38	8/13/02	8/30/02	81	98	2
72	360691	6/10/02	6/30/02	37	8/13/02	8/30/02	81	98	3
73	450600	6/10/02	6/30/02	37	8/20/02	8/30/02	88	98	3
74	450634	6/10/02	7/1/02	38	8/23/02	8/30/02	91	98	2
75	451061	6/10/02	7/2/02	39	8/30/02	9/3/02	98	102	4
76	451157	6/10/02	6/28/02	35	8/20/02	8/30/02	88	98	4
77	451329	6/10/02	7/3/02	40	8/13/02	8/30/02	81	98	3
78	451470	6/10/02	7/3/02	40	8/26/02	8/30/02	94	98	4
79	451664	6/10/02	6/27/02	34	8/18/02	8/30/02	86	98	2
80	462023	6/10/02	6/30/02	37	9/3/02	9/3/02	102	102	4
81	543051	6/10/02	6/28/02	35	8/9/02	8/30/02	77	98	3
82	195561	6/10/02	6/24/02	31	8/9/02	8/30/02	77	98	4
83	533676	6/10/02	7/2/02	39	9/3/02	9/3/02	102	102	4
84	250143	6/10/02	6/30/02	37	8/15/02	8/30/02	83	98	3
85	273879	6/10/02	7/2/02	39	9/3/02	8/30/02	102	98	5
86	359014	6/10/02	6/30/02	37	8/20/02	8/30/02	88	98	3
87	359115	6/10/02	6/28/02	35	8/26/02	8/30/02	94	98	3
88	359257	6/10/02	6/30/02	37	8/18/02	8/30/02	86	98	4
89	359348	6/10/02	6/30/02	37	8/20/02	8/30/02	88	98	3
90	359489	6/10/02	6/28/02	35	8/9/02	8/30/02	77	98	3
91	359769	6/10/02	7/1/02	38	9/3/02	9/3/02	102	102	4
92	359919	6/10/02	6/28/02	35	8/9/02	8/30/02	77	98	2
93	360078	6/10/02	6/30/02	37	8/9/02	8/30/02	77	98	2
94	360418	6/10/02	6/28/02	35	8/20/02	8/30/02	88	98	4
95	360425	6/10/02	6/27/02	34	8/9/02	8/27/02	77	95	4
96	360642	6/10/02	6/27/02	34	8/20/02	8/30/02	88	98	4

* Did not mature by 17 Sept.

** 1=susceptible, 2=somewhat susceptible, 3=neither susceptible nor tolerant, 4=somewhat tolerant, 5=tolerant

Table 18 (Continue)

item no.	accession no.	50% emergence	first flower	days to 1st flower	80% pod maturity dry cond.	80% pod maturity wet cond.	days to pod maturity dry cond.	days to pod maturity wet cond.	drought tolerance**
97	360667	6/10/02	6/28/02	35	8/20/02	8/30/02	88	98	4
98	360698	6/10/02	6/30/02	37	8/20/02	8/30/02	88	98	4
99	420908	6/10/02	6/28/02	35	8/26/02	9/13/02	94	112	3
100	509224	6/10/02	6/30/02	37	8/26/02	9/9/02	94	108	4
101	331381	6/10/02	6/28/02	35	8/13/02	8/30/02	81	98	3
102	370417	6/10/02	7/8/02	45	*	*	*	*	4
103	212091	6/10/02	7/2/02	39	9/3/02	8/30/02	102	98	4
104	315813	6/10/02	7/2/02	39	*	8/30/02	*	98	4
105	359041	6/10/02	6/30/02	37	8/20/02	8/30/02	88	98	4
106	359159	6/10/02	6/30/02	37	8/20/02	8/30/02	88	98	3
107	359249	6/10/02	7/1/02	38	8/23/02	8/30/02	91	98	3
108	359611	6/10/02	6/30/02	37	8/18/02	8/30/02	86	98	3
109	359658	6/10/02	6/26/02	33	8/5/02	8/30/02	73	98	5
110	359914	6/10/02	6/30/02	37	8/5/02	8/27/02	73	95	3
111	359975	6/10/02	6/25/02	32	*	8/30/02	*	98	4
112	360244	6/10/02	6/30/02	37	8/23/02	8/30/02	91	98	4
113	360658	6/10/02	7/1/02	38	*	9/3/02	*	102	4
114	374093	6/10/02	7/1/02	38	8/23/02	8/30/02	91	98	3
115	426583	6/10/02	7/2/02	39	8/23/02	8/30/02	91	98	3
116	450728	6/10/02	6/27/02	34	8/9/02	8/30/02	77	98	4
117	450993	6/10/02	6/30/02	37	8/30/02	8/30/02	98	98	3
118	451143	6/10/02	7/12/02	49	*	9/13/02	*	112	5
119	451248	6/10/02	6/25/02	32	8/26/02	8/30/02	94	98	4
120	451435	6/10/02	6/28/02	35	8/18/02	8/27/02	86	95	5
121	503007	6/10/02	7/3/02	40	*	9/6/02	*	105	4
122	503014	6/10/02	6/30/02	37	8/23/02	8/30/02	91	98	3
123	343016	6/10/02	7/7/02	44	*	9/9/02	*	108	4
124	462168	6/10/02	6/28/02	35	8/20/02	8/30/02	88	98	4
125	477297	6/10/02	7/2/02	39	8/20/02	8/30/02	88	98	4
126	250144	6/10/02	6/30/02	37	8/20/02	8/30/02	88	98	3
127	315803	6/10/02	7/1/02	38	8/20/02	8/30/02	88	98	3
128	359417	6/10/02	7/2/02	39	8/20/02	8/30/02	88	98	3

* Did not mature by 17 Sept.

** 1=susceptible, 2=somewhat susceptible, 3=neither susceptible nor tolerant, 4=somewhat tolerant, 5=tolerant

Table 18 (Continue)

item no.	accession no.	50% emergence	first flower	days to 1st flower	80% pod maturity dry cond.	80% pod maturity wet cond.	days to pod maturity dry cond.	days to pod maturity wet cond.	drought tolerance**
129	359595	6/10/02	7/1/02	38	8/26/02	8/30/02	94	98	3
130	359878	6/10/02	6/30/02	37	8/26/02	8/30/02	94	98	2
131	360029	6/10/02	7/1/02	38	8/18/02	8/30/02	86	98	3
132	360189	6/10/02	6/30/02	37	8/20/02	8/30/02	88	98	1
133	360230	6/10/02	6/25/02	32	8/15/02	8/30/02	83	98	3
134	360649	6/10/02	6/28/02	35	8/15/02	8/30/02	83	98	3
135	360686	6/10/02	6/28/02	35	8/26/02	8/30/02	94	98	3
136	450884	6/10/02	6/28/02	35	8/20/02	8/30/02	88	98	4
137	451049	6/10/02	7/12/02	49	9/3/02	9/3/02	102	102	4
138	451161	6/10/02	7/11/02	48	9/3/02	9/3/02	102	102	5
139	451344	6/10/02	7/2/02	39	8/23/02	8/30/02	91	98	4
140	451622	6/10/02	6/27/02	34	8/23/02	9/3/02	91	102	3
141	503010	6/10/02	7/1/02	38	9/3/02	9/3/02	102	102	4
142	244333	6/10/02	6/24/02	31	8/9/02	8/30/02	77	98	3
143	193486	6/10/02	6/25/02	32	8/9/02	8/30/02	77	98	3
144	439831	6/10/02	6/27/02	34	8/20/02	9/9/02	88	108	4
145	215702	6/10/02	6/28/02	35	8/20/02	8/30/02	88	98	2
146	254548	6/10/02	6/26/02	33	8/20/02	8/30/02	88	98	2
147	315810	6/10/02	6/30/02	37	8/23/02	8/30/02	91	98	3
148	359061	6/10/02	6/28/02	35	8/9/02	8/30/02	77	98	3
149	359289	6/10/02	6/27/02	34	8/20/02	8/30/02	88	98	4
150	359588	6/10/02	7/1/02	38	8/20/02	8/27/02	88	95	4
151	359913	6/10/02	7/1/02	38	8/23/02	8/30/02	91	98	4
152	360162	6/10/02	6/30/02	37	8/23/02	8/30/02	91	98	4
153	360365	6/10/02	6/28/02	35	8/20/02	8/27/02	88	95	4
154	360630	6/10/02	6/25/02	32	8/15/02	8/30/02	83	98	4
155	360687	6/10/02	7/1/02	38	8/18/02	8/30/02	86	98	3
156	360697	6/10/02	6/28/02	35	*	8/30/02	*	98	5
157	426593	6/10/02	7/2/02	39	8/20/02	8/30/02	88	98	3
158	450670	6/10/02	7/1/02	38	8/20/02	8/27/02	88	95	2
159	359773	6/10/02	7/1/02	38	8/30/02	8/30/02	98	98	2
160	451598	6/10/02	6/28/02	35	8/18/02	8/27/02	86	95	3

* Did not mature by 17 Sept.

** 1=susceptible, 2=somewhat susceptible, 3=neither susceptible nor tolerant, 4=somewhat tolerant, 5=tolerant

Table 18 (Continue)

item no.	accession no.	50% emergence	first flower	days to 1st flower	80% pod maturity dry cond.	80% pod maturity wet cond.	days to pod maturity dry cond.	days to pod maturity wet cond.	drought tolerance**
161	359827	6/10/02	7/1/02	38	8/20/02	8/30/02	88	98	4
162	451649	6/10/02	6/28/02	35	8/23/02	8/30/02	91	98	4
163	451680	6/10/02	6/29/02	36	8/23/02	8/30/02	91	98	4
164	451685	6/10/02	7/3/02	40	8/26/02	8/30/02	94	98	5
165	471915	6/10/02	7/1/02	38	*	9/3/02	*	102	5
166	359944	6/10/02	6/26/02	33	8/18/02	8/30/02	86	98	4
167	509156	6/10/02	6/27/02	34	*	8/30/02	*	98	4
168	509178	6/10/02	6/28/02	35	8/23/02	8/30/02	91	98	4
169	360159	6/10/02	7/1/02	38	8/23/02	8/30/02	91	98	4
170	518255	6/10/02	7/1/02	38	8/20/02	8/30/02	88	98	3
171	193487	6/10/02	6/25/02	32	8/26/02	8/30/02	94	98	3
172	347261	6/10/02	7/3/02	40	9/3/02	9/3/02	102	102	5
173	360268	6/10/02	7/1/02	38	8/20/02	9/13/02	88	112	4
174	357654	6/10/02	6/30/02	37	8/26/02	9/17/02	94	116	3
175	439832	6/10/02	6/26/02	33	9/3/02	9/3/02	102	102	3
176	468927	6/10/02	6/30/02	37	9/3/02	9/3/02	102	102	3
177	360383	6/10/02	6/25/02	32	8/13/02	8/30/02	81	98	3
178	503006	6/10/02	6/30/02	37	9/3/02	9/3/02	102	102	3
179	214311	6/10/02	6/28/02	35	8/23/02	9/3/02	91	102	2
180	255138	6/10/02	6/28/02	35	8/15/02	no germ.	83	no germ.	3
181	315826	6/10/02	6/30/02	37	8/23/02	8/30/02	91	98	3
182	359007	6/10/02	6/30/02	37	8/26/02	8/30/02	94	98	4
183	359051	6/10/02	7/1/02	38	8/20/02	8/30/02	88	98	4
184	359065	6/10/02	6/30/02	37	8/20/02	8/30/02	88	98	4
185	360530	6/10/02	6/28/02	35	8/15/02	8/27/02	83	95	4
186	359085	6/10/02	7/1/02	38	8/23/02	8/30/02	91	98	3
187	359099	6/10/02	7/1/02	38	8/23/02	8/30/02	91	98	3
188	359313	6/10/02	6/30/02	37	8/20/02	8/30/02	88	98	5
189	359406	6/10/02	7/1/02	38	8/20/02	8/25/02	88	93	4
190	360657	6/10/02	6/30/02	37	8/20/02	8/27/02	88	95	4
191	359531	6/10/02	6/30/02	37	8/23/02	8/27/02	91	95	3
192	360663	6/10/02	6/30/02	37	8/26/02	8/30/02	94	98	3

* Did not mature by 17 Sept.

** 1=susceptible, 2=somewhat susceptible, 3=neither susceptible nor tolerant, 4=somewhat tolerant, 5=tolerant

Table 18 (Continue)

item no.	accession no.	50% emergence	first flower	days to 1st flower	80% pod maturity dry cond.	80% pod maturity wet cond.	days to pod maturity dry cond.	days to pod maturity wet cond.	drought tolerance**
193	359560	6/10/02	7/2/02	39	8/26/02	9/3/02	94	102	2
194	359641	6/10/02	6/30/02	37	8/26/02	8/30/02	94	98	2
195	359673	6/10/02	6/30/02	37	9/3/02	8/30/02	102	98	3
196	359687	6/10/02	7/2/02	39	8/30/02	8/30/02	98	98	3
197	360669	6/10/02	7/1/02	38	8/15/02	8/30/02	83	98	4
198	359716	6/10/02	7/2/02	39	8/20/02	8/30/02	88	98	3
199	360684	6/10/02	7/1/02	38	*	8/30/02	*	98	3
200	359746	6/10/02	6/30/02	37	9/3/02	8/30/02	102	98	3
201	360690	6/10/02	6/28/02	35	8/26/02	9/3/02	94	102	4
202	360695	6/10/02	6/30/02	37	8/26/02	9/3/02	94	102	4
203	426190	6/10/02	6/25/02	32	8/20/02	8/30/02	88	98	4
204	426195	6/10/02	6/25/02	32	8/20/02	8/30/02	88	98	5
205	426586	6/10/02	6/30/02	37	8/13/02	9/6/02	81	105	3
206	450553	6/10/02	6/26/02	33	8/20/02	8/30/02	88	98	3
207	450615	6/10/02	7/1/02	38	8/23/02	8/30/02	91	98	2
208	450760	6/10/02	6/27/02	34	8/26/02	9/3/02	94	102	2
209	450820	6/10/02	6/26/02	33	8/20/02	9/3/02	88	102	4
210	450852	6/10/02	7/16/02	53	*	9/3/02	*	102	5
211	450870	6/10/02	6/28/02	35	8/20/02	8/30/02	88	98	3
212	450955	6/10/02	7/6/02	43	9/3/02	9/3/02	102	102	4
213	451420	6/10/02	6/28/02	35	8/18/02	8/23/02	86	91	4
214	451501	6/10/02	7/3/02	40	9/9/02	9/3/02	108	102	4
215	451552	6/10/02	7/1/02	38	8/23/02	8/30/02	91	98	3
216	478421	6/10/02	7/3/02	40	8/23/02	8/30/02	91	98	3
217	193485	6/10/02	6/24/02	31	8/15/02	8/30/02	83	98	3
218	196840	6/10/02	6/26/02	33	8/15/02	8/25/02	83	93	3
219	251514	6/10/02	6/27/02	34	8/20/02	8/30/02	88	98	4
220	343014	6/10/02	7/9/02	46	*	9/17/02	*	116	4
221	368485	6/10/02	7/1/02	38	9/3/02	8/30/02	102	98	4
222	439779	6/10/02	6/28/02	35	8/26/02	8/27/02	94	95	3
223	439829	6/10/02	6/30/02	37	9/3/02	9/3/02	102	102	3
224	533681	6/10/02	7/8/02	45	9/3/02	9/9/02	102	108	3

* Did not mature by 17 Sept.

** 1=susceptible, 2=somewhat susceptible, 3=neither susceptible nor tolerant, 4=somewhat tolerant, 5=tolerant

Table 18 (Continued)

item no.	accession no.	50% emergence	first flower	days to 1st flower	80% pod maturity dry cond.	80% pod maturity wet cond.	days to pod maturity dry cond.	days to pod maturity wet cond.	drought tolerance**
225	115449	6/10/02	7/1/02	38	8/26/02	8/30/02	94	98	3
226	251024	6/10/02	6/30/02	37	*	9/3/02	*	102	3
227	251783	6/10/02	7/7/02	44	*	9/9/02	*	108	4
228	358916	6/10/02	7/1/02	38	8/26/02	9/6/02	94	105	2
229	359277	6/10/02	6/29/02	36	8/15/02	8/30/02	83	98	3
230	359311	6/10/02	6/30/02	37	8/23/02	9/3/02	91	102	3
231	359471	6/10/02	7/1/02	38	8/26/02	9/6/02	94	105	3
232	359697	6/10/02	6/30/02	37	8/20/02	9/6/02	88	105	3
233	359715	6/10/02	6/30/02	37	9/3/02	8/30/02	102	98	4
234	360010	6/10/02	7/1/02	38	8/23/02	8/30/02	91	98	4
235	360050	6/10/02	7/1/02	38	8/23/02	8/25/02	91	93	4
236	360111	6/10/02	6/28/02	35	8/23/02	8/30/02	91	98	4
237	360304	6/10/02	6/27/02	34	8/15/02	8/30/02	83	98	3
238	360347	6/10/02	6/27/02	34	8/5/02	8/27/02	73	95	2
Average				**37.5**			**89.4**	**99.3**	**3.4**
Median				**37**			**88**	**98**	**3**
Minimum				**31**			**73**	**91**	**1**
Maximum				**59**			**116**	**116**	**5**

* Did not mature by 17 Sept.

** 1=susceptible, 2=somewhat susceptible, 3=neither susceptible nor tolerant, 4=somewhat tolerant, 5=tolerant

Table 19. Chickpea drought evaluation—2003 results

item no.	accession no.	50% emergence	first flower	days to 1st flower	80% pod maturity dry cond.	80% pod maturity wet cond.	days to pod maturity dry cond.	days to pod maturity wet cond.	drought tolerance**
239	360350	6/3/03	7/4/03	42	8/26/03	9/4/03	95	104	3
240	360410	6/6/03	6/30/03	38	9/4/03	9/4/03	104	104	5
241	360439	6/3/03	6/26/03	34	9/8/03	9/2/03	108	102	3
242	360585	6/3/03	6/27/03	35	9/4/03	9/2/03	104	102	4
243	360641	6/3/03	6/28/03	36	8/26/03	8/26/03	95	95	3
244	426194	6/3/03	6/26/03	34	8/15/03	9/2/03	84	102	4
245	426608	6/3/03	6/30/03	38	9/4/03	9/10/03	104	110	5
246	450565	6/3/03	6/30/03	38	8/20/03	9/4/03	89	104	3
247	450717	6/3/03	6/26/03	34	8/15/03	8/23/03	84	92	4
248	450806	6/3/03	6/27/03	35	9/4/03	8/26/03	104	95	5
249	450867	6/6/03	7/4/03	42	8/20/03	8/23/03	89	92	2
250	451278	6/3/03	6/27/03	35	*	*	*	*	5
251	451315	6/6/03	6/29/03	37	*	*	*	*	5
252	451389	6/6/03	6/29/03	37	8/20/03	8/26/03	89	95	2
253	451394	6/6/03	7/8/03	46	9/12/03	9/10/03	112	110	4
254	451500	6/3/03	7/6/03	44	9/4/03	9/4/03	104	104	5
255	451554	6/3/03	6/29/03	37	8/20/03	9/2/03	89	102	3
256	468943	6/3/03	6/26/03	34	8/20/03	9/4/03	89	104	2
257	509209	6/3/03	6/27/03	35	8/26/03	9/4/03	95	104	4
259	251782	6/3/03	6/26/03	34	8/15/03	9/4/03	84	104	2
260	339165	6/3/03	6/25/03	33	8/20/03	8/26/03	89	95	1
261	379217	6/3/03	6/28/03	36	8/15/03	9/2/03	84	102	4
262	439810	6/3/03	6/26/03	34	8/12/03	8/23/03	81	92	2
263	462172	6/3/03	6/26/03	34	8/15/03	8/20/03	84	89	2
264	502991	6/6/03	7/10/03	48	9/4/03	9/10/03	104	110	4
265	253227	6/3/03	6/27/03	35	*	9/15/03	*	115	4
266	288315	6/11/03	7/16/03	54	9/15/03	9/10/03	115	110	5
267	359363	6/3/03	6/26/03	34	8/26/03	9/4/03	95	104	3
268	359450	6/3/03	7/4/03	42	8/20/03	8/23/03	89	92	3
269	359582	6/3/03	7/8/03	46	9/2/03	9/4/03	102	104	4
270	359805	6/3/03	7/6/03	44	8/23/03	8/26/03	92	95	4
271	359844	6/3/03	7/6/03	44	8/23/03	8/26/03	92	95	3

* Did not mature by mid-Sept.

** 1=susceptible, 2=somewhat susceptible, 3=neither susceptible nor tolerant, 4=somewhat tolerant, 5=tolerant

Table 19 (Continue)

item no.	accession no.	50% emergence	first flower	days to 1st flower	80% pod maturity dry cond.	80% pod maturity wet cond.	days to pod maturity dry cond.	days to pod maturity wet cond.	drought tolerance**
272	360291	6/3/03	7/8/03	46	9/10/03	9/2/03	110	102	4
273	360342	6/3/03	7/8/03	46	9/10/03	9/12/03	110	112	5
274	360344	6/6/03	6/29/03	37	8/15/03	8/26/03	84	95	2
275	360493	6/3/03	6/28/03	36	8/12/03	9/4/03	81	104	2
276	360596	6/3/03	7/1/03	39	8/26/03	8/30/03	95	99	2
277	360673	6/3/03	6/29/03	37	8/12/03	8/23/03	81	92	2
278	426196	6/3/03	6/26/03	34	8/15/03	9/2/03	84	102	2
279	426546	6/3/03	6/27/03	35	8/15/03	8/26/03	84	95	1
280	450622	6/3/03	6/29/03	37	8/15/03	8/26/03	84	95	3
281	450906	6/6/03	7/16/03	54	9/10/03	9/2/03	110	102	3
282	450950	6/3/03	6/27/03	35	9/12/03	9/4/03	112	104	5
283	451085	6/3/03	7/10/03	48	9/15/03	9/12/03	115	112	5
284	451244	6/3/03	6/26/03	34	8/15/03	9/4/03	84	104	2
285	451331	6/6/03	7/8/03	46	9/10/03	9/12/03	110	112	4
286	451410	6/6/03	6/26/03	34	9/10/03	9/4/03	110	104	3
287	451619	6/3/03	6/27/03	35	8/26/03	9/4/03	95	104	1
288	451634	6/3/03	7/4/03	42	9/4/03	9/2/03	104	102	5
289	462021	6/3/03	7/1/03	39	9/15/03	9/12/03	115	112	5
290	509121	6/3/03	6/27/03	35	9/10/03	9/4/03	110	104	4
291	509256	6/3/03	6/26/03	34	8/15/03	8/23/03	84	92	3
292	268376	6/3/03	6/25/03	33	8/12/03	8/23/03	81	92	3
293	374079	6/6/03	6/27/03	35	*	9/12/03	*	112	5
294	462189	6/3/03	6/27/03	35	9/10/03	8/26/03	110	95	3
295	215588	6/3/03	6/30/03	38	8/26/03	8/23/03	95	92	4
296	219728	6/3/03	7/1/03	39	9/10/03	8/23/03	110	92	4
297	269883	6/3/03	7/24/03	62	*	9/25/03	*	125	5
298	315781	6/3/03	6/30/03	38	9/10/03	8/26/03	110	95	5
299	343017	6/3/03	7/4/03	42	9/10/03	9/2/03	110	102	4
300	359100	6/3/03	6/30/03	38	8/12/03	8/20/03	81	89	2
301	359179	6/3/03	6/30/03	38	8/26/03	8/26/03	95	95	4
302	359241	6/3/03	6/29/03	37	8/10/03	8/20/03	79	89	4

* Did not mature by mid-Sept.

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Table 19 (Continue)

item no.	accession no.	50% emergence	first flower	days to 1st flower	80% pod maturity dry cond.	80% pod maturity wet cond.	days to pod maturity dry cond.	days to pod maturity wet cond.	drought tolerance**
303	359260	6/3/03	6/29/03	37	8/10/03	8/26/03	79	95	3
304	359316	6/3/03	7/1/03	39	8/10/03	8/26/03	79	95	4
305	359372	6/6/03	7/1/03	39	8/10/03	9/4/03	79	104	3
306	359591	6/3/03	7/1/03	39	8/26/03	8/26/03	95	95	4
307	359692	6/11/03	6/29/03	37	8/12/03	9/4/03	81	104	4
308	359815	6/3/03	7/4/03	42	8/20/03	8/20/03	89	89	3
309	359891	6/3/03	6/30/03	38	8/12/03	9/2/03	81	102	3
310	359986	6/3/03	6/29/03	37	8/10/03	8/20/03	79	89	2
311	360133	6/3/03	6/30/03	38	8/10/03	8/20/03	79	89	2
312	360262	6/3/03	7/10/03	48	9/25/03	9/15/03	125	115	5
313	360422	6/3/03	6/29/03	37	8/10/03	8/20/03	79	89	5
314	360561	6/3/03	6/28/03	36	8/10/03	9/4/03	79	104	5
315	360574	6/6/03	6/28/03	36	8/10/03	8/26/03	79	95	5
316	360659	6/11/03	7/15/03	53	9/15/03	9/15/03	115	115	5
317	360660	6/3/03	7/1/03	39	9/2/03	9/12/03	102	112	4
318	372596	6/3/03	6/30/03	38	8/12/03	8/20/03	81	89	2
319	374085	6/3/03	7/6/03	44	8/12/03	8/26/03	81	95	4
320	451401	6/3/03	6/30/03	38	8/10/03	8/26/03	79	95	4
321	451539	6/3/03	6/30/03	38	8/10/03	8/26/03	79	95	2
322	451584	6/3/03	6/29/03	37	8/12/03	8/26/03	81	95	3
323	357649	6/3/03	7/1/03	39	9/2/03	9/4/03	102	104	4
324	370419	6/3/03	7/6/03	44	9/4/03	9/12/03	104	112	5
325	374080	6/3/03	7/14/03	52	9/12/03	9/10/03	112	110	5
326	439785	6/3/03	7/2/03	40	8/17/03	8/20/03	86	89	4
327	439834	6/3/03	7/4/03	42	8/15/03	9/4/03	84	104	3
328	462176	6/3/03	7/1/03	39	8/15/03	9/2/03	84	102	4
329	468929	6/3/03	6/30/03	38	8/20/03	9/4/03	89	104	1
330	502995	6/6/03	6/30/03	38	8/20/03	9/4/03	89	104	1
331	502998	6/3/03	7/4/03	42	9/4/03	9/4/03	104	104	4
332	533672	6/3/03	7/4/03	42	9/12/03	9/10/03	112	110	5
333	533683	6/3/03	7/4/03	42	9/12/03	9/12/03	112	112	5
334	207470	6/3/03	6/29/03	37	8/26/03	9/4/03	95	104	3

* Did not mature by mid-Sept.

** 1=susceptible, 2=somewhat susceptible, 3=neither susceptible nor tolerant, 4=somewhat tolerant, 5=tolerant

Table 19 (Continue)

item no.	accession no.	50% emergence	first flower	days to 1st flower	80% pod maturity dry cond.	80% pod maturity wet cond.	days to pod maturity dry cond.	days to pod maturity wet cond.	drought tolerance**
335	251027	6/3/03	6/29/03	37	8/26/03	9/10/03	95	110	3
336	315790	6/3/03	7/4/03	42	8/12/03	8/20/03	81	89	2
337	358935	6/3/03	7/4/03	42	9/12/03	9/12/03	112	112	4
338	359075	6/3/03	6/30/03	38	8/12/03	8/20/03	81	89	2
339	359239	6/3/03	6/30/03	38	8/12/03	8/26/03	81	95	2
340	359245	6/3/03	6/30/03	38	8/12/03	8/20/03	81	89	2
341	359268	6/3/03	6/29/03	37	8/26/03	8/26/03	95	95	3
342	359304	6/3/03	7/4/03	42	8/12/03	8/20/03	81	89	2
343	359329	6/6/03	7/4/03	42	8/12/03	9/4/03	81	104	2
344	359544	6/3/03	6/29/03	37	8/23/03	9/4/03	92	104	3
345	359552	6/3/03	7/1/03	39	8/15/03	8/18/03	84	87	1
346	359607	6/3/03	6/27/03	35	8/12/03	8/12/03	81	81	3
347	359836	6/3/03	6/29/03	37	8/20/03	8/20/03	89	89	2
348	359841	6/6/03	7/1/03	39	8/20/03	8/26/03	89	95	3
349	359862	6/3/03	6/29/03	37	8/18/03	8/23/03	87	92	1
350	359916	6/3/03	7/1/03	39	8/12/03	8/23/03	81	92	2
351	359922	6/3/03	6/30/03	38	9/12/03	9/2/03	112	102	4
352	360180	6/6/03	7/4/03	42	9/2/03	9/2/03	102	102	4
353	360193	6/3/03	6/29/03	37	8/15/03	8/15/03	84	84	2
354	360288	6/6/03	7/6/03	44	8/26/03	8/30/03	95	99	4
355	360315	6/3/03	7/8/03	46	*	9/10/03	*	110	5
356	360358	6/6/03	7/6/03	44	9/12/03	9/4/03	112	104	4
357	360485	6/3/03	6/27/03	35	8/10/03	8/10/03	79	79	2
358	360505	6/3/03	6/26/03	34	8/1/03	8/10/03	70	79	2
359	360599	6/3/03	6/28/03	36	8/10/03	9/10/03	79	110	1
360	360655	6/3/03	6/26/03	34	8/10/03	8/20/03	79	89	3
361	426193	6/3/03	6/26/03	34	8/10/03	8/26/03	79	95	3
362	426552	6/3/03	6/27/03	35	8/12/03	8/20/03	81	89	2
363	426587	6/3/03	6/30/03	38	8/16/03	8/26/03	85	95	2
364	450577	6/3/03	6/26/03	34	8/12/03	8/20/03	81	89	3
365	450734	6/3/03	6/26/03	34	8/12/03	9/8/03	81	108	2

* Did not mature by mid-Sept.

** 1=susceptible, 2=somewhat susceptible, 3=neither susceptible nor tolerant, 4=somewhat tolerant, 5=tolerant

Table 19 (Continue)

item no.	accession no.	50% emergence	first flower	days to 1st flower	80% pod maturity dry cond.	80% pod maturity wet cond.	days to pod maturity dry cond.	days to pod maturity wet cond.	drought tolerance**
366	450739	6/3/03	6/29/03	37	8/10/03	9/4/03	79	104	3
367	450772	6/3/03	7/1/03	39	8/26/03	9/2/03	95	102	4
368	450787	6/3/03	6/26/03	34	8/8/03	8/20/03	77	89	2
369	450817	6/3/03	6/27/03	35	9/10/03	8/30/03	110	99	5
370	450851	6/3/03	7/1/03	39	8/12/03	8/26/03	81	95	4
371	450872	6/6/03	6/27/03	35	8/12/03	8/26/03	81	95	3
372	450908	6/3/03	6/29/03	37	8/10/03	9/4/03	79	104	5
373	450985	6/3/03	6/29/03	37	8/12/03	9/4/03	81	104	3
374	451066	6/3/03	7/8/03	46	9/12/03	9/15/03	112	115	5
375	451212	6/3/03	6/27/03	35	8/12/03	8/26/03	81	95	3
376	451242	6/3/03	7/1/03	39	8/26/03	9/12/03	95	112	3
377	451597	6/3/03	6/29/03	37	8/12/03	8/26/03	81	95	2
378	451657	6/3/03	6/28/03	36	9/4/03	9/4/03	104	104	5
379	451660	6/3/03	6/26/03	34	8/10/03	9/4/03	79	104	3
380	451671	6/3/03	6/30/03	38	8/26/03	9/4/03	95	104	3
381	462020	6/3/03	7/4/03	42	9/15/03	9/15/03	115	115	5
382	509141	6/3/03	6/27/03	35	8/20/03	9/2/03	89	102	1
383	513144	6/3/03	7/6/03	44	8/20/03	8/30/03	89	99	2
384	458872	6/3/03	6/28/03	36	8/26/03	8/30/03	95	99	1
385	357653	6/3/03	6/29/03	37	9/4/03	9/2/03	104	102	4
386	379221	6/3/03	7/1/03	39	8/26/03	9/4/03	95	104	4
387	254889	6/3/03	6/30/03	38	8/26/03	9/12/03	95	112	3
388	339221	6/3/03	6/26/03	34	8/15/03	9/4/03	84	104	4
389	358922	6/3/03	6/27/03	35	8/12/03	9/4/03	81	104	2
390	359150	6/3/03	6/28/03	36	8/15/03	8/26/03	84	95	3
391	359186	6/3/03	6/28/03	36	8/15/03	8/20/03	84	89	3
392	359213	6/3/03	6/27/03	35	8/10/03	8/26/03	79	95	2
393	359307	6/3/03	6/28/03	36	8/12/03	8/26/03	81	95	1
394	359525	6/3/03	6/26/03	34	8/8/03	8/26/03	77	95	1
395	359631	6/3/03	6/27/03	35	8/12/03	8/20/03	81	89	2
396	359751	6/3/03	6/29/03	37	8/26/03	8/26/03	95	95	4
397	359753	6/3/03	6/29/03	37	8/10/03	8/20/03	79	89	2

* Did not mature by mid-Sept.

** 1=susceptible, 2=somewhat susceptible, 3=neither susceptible nor tolerant, 4=somewhat tolerant, 5=tolerant

Table 19 (Continue)

item no.	accession no.	50% emergence	first flower	days to 1st flower	80% pod maturity dry cond.	80% pod maturity wet cond.	days to pod maturity dry cond.	days to pod maturity wet cond.	drought tolerance**
398	359924	6/6/03	7/1/03	39	8/23/03	9/10/03	92	110	2
399	359968	6/3/03	6/27/03	35	8/20/03	9/12/03	89	112	2
400	359988	6/3/03	6/30/03	38	8/12/03	8/26/03	81	95	3
401	360258	6/3/03	6/27/03	35	8/12/03	8/26/03	81	95	3
402	360399	6/3/03	6/26/03	34	8/12/03	8/26/03	81	95	4
403	360662	6/3/03	6/26/03	34	8/12/03	8/23/03	81	92	2
404	426535	6/3/03	6/27/03	35	8/15/03	8/30/03	84	99	4
405	426571	6/3/03	6/26/03	34	8/12/03	8/30/03	81	99	3
406	450654	6/6/03	6/28/03	36	8/10/03	8/23/03	79	92	3
407	450658	6/6/03	6/30/03	38	8/10/03	8/20/03	79	89	3
408	450755	6/6/03	7/6/03	44	8/20/03	8/23/03	89	92	4
409	451005	6/3/03	7/6/03	44	9/10/03	9/12/03	110	112	5
410	451112	6/3/03	7/8/03	46	9/10/03	9/12/03	110	112	4
411	451191	6/3/03	6/26/03	34	8/10/03	8/20/03	79	89	2
412	451301	6/6/03	6/29/03	37	8/12/03	8/26/03	81	95	3
413	451330	6/3/03	7/1/03	39	8/12/03	8/26/03	81	95	3
414	451646	6/6/03	6/26/03	34	8/12/03	8/26/03	81	95	3
415	451673	6/3/03	6/28/03	36	9/12/03	9/4/03	112	104	4
416	503009	6/6/03	7/4/03	42	9/12/03	9/4/03	112	104	4
417	516518	6/3/03	6/27/03	35	9/4/03	9/2/03	104	102	4
418	193482	6/3/03	6/26/03	34	8/1/03	8/12/03	70	81	1
419	343019	6/3/03	7/10/03	48	*	9/15/03	*	115	5
420	477296	6/3/03	6/26/03	34	8/5/03	8/18/03	74	87	4
421	203142	6/3/03	6/27/03	35	8/5/03	9/2/03	74	102	4
422	212595	6/3/03	6/27/03	35	9/12/03	9/12/03	112	112	5
423	253228	6/3/03	6/26/03	34	8/15/03	9/4/03	84	104	3
424	358938	6/3/03	6/30/03	38	8/12/03	9/10/03	81	110	5
425	359335	6/3/03	6/29/03	37	8/15/03	8/20/03	84	89	4
426	359429	6/3/03	6/30/03	38	8/10/03	8/12/03	79	81	3
427	359460	6/3/03	6/30/03	38	8/12/03	9/4/03	81	104	4
428	359830	6/3/03	7/6/03	44	8/20/03	8/17/03	89	86	4
429	359969	6/6/03	6/30/03	38	8/26/03	8/26/03	95	95	3

* Did not mature by mid-Sept.

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Table 19 (Continue)

item no.	accession no.	50% emergence	first flower	days to 1st flower	80% pod maturity dry cond.	80% pod maturity wet cond.	days to pod maturity dry cond.	days to pod maturity wet cond.	drought tolerance**
430	359997	6/6/03	6/29/03	37	8/20/03	8/23/03	89	92	2
431	360095	6/3/03	6/28/03	36	8/17/03	8/23/03	86	92	4
432	360108	6/3/03	6/29/03	37	8/17/03	9/2/03	86	102	3
433	360194	6/3/03	7/1/03	39	8/20/03	9/4/03	89	104	2
434	360433	6/3/03	6/28/03	36	8/10/03	8/26/03	79	95	3
435	360545	6/3/03	6/27/03	35	8/12/03	9/12/03	81	112	2
436	360670	6/3/03	6/30/03	38	8/12/03	9/2/03	81	102	3
437	426569	6/3/03	6/29/03	37	8/12/03	8/20/03	81	89	3
438	450669	6/3/03	7/1/03	39	8/10/03	8/20/03	79	89	3
439	450930	6/3/03	6/25/03	33	8/10/03	8/26/03	79	95	2
440	451015	6/3/03	6/28/03	36	8/10/03	9/2/03	79	102	4
441	451084	6/3/03	7/6/03	44	9/15/03	9/4/03	115	104	4
442	451199	6/3/03	6/27/03	35	8/15/03	8/26/03	84	95	3
443	451287	6/3/03	7/12/03	50	9/15/03	9/10/03	115	110	5
444	451363	6/6/03	6/29/03	37	8/20/03	8/18/03	89	87	3
445	451653	6/11/03	7/1/03	39	9/10/03	9/10/03	110	110	4
446	451656	6/3/03	7/6/03	44	9/15/03	9/15/03	115	115	5
447	509197	6/3/03	6/27/03	35	8/12/03	9/4/03	81	104	4
448	358930	6/3/03	7/4/03	42	8/20/03	8/23/03	89	92	4
449	193767	6/3/03	6/30/03	38	8/8/03	8/23/03	77	92	1
450	502994	6/3/03	7/1/03	39	9/4/03	9/4/03	104	104	4
451	343018	6/3/03	7/1/03	39	8/15/03	8/26/03	84	95	1
452	439847	6/3/03	7/1/03	39	8/15/03	8/26/03	84	95	3
453	468932	6/6/03	7/8/03	46	9/4/03	9/15/03	104	115	5
454	257584	6/3/03	6/27/03	35	8/5/03	8/26/03	74	95	3
455	257586	6/6/03	6/26/03	34	8/12/03	8/26/03	81	95	2
456	359009	6/3/03	6/29/03	37	8/10/03	8/20/03	79	89	2
457	359127	6/3/03	6/29/03	37	8/12/03	8/26/03	81	95	3
458	359170	6/3/03	6/29/03	37	8/10/03	8/26/03	79	95	3
459	359481	6/3/03	6/30/03	38	8/12/03	9/2/03	81	102	3
460	359502	6/3/03	6/28/03	36	8/12/03	9/4/03	81	104	2

* Did not mature by mid-Sept.

** 1=susceptible, 2=somewhat susceptible, 3=neither susceptible nor tolerant, 4=somewhat tolerant, 5=tolerant

Table 19 (Continued)

item no.	accession no.	50% emergence	first flower	days to 1st flower	80% pod maturity dry cond.	80% pod maturity wet cond.	days to pod maturity dry cond.	days to pod maturity wet cond.	drought tolerance**
461	359801	6/3/03	7/6/03	44	8/20/03	9/2/03	89	102	4
462	360070	6/3/03	6/30/03	38	8/15/03	8/23/03	84	92	2
463	360122	6/3/03	6/27/03	35	8/12/03	8/23/03	81	92	2
464	360328	6/3/03	6/27/03	35	8/26/03	9/10/03	95	110	4
465	360517	6/6/03	6/26/03	34	8/12/03	8/20/03	81	89	3
466	360609	6/6/03	7/4/03	42	8/23/03	9/4/03	92	104	2
467	360672	6/6/03	7/1/03	39	9/10/03	8/30/03	110	99	3
468	360680	6/3/03	7/1/03	39	8/15/03	8/23/03	84	92	4
469	360688	6/3/03	7/6/03	44	9/12/03	9/2/03	112	102	5
470	426536	6/3/03	6/29/03	37	8/20/03	9/2/03	89	102	2
471	426554	6/3/03	6/29/03	37	8/12/03	8/20/03	81	89	2
472	450564	6/3/03	6/27/03	35	8/10/03	8/18/03	79	87	3
473	450640	6/3/03	6/27/03	35	8/15/03	8/18/03	84	87	3
474	450763	6/3/03	7/4/03	42	8/26/03	8/26/03	95	95	5
475	450843	6/6/03	7/6/03	44	8/10/03	8/18/03	79	87	1
476	451032	6/3/03	7/4/03	42	9/10/03	9/4/03	110	104	5
477	451127	6/11/03	7/10/03	48	*	9/15/03	*	115	4
Average				**38.5**			**90.4**	**99.1**	**3.2**
Median				**37**			**84**	**99**	**3**
Minimum				**33**			**70**	**79**	**1**
Maximum				**62**			**125**	**125**	**5**

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** 1=susceptible, 2=somewhat susceptible, 3=neither susceptible nor tolerant, 4=somewhat tolerant, 5=tolerant