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Garbanzo Bean Production Trials In Colorado and Wyoming

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INTRODUCTION

Garbanzo bean (*Cicer arietinum* L.) is a drought tolerant, cool-season, legume crop used for human consumption. The crop is also called chickpea in many regions of the world where it is widely grown. The plant grows upright 18 to 24 inches and produces numerous pods that contain one to two seeds each (back cover). Because the plant is tolerant to cool temperatures, it is often grown in semiarid subtropics as a winter annual, following a summer cereal crop, such as wheat or barley. The garbanzo bean can be grown on a range of well-drained deep soils. The seed contains 13 to 33% protein, 40 to 55 % carbohydrate and 4 to 10 % oil, and is a valuable source of complex carbohydrates and fiber in the human diet (Stallknecht et al.,1995).

Garbanzo beans are classified into two distinct groups, including, small seeded "desi' and large seeded "kabuli" types. Desi type garbanzo beans are usually small (more than 100 seeds/oz), irregular in shape and often dark brown to black colored. Desi types are extensively grown in the Middle East, Pakistan and India where they are used in soups and to make flour for bread. Kabuli garbanzo beans are larger (less than 100 seeds/oz), more rounded and pale cream in color. Most garbanzo beans consumed in the US are kabuli, prepared as whole cooked seeds for soups and salads. Garbanzo seed is usually sold as dry pack or as a cooked canned product in the US. High quality garbanzo seed must be large (52 to 60 seed/oz), cream colored and free from cracks, splits or seed coat damage to produce a desirable canned product. More than 90 % of garbanzos grown in the US are sold for canning, while the remaining are sold for dry packaging or as animal feed (Stan Murray of Klein-Berger Co., Personal Communication).

Consumption of garbanzo bean in the US is higher than production, so much of the crop must be imported. Approximately $12 million of garbanzo are imported each year, compared to domestic production of $2 million (Yarris, 1984). Production in the US was 507,000 cwt during 1996 (National Agricultural Statistical Service), almost exclusively kabuli type. Commercial production is concentrated in the Central Valleys of California and Palouse Region in eastern Washington and northern Idaho. California led the US in production with 355,000 cwt or 70% of the US crop in 1995. Washington and Idaho produced an additional 118,000 cwt in 1996.

The crop is grown as a winter annual in the San Joaquin Valley of California, where it is planted in the late fall and harvested in late spring. In the Palouse region of the Pacific Northwest, it is grown as a summer crop where it is planted in spring and harvested in late summer. Garbanzo production in the Palouse relies on precipitation (20-22 inches/year), while California relies on irrigation to produce the crop. Average yield levels in California, Idaho and Washington during 1996 were 1540, 1400 and 2280 lbs/acre, respectively (National Agriculture Statistical Service).

Garbanzo beans should be well suited to non-irrigated production in our region because they do not require high levels of soil moisture and are produced extensively in the Middle East where there is inadequate soil moisture to produce other crops. If the crop is grown under irrigation, excessive irrigation water will cause damage to the crop by promoting disease development, especially damping off of seedlings, and *Fusarium* wilt, delay harvest maturity and promote

excessive vegetative growth. The crop normally matures 120 to 140 days after planting if the crop is planted during April. Harvest maturity is accelerated by high daytime temperatures and depletion of soil moisture in the root zone.

Garbanzo beans can be swathed or combined directly if the crop is dry enough. Garbanzo bean may be more suitable than dry bean (*Phaseolus vulgaris* L.) for production under dryland conditions in our region where soil erosion is a concern because it does not require disturbing the soil surface by undercutting prior to harvest. Furthermore, the use of garbanzo bean in a cereal crop rotation has been shown to reduce the incidence of cereal diseases, fertilizer cost and weed problems associated with cereal crop monoculture (Murray et al., 1987). Alternative crops such as garbanzo, can also diversify the economic base of a cereal-based cropping system.

The purpose of this bulletin is to provide producers and processors with basic garbanzo bean production information and report results from variety trials conducted in Colorado and Wyoming. Much of the information regarding cultural practices was taken from the University of Idaho Extension publications entitled "Dry Pea, Lentil and Chickpea Production in Northern Idaho" (Murray et al., 1987), and "Chickpeas, a Potential New Pulse Crop for Northern Idaho" (Auld and Lee, 1982).

Commercial Varieties And Seed Sources

Almost all commercial varieties grown in the US are kabuli type developed at Washington State University or the University of California-Davis. Four widely grown varieties are; UC-15, UC-27, Sanford and Dwelley. UC-15 and UC-27 are varieties released by the University of California-Davis for production in the coastal areas and central valleys of California, respectively (Helms et al., 1992a, 1992b). These varieties produce seed with excellent canning quality characterized by straw color, uniformity in size, and good seed-coat crinkle. Sanford and Dwelley are new varieties released by Washington State University that have resistance to Ascochyta blight, a serious foliar disease of garbanzo bean world wide. In the Palouse region, only Ascochyta resistant varieties can be grown.

Certified seed of commercial garbanzo bean varieties are available in California and Washington. Contact the California Crop Improvement Association (916-752-0544) or the Washington State Crop Improvement Association (509-966-2234) for a list of Certified seed distributors in that region. The seed should be inoculated with the appropriate strain of *Rhizobium* bacteria prior to planting (Beck, 1992) to ensure good nodulation and nitrogen fixation. The seed is not preinoculated with *Rhizobium* because bactericide seed treatments may harm the *Rhizobium*. Some commercial inoculants are sold in granular form that can be applied through a granular applicator box using a separate delivery tube into or near the seed furrow. When storing inoculant, minimize exposure to direct sunlight or high temperature which will kill the bacteria.

Seedbed Preparation And Planting

Seedbed preparation is the first step to a successful garbanzo crop. Murray et al. (1987) state that chickpeas do best when planted in a seedbed with minimal residue on the soil surface. The soil should be tilled enough to eliminate large clods, but not overworked to the point of pulverizing the surface layer or causing soil compaction. Soil tilth for planting garbanzo bean should be

similar to that required for dry edible beans such as pinto, great northern or light red kidney.

Seed should be placed 1.5 to 3 inches deep and covered with a packer wheel to ensure good seed to soil contact. Seeding rates should vary with soil moisture availability and seed size of the variety planted. In general, non-irrigated fields should be planted with approximately 50,000 to 80,000 viable seeds/acre, while irrigated fields can be planted to 100,000 to 120,000 viable seeds/acre. Because seed size for most kabuli type chickpeas range between 750 to 900 seeds/lb, actual planting rates will vary from about 60 to 120 lbs/acre under different soil moisture regimes. Seeding rates for the trials reported herein are noted in the Materials and Methods section of each trial.

Garbanzos can be planted in solid stands (6 to 12 inch row spacing) or in wide rows 22 to 30 inches. Solid stands are often superior for weed control and to provide crop stubble for prevention of soil erosion after the crop is removed. Garbanzo should be planted when the soil temperature reaches 42 to 45^0 F at planting depth. This soil temperature occurs in early to mid April in the eastern regions of Colorado and early to mid May in parts of western Colorado and Wyoming. Delayed planting will enhance seedling diseases and result in crop exposure to high temperatures during the flower and early pod fill stages. The crop must flower and set pods during the relatively cool months of June and early July for optimum yield. High temperatures that occur by mid-July to early August cause the crop to terminate flowering.

Nutrient Requirements of The Crop

Base all nutrient fertilizer requirements on a laboratory soil test result. The crop needs 20 to 30 lbs of available nitrogen for stand establishment, however, the crop is capable of fixing atmospheric nitrogen. After the plant becomes established it can utilize nitrogen fixation to fulfill the season long nitrogen requirement. Avoid excessive N, because it will cause increased vegetative growth, prolong the maturation period and reduce seed yield. Phosphorus requirements are not well known, but crop requirements are considered to be approximately 60 lbs/acre. Potassium is generally not limiting in our region, but if soil test results indicate low (50 to 75 ppm) to very low (0 to 50 ppm) potassium, add 40 to 80 lbs K_20. Soil pH between 6.0 and 8.0 is suitable for garbanzo production.

Weed Control

A good weed control program is essential to obtain good yield results. If the crop is grown in solid stands, a pre-plant herbicide is needed if the field has a history of grassy or broadleaf weed problems. Fields planted to 22 or 30 in rows can be cultivated once or twice to control weeds growing between the rows, but may also benefit from a herbicide. Metolachlor (Dual 8E) is labeled for use on garbanzo at 1.5 to 3.0 lbs ai/acre to control annual grasses and broadleaf weeds in CO and WY. The herbicide can be incorporated pre-plant 1 to 2 inches deep, not over 2 weeks before planting, or applied pre-emergence. Metolachlor is reported to be weak on lambsquarter but provides some nightshade control (Murray et al., 1987). Other herbicides are currently labeled for use on garbanzo bean in CA, ID and WA but not in our region. Read all label directions prior to use of any pesticide.

Insect Pests

Insects have not been a serious problem on garbanzos grown in the Northwestern US (Murray et al., 1987). We did not observe any serious insect pests on garbanzo bean grown in our research trials. Some foliar damage from leaf minors was observed, but they did not cause economic damage.

Diseases

Pathogens that affect the crop are classified as either causing seedling or adult plant diseases. Among seedling diseases, seedling rot and damping off due to the fungi *Pythium* spp., *Fusarium solani* and *Rhizoctonia solani* are the most prevalent. These pathogens infect the seedling shortly after germination and kill or weaken it during seedling emergence, resulting in poor stands or reduced plant vigor (Haware, 1998). Proper use of a seed treatment fungicide can provide cost-effective protection from seed rotting fungi and improve stand establishment. Fungicides such as Captan and Metalaxyl are labeled for prevention of many fungi that attack seedlings. Captan has activity against *Pythium* spp., *Fusarium solani* and *Rhizoctonia solani*, while Metalaxyl has activity specifically against *Pythium* spp. that attack both the seedling and mature plant.

Ascochyta blight is the principal foliar disease of garbanzo bean worldwide (Haware, 1998; Murray et al., 1987; Wiese, et al., 1995). This disease is caused by the fungus *Ascochyta rabiei* and became so severe in some regions of the Palouse during 1987, that it destroyed 50 % of the crop. After 1987, garbanzo production was reduced or eliminated in an attempt to eradicate the blight fungus (Wiese et al., 1995). By 1991, this effort significantly reduced residual levels of the pathogen, but the pathogen was not completely eliminated. Today, Ascochyta resistant varieties such as Sanford and Dwelley are widely grown in the Palouse. Aschocyta has not been identified in Colorado, however, if the crop becomes widely cultivated in the state, it may become a problem during periods of prolonged moisture and moderate to low temperatures. Symptoms of Ascochyta are elliptical lesions that occur on the stems, leaves and pods. The lesions have concentric whorls of dark fruiting bodies called pycnidia that can be observed with a hand lens. The lesions often girdle the stems, causing upper portions of the plant to yellow, wilt and eventually die. Infection and spread is favored by wet weather occurring at moderate (65-75 ^{0}F) air temperature. Spores are spread by wind driven rain, machinery, clothing or other mechanical means. Infected fields exhibit yellow areas that increase in size during cool, wet weather. Infected plants can recover with warm, dry weather, but will mature later and suffer yield and quality losses.

The Ascochyta organism is spread through infected crop residue or infected seed. The use of Certified, pathogen-free seed treated with either benomyl or thiabendazole should minimize seed-borne spread. The pathogen is short lived in the soil if crop residue is incorporated by mold board plowing or discing immediately after the crop is harvested. Residue and seed lost during the prior harvest on or near the surface can provide a source of inoculum for at least 2 to 3 years. In the Palouse, recommendation include the use of pathogen-free Certified Seed, rotations that include garbanzo beans only once every 3 to 4 years, and destruction of blight-infested crop residue immediately after harvest (Wiese et al., 1995).

Pea Enation Mosaic Virus (PEMV) can be a problem in garbanzo. PEMV was observed in the

garbanzo trials conducted in Ft. Collins during both 1995 and 1996. This virus is transmitted by aphids and causes chlorotic flecks, stunting, enation and distorting of leaf tissue. Infected plants had severe chlorosis and stunting and failed to produce seed. The virus was likely transmitted by aphids from nearby alternate host plants such as alfalfa (*Medicago sativa* L.) or clovers (*Trifolium* spp.). The incidence of infected plants was 3 to 5%, consequently the disease did not significantly influence the final yield.

Harvest Procedures

On-farm threshing and transportation of garbanzo bean are somewhat similar to dry edible beans. Garbanzo beans are swathed or harvested directly with a sickle bar header rather than undercut as with dry beans. Swathing or direct cutting is possible because pods are produced 3 to 6 inches above the soil surface. Direct harvest requires that the crop be uniformly mature and dry prior to combining. Plants that are immature or green at the time of cutting will produce dark, discolored and immature green seed. Dark colored seed reduces quality and cannot be easily removed during the conditioning process (Canevari, 1994). Foliar desiccants can be used to dry the crop and facilitate threshing. The use of desiccants increases production costs and uniform desiccation may be difficult if the crop is planted in narrow rows or weed problems prevent good coverage of the dessicant. Swathing can also be used to dry the crop. Swathed windrows should be relatively small to allow good aeration and rapid drying of pods. Large windrows can cause moisture to accumulate in the lower part of the windrow, resulting in discoloration and poor seed quality.

The crop should be threshed at approximately 14 to 18 % seed moisture. Excessively dry seeds will crack and break, reducing their quality for market. Combine settings should be similar to those for threshing large seeded dry edible beans such as light red kidney. Rotary combines are superior to cylinder combines because they do less damage to the seed during threshing. If a cylinder combine is used, the concave clearance must be set wider than the diameter of the seed and operated at a slow cylinder speed to provide good separation of the seed and plant residue.

Processing And Marketing

Because garbanzo beans are not traditionally grown in our area, marketing the unprocessed product may be difficult. The key to successful marketing is the production of seed that has high quality. Seed that meets canning quality standards is characterized by large size, typically 54 to 60 seeds/oz, free from cracks, splits and seed coat checks, with light cream color. Garbanzo seed that does not meet canning standards can be difficult to market. Field harvested garbanzo seed lots should have minimal mechanical damage and light cream color. Field weathering and small seeded lots will be greatly reduced in value. Seed quality is dependent upon environmental conditions that are advantageous to large seed production, uniformity in maturation of the crop, and harvest conditions that favor minimal seed damage and field weathering.

Most garbanzo beans are processed with conditioning equipment similar to that used for dry edible bean. Bins, elevator legs, conveyors, air screen cleaners and secondary conditioning equipment used for processing dry beans should be adequate to prepare the crop for final market. Garbanzo seeds are marketed in dry pack containers or as a canned product. Commercial processing includes seed conditioning, sizing and packaging or canning of the product. Grower prices for the large seeded lots ranged from $20 to $50/cwt in the past 5 years. Prices decline

rapidly for lesser quality and smaller seed. Market price is largely influenced by the annual volume and quality of the garbanzo crop available in Mexico and Turkey.

Consult with a local bean elevator or buyers for possible market outlets of garbanzo beans in our region before you produce garbanzo on large acerage. Many dry bean packers use small seeded garbanzo beans in their soup mix beans or market them in dry packages, so there is limited local demand for garbanzo.

Garbanzo Yield and Adaptation Trials at Ft. Collins, CO

Mark A. Brick, Amare Abebe, and James Barry Ogg

Methods

The study was designed to compare yield levels among four commercial kabuli type chickpea cultivars planted on two dates under irrigated and non-irrigated conditions. This study was conducted at the Colorado State University Agricultural Research, Demonstration and Education Center (ARDEC), Ft. Collins, CO during 1995 and 1996. The site is located 4 miles north of Ft. Collins on the east side of Interstate-25. The soil at this site is classified as a Ft. Collins series, fine-loamy, mixed, mesic Ustollic Haplargids in the order Aridosols, pH 8.0. The cultivars evaluated were 'UC-15' and 'UC-27' from the University of California-Davis, and 'Sanford' and 'Dwelley' from Washington State University.

The trials were planted with a cone planter on two planting dates. The early planting dates were 6 and 9 April and late planting dates were 27 April and 3 May in 1995 and 1996, respectively. Seed was placed 2 inches below the soil surface in rows spaced 30 in. Bulk seeding rates were 70 and 115 lbs seed/acre in the dryland and irrigated environments, respectively. This rate provided a pure live seed planting rate of 60,000 and 98,000 seeds/acre, respectively. A granular form of *Rhizobium* (Implant Plus, Nitragin-Brand Inoculant for Garbanzo) was mixed with the seed in the seeder box at the time of planting.

Irrigation water was applied with an overhead sprinkler irrigation system in both years. The irrigated plots were first irrigated in late May during both years, consequently, the effects of irrigation did not influence stand establishment. The irrigated plots received approximately 8 in of supplemental water in 1995 and approximately 20 inches in 1996. The irrigated plots received more irrigation water than necessary in 1996, because relatively high amounts of rainfall occurred during the growing season and irrigation was scheduled to meet the evapotranspiration needs of an adjacent plot of corn (*Zea mays* L).

The pre-emergence herbicide Dual 8E (metolachlor) was applied on 1 April at 2 lbs/acre of product for both the early and late plantings. All plots received one interrow cultivation in mid June.

Seed yield was evaluated from three replicates of one 20 ft linear section of row in 1995 and from two 27 ft rows in 1996. A randomized complete block design was used in both years. The plots were cut with a sickle mower and plants allowed to air dry in the field for 5 to 10 days prior to threshing. Seeds were threshed with a stationary plot thresher. The dryland plots were cut on 9 and 10 August in 1995 and 1996, respectively. The irrigated plots were cut on 8 and 12 September in 1995 and 1996, respectively. Plot yields were adjusted for missing areas in the row and yield levels reported herein are likely 10 to 20% higher than what would be obtained on a farmers field because of that adjustment.

1995

cool, wet weather during April and early May. There was a severe weed infestation in the late

delayed planting date. The label for this herbicide recommends that it should be applied no more

herbicide too far in advance of label requirements. Some weed problems were caused by Canada
Cirsium arvense
weed problems reduced plant vigor and seed yield in the irrigated plots. Weed competition did

weed density than the early trial.

any environment. Mean yield was higher in the early than late planting in both environments.

season. Mean yield did not differ statistically between the irrigated and dryland environments for

yield potential in the irrigated environment was likely due to weed problems that reduced yield

Seed quality among varieties was evaluated by a commercial garbanzo trader to determine if the

for evaluation and may have biased the quality evaluations downward, because seed conditioning

samples met the standards for canning. Most of the seed was too small, however, UC 27

uneven maturation and some immature green seed was present in all seed lots. Seed lots from the

suggest that garbanzo beans appear to yield well and are adapted to dryland production in our

Seedling emergence was faster in 1996 due to warmer climatic and soil temperatures than during

date of physiological maturity (DTM= date of maximum yield accumulation) were recorded in

29 June in the irrigated trials (Table 2). Late planting delayed the average date of first flowering

differ between the dryland and irrigated trials. These results suggest that the date of flowering was

The average DTM occurred 11 days earlier in the early than the late planted trials (Table 2).

These results substantiate the need to plant garbanzo bean in early April to assure early maturity and that the crop reach harvest maturity prior to the onset of daytime temperatures near or above 90^0 F. DTM was not recorded in the irrigated trials because excessive irrigation water stimulated plant growth and delayed maturity. The plots were ultimately cut prior to maximum yield accumulation on September 10.

Mean yield among varieties was higher in dryland than irrigated plots (Table 3). Relatively low yields were observed in irrigated plots due to excessive irrigation water which stimulated vegetative growth and delayed harvest maturity. This result substantiates the need to limit irrigation water on garbanzo bean, especially in July and August when the crop should be allowed to dry down for harvest. The problems associated with over-irrigation in this study prevented a valid comparison of varieties for yield potential under proper irrigation.

Yield levels among varieties did not differ statistically in the dryland trials, however, UC-27 had the highest observed yield when planted in early April (Table 3). Observed seed yield was lower for the late planting of all varieties under dryland conditions.

Seed size was influenced by planting date, variety and irrigation. The only seed lots that had 54 to 56 seeds/oz were produced by the cultivars UC 15, UC 27 and Dwelley in the early planted plots under dryland conditions (Table 4). The variety UC 27 produced 58 seeds/oz in the late planted dryland plots, while all other varieties produced seed smaller than 63 seeds/oz. Seed color from dryland production was superior to irrigated production. In general, seed color of UC 27 was superior to the other varieties because it had fewer discolored seeds and very few green seeds. Because the irrigated plots were late and immature when harvested, the seed was discolored and had many green immature seeds. None of the seed from irrigated plots met canning quality standards.

All plots were relatively disease free in both years. Symptoms of Pea Enation Mosaic Virus appeared on 3 to 5 % of the plants in both years. The virus significantly reduced yield of infected plants, however, because disease incidence was low, there was minimal impact on total yield. We did not observe any serious insect pests on the garbanzo beans grown in our research trials. Some damage from leaf minors was observed on foliage, but there did not appear to be any economic damage.

Summary

Planting Date

These trials clearly demonstrated the need to plant garbanzo bean in early April in eastern Colorado and limit the amount of irrigation water applied during the growing season. In general, when the crop was planted in early April, date of flowering, date of maturity, seed size and quality and yield were superior to planting in late April or early May. The results confirm that the crop should be planted when soil temperatures reach 42-45 ^{O}F at planting depth. Delayed planting, delays plant maturity and produces lower quality seed with more discoloration and immature pods at harvest.

Dryland vs Irrigated Production

Irrigated trials did not perform superior to the dryland trials, and in 1996, the dryland plots had higher yield than irrigated plots. Weed problems and over irrigation prevented an adequate assessment of yield potential under irrigation. More studies are needed to determine the optimum timing and application of irrigation water. Alternatively, the dryland trials were very representative of garbanzo production potential under rainfed conditions in our region. These trials suggest that it should be feasible to produce a 600 to 800 lb/acre garbanzo crop in rainfed environments.

Variety Performance

Yield performance among varieties was not statistically different in the dryland environment and only differed in the irrigated environment in 1996. Seed size and plant maturity differed among varieties. The varieties UC 27, UC15 and Dwelley produced seed with acceptable size only when planted in early April under dryland conditions. In the late dryland planting, only UC 27 produced seed larger than 59 seeds/oz. In general, UC 27 was the only variety that consistently produced larger and higher quality seed than the other varieties. The ability of UC 27 to produce high quality seed was directly related to early plant maturity. The variety UC 27 flowered 10 to 12 days earlier and reached plant maturity 4 days earlier than Dwelley or Sanford. Early maturity also provided more uniform pod maturity and fewer green pods at harvest. Based on these results, UC 27 appears to be a suitable variety under dryland conditions in our region. However, if Ascochyta becomes a disease problem in our area, UC 27 would not be suitable because it is susceptible to the pathogen.

Conclusions

The results from this research suggest that garbanzo beans can be produced in eastern Colorado. However, production of a high quality seed is difficult. These studies suggest that the producer should follow several basic production principles including, the use of *Rhizobium* seed inoculant, a good weed control program and planting during the first 10 days of April to ensure timely harvest maturity. The crop can be grown under dryland or minimally irrigated conditions, however, if irrigation is used, it should be terminated in early July. Harvest operations must be carefully planned to adequately dry the crop prior to threshing and prevent the seed from becoming discolored or dry. Gentle threshing of the seed and proper seed conditioning will provide a product with light cream color and freedom from splits and cracks that meets standards for canning quality.

Table 1. Yield of four chickpea varieties planted on two dates in 1995 in irrigated and non-irrigated environments at Ft. Collins, CO.

	Environments/Planting Dates†			
	Dryland		Irrigated	
Variety	Early	Late	Early	Late
	----------Yield lbs/acre*----------			
UC-15	944	951	1147	1224
UC-27	1022	853	981	1079
Sanford	854	737	1163	639
Dwelley	853	784	1070	870
Mean	918	831	1090	953
$LSD_{(0.05)}$	NS	NS	NS	NS

*Means of three replicates in each environment.
† Early planted: 6 April; Late planted: 27 April, 1995.

Table 2. Date to flower and physiological maturity of four chickpea varieties planted on April 9 and May 3, 1996 in irrigated and non-irrigated environments at Ft. Collins, CO.

	Planting Dates/Environments					
	Early ‡		Late ‡		Early	Late
Variety	----------Dryland----------				----------Irrigated----------	
	DTF†	DTM†	DTF	DTM	DTF	DTF
UC-15	10 June	24 July	27 June	3 Aug	10June	23 June
UC-27	7 June	24 July	17 June	2 Aug	7 June	19 June
Sanford	15 June	29 July	30 June	6 Aug	17 June	27 June
Dwelley	18 June	27 July	1 July	6 Aug	15 June	29 June

† DTF = Date that 50% of the plants produced the first flower.
† DTM= Date that plots reached physiological maturity or maximum yield accumulation.
‡ Early planted: 9 April; Late planted: 3 May, 1996.

Table 3. Yield of four chickpea varieties planted on two dates in 1996 in irrigated and non-

	Environments/Planting Dates			
	Dryland			
Variety	Early		Early	
	----------Yield lbs/acre*----------			
	872		479	
UC-27		753		538
	934		830	
Dwelley		485		937
	955		575	
$LSD_{(0.05)}$	NS		388	

*Means of three replicates in each environment.
Early planted: 9 April; Late planted: 3 May, 1996.

Seed size of four chickpea varieties planted on two dates in 1996 in irrigated and non-

	Environments/Planting Dates			
	Dryland			
Variety		Late	Early	Late
UC-15		63.1		70.8
	54.4		67.6	
Sanford		71.8		76.4
	54.9		68.8	
$_{(0.05)}$		2.8		5.1

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Garbanzo Bean Yield and Adaptation Trials at Yellow Jacket, CO

Abdel Berrada, David V. Sanford, and Mark W. Stack

OBJECTIVES

1. Evaluate the adaptation and yield potential of garbanzo bean in southwestern Colorado.
2. Determine the response of garbanzo bean to irrigation and nitrogen fertilizer.

METHODS

Field studies were conducted at the Southwestern Colorado Research Center in Yellow Jacket, CO from 1994 to 1996 to evaluate the potential of garbanzo bean under dryland and irrigated conditions. Elevation at the research center is 6980 ft. The number of days with minimum temperature > 28 ^{o}F is 143 in 8 out of 10 years (Colorado Climate Center). The average annual precipitation is almost 16 inches with June usually being the driest month. The predominant soil series is Wetherill silty clay loam (fine-silty, mixed, superactive, mesic, Aridic haplustalf).

Dryland trials

Two variety trials were conducted in 1995 and one in 1996. The first trial in 1995 included four kabuli-type varieties (Dwelley, Sanford, UC-15, UC-27) and one desi type, 'Myles'. The second trial included eight advanced lines from the chickpea-breeding program at the International Crops Research Institute for the Semi-Arid Tropics, India (ICRISAT). These lines were all kabuli type and were selected based on their resistance to Fusarium wilt (*Fusarium oxysporum*). In 1996 the two trials were combined but were not harvested due to extremely dry conditions before planting and during most of the growing season.

The kabuli-type entries were planted with the White 3407 Air Planter. Myles was planted with a hand-pushed Precision Garden Seeder due to its small and irregularly shaped seeds. Row spacing was 30 inches and planting rate 2 seeds/ft. A randomized complete block design with four replicates was used in each trial. Plot size was 10 ft x 40 ft. Seed and dry matter production were estimated from the two middle rows in each 4-row wide plot.

Irrigated trials

Four irrigated trials were conducted from 1994 through 1996 at Yellow Jacket. To evaluate the effects of irrigation and applied nitrogen, the varieties Dwelley and Sanford were planted in 1994 and Sanford only in 1995 and 1996. Plots were seeded at 4 seeds/ft with 30-in row spacing. The number of replicates in each trial was three, four and six in 1994, 1995, and 1996, respectively. Planting and harvest dates and other management information are shown in Table 5. Each plot consisted of four 6-ft rows. Garbanzo bean plants in the two middle rows were pulled by hand at or near harvest maturity, left to dry for several days and threshed with a Hege 125 combine.

A sprinkler gradient irrigation system, also known as line-source irrigation similar to the one described by Hanks et al. (1976) was used. Sprinkler heads with 3/16" x 3/32" double nozzles were mounted on 2-ft high risers one inch in diameter attached to 3-inch diameter quick-coupling

portable aluminum pipes. The spacing between sprinklers was 20 ft. The wetted radius was measured at 6, 18, 30, 42, and 54 ft from the sprinkler line. A strong linear correlation existed perpendicular to the sprinkler line. Nine irrigation levels were distinguished for harvest purposes.

Irrigation level:	1	2	3	4	5	6	7	8	9
Distance (ft):	51-57	45-51	39-45	33-39	27-33	21-27	5- 21	9-15	3-9

completely randomized block design. Nitrogen in the form of ammonium nitrate was broadcast by Approximately 40 lb P O /acre was applied uniformly over the whole plot area each year. The soil phosphorus. Pre-fertilization levels of NO -N and AB-DTPA extractable P in the upper foot of

RESULTS & DISCUSSION

Results from the dryland variety trials are shown in Tables 6 and 7. Dryland variety trial No. 1 (Table 6). Dwelley had the lowest dry matter and seed yield likely due to lower plant population at days later than the other varieties, which may have affected its yield. Myles was the earliest August. Myles is visually recognizable from the kabuli-type garbanzo beans due to its purple

There were no significant differences in dry matter or seed yield in trial No. 2 among the lines (ICRISAT) (Table 7). Yield levels in trials No.1 and 2 were similar, with the exception of Dwelley virus. Percent infestation was 6 to 12 % in trial No.1, and 5 to 24 % in trial No. 2. Leafminer of leafminer and bean leaf roll virus were not quantified.

which is typical for this type of chickpea. Among the kabuli-type cultivars, UC-27 probably had and acceptable seed shape (round) and color (light cream). Both UC-27 and UC-15 had round wrinkled. Dwelley and UC-15 had similar seed size to that of UC-27 but had more cracked and/or

stained seeds. Desirable qualities for canning are medium seed size (54-56 seeds/oz), golden color, rough texture, high water intake, and a seed coat that does not fracture easily. Stan Murray, Klein Burger Co., believes that UC-27 has the best qualities for canning of all three varieties. Unfortunately UC-27 is susceptible to Ascochyta blight and should only be grown in dry climates like those in Colorado. Sanford had smaller seeds as did most of the ICRISAT lines. The only ICRISAT line with acceptable seed size for canning was 'ICCV 95402', but it had more cracked and stained seeds than UC-27 (data not shown).

Several older chickpea cultivars were tested in Mountezuma County in 1981, 1983, and 1984. They averaged 753 lb/acre yield over the three-year period (unpublished data). In comparison, dry bean yields rarely exceed 500 lb/acre and the county average during 1991 to 1995 was 396 lb/acre (Colorado Agricultural Statistics).

Irrigated trials

Results of the irrigated trials are shown in Tables 8, 9 and 10. Irrigation, nitrogen fertilization, and their interaction all had a highly significant effect on seed yield and size of Dwelley and Sanford in 1994 (Table 8). The yield of Dwelley more than doubled and Sanford improved by almost one-half with the application of 50 lb N/acre compared to no nitrogen. The maximum seed yield of both Dwelley and Sanford was approximately 2200 lb/acre with 50 lbs/acre N fertilization and approximately 8 inches of supplemental irrigation. In addition, a uniform irrigation of 2 inches before planting and 1 inch after planting was applied to ensure adequate stand establishment. Total rainfall from planting to harvest was 2.3 inches. The increase in yield due to irrigation was more pronounced where nitrogen was applied, particularly in the case of Dwelley.

Larger seeds of Dwelley and Sanford were produced with 50 lb N/acre and in the drier treatments as evidenced by the smaller number of seeds per ounce. Dwelley averaged as few as 50 seeds/oz with nitrogen fertilization at irrigation levels 1 to 5 and as many as 74 seeds/oz with no nitrogen fertilization at high irrigation levels. A composite sample of Sanford seeds from the 1994 harvest had few defects, good seed color, and excellent imbibing quality (Stan Murray of Klein-Berger Co, personal communication). However, none of the seed lots produced by Sanford were acceptable for canning.

Sanford seed yield increased significantly with increasing amounts of irrigation in 1995 (Table 9). A maximum yield of 1840 lb/acre was obtained with 11.3 inches of irrigation plus precipitation. Seed size averaged approximately 59 seeds/oz with no significant differences among irrigation levels. Nitrogen fertilization did not influence seed yield or size despite low soil test levels. Much cooler conditions prevailed during and following garbanzo bean planting in 1995 than in 1994 or 1996 (CSU CoAgMet weather data). Consequently, 50% emergence did not occur until at least four weeks after planting in 1995 compared to about two weeks in 1994 and 1996. The cooler conditions in 1995 may have reduced soil nitrogen mineralization and plant uptake. Saxena (1980) reported a positive response to 13-22 lb N/acre of starter fertilizer in soils low in organic matter. Murray et al. (1987) recommended the application of 20-30 lb N/acre at planting on soils with less than 20 lb/acre of residual nitrogen. Starter nitrogen may be beneficial for stand establishment or until the garbanzo bean crop is able to fix its own nitrogen.

The period from October 1995 through May 1996 was extremely dry. Consequently, the amount of pre-irrigation in 1996 was barely enough to ensure adequate seed germination and plant emergence. The soil profile below 8 to 10 inches was at or near the wilting point at planting. Subsequent irrigations and rainfall were not enough to fill the root zone or meet the crop water demand, which would explain the relatively low yields in 1996 (Table 10). Both irrigation and nitrogen fertilization had a significant effect on seed yield and size in 1996. Seed size was smaller at the lowest irrigation level than at the highest level, contrary to the 1994 results. Studies at the ICRISAT Center in India showed an increase in the number of seeds/oz and number of pods/plant due to irrigation (ICRISAT, 1987 Annual Report; Saxena, 1980).

CONCLUSIONS

The results of the garbanzo bean trials at Yellow Jacket in the early 1980's and during 1994 to 1996 showed good yield potential and adaptation of several varieties. Yield levels of about 1000 lb/acre under rainfed conditions and 2000 lb/acre under irrigation were obtained, thus garbanzo bean seems to be a feasible crop for southwestern Colorado. The varieties Dwelley and Sanford responded well to irrigation in 1994 through 1996, and to nitrogen fertilization in 1994 and 1996.

Because garbanzo bean is more frost tolerant than dry bean, it could have an advantage over dry bean in a wheat-bean rotation in the San Juan Basin. Dry bean is usually not planted in southwestern Colorado until early June to minimize the risk of a late spring killing frost. In contrast, garbanzo bean was planted as early as 1 May at the research center with no significant yield loss compared to 1 June planting (unpublished data). Muehlbauer et al. (1982) recommended planting garbanzo bean when soil temperature is at least 42 ^{0}F. Early garbanzo bean planting and harvest would allow for a more optimum winter wheat planting date than wheat following dry bean (Berrada et al., 1995).

Garbanzo bean is susceptible to several diseases, the most common of which has been the bean leaf roll virus at Yellow Jacket. This disease is spread by pea aphids from nearby alfalfa fields. Alfalfa is host to other pathogens such as alfalfa mosaic virus which has also been found in garbanzo bean (Nene et al., 1991). The incidence of diseases and insects (leafminer) could present a formidable challenge to irrigated garbanzo bean production in the Dolores Project area since 70 to 80% of the crop acreage is in alfalfa. In addition, it may be harder to attain good seed size and color under irrigation. There appears to be more potential for garbanzo bean as an alternative to dry bean (mainly pintos) in the commonly practiced dryland winter wheat-bean rotation in southwestern Colorado. Both crops can be grown using similar production practices. The incidence of diseases would be less under dryland conditions and winter wheat could be planted at or near its optimum date following garbanzo bean.

Table 5. Management information of garbanzo bean trials conducted at Yellow Jacket, CO.

Year		1995	1996
	6/02 & 6/03	5/04	
Harvest Date	9/20 - 10/03		8/28 - 9/10
Pre-irrigation	a uniform irrigation of 1 inch on 6/17		1.4 inch on 5/09
Date and number of First Last	6/30 8/29	6/21 8/09	6/20 8/24
Precipitation January-Planting	6.7 inches 2.3 inches	5.3 inches	2.4 inches
Weed Control Herbicide (PPI)	pt/acre on 6/01	Prowl 3.3 EC @ 2.5	Dual 8E @ 2.0 pt/acre on 5/08
	7/11	6/14 & 7/24	
Previous crop	Winter wheat		Winter wheat

Table 6. Results of dryland garbanzo bean variety trial No. 1 at Yellow Jacket, CO in 1995.

	Type	Plants/acre	Dry matter (lb/acre)	Seed yield (lb/acre)		Diseased plants (%)*
	Desi	30,347		1130	152.4	
UC-27		23,522	2048		56.4	11.9
UC-15	Kabuli		2127	1080		8.0
	Kabuli	33,832		1052	66.3	
Dwelley		11,616	1604		55.1	11.3
Average			1999	972		9.3
(0.05)		6,069		179	1.8	

Planting date: 3 May; Harvest date: 23 August (Dwelley: 29 August)

* Bean (pea) leaf roll virus

Entry (Kabuli)	at harvest	Dry matter [1]	Seed yield	Seeds/oz	Diseased
ICCV95301		1976	1141		6.5
ICCV94305	26,910		999	66.5	
	30,008	1882		72.3	11.8
ICCV94304		1979	965		12.5
ICCV92328	28,459		959	71.5	
	28,459	1833		70.2	12.1
ICCV95402		1836	951		4.6
ICCV95501	27,491		950	75.2	
Average	28,459	1870		69.6	12.1
LSD	NS	NS	NS		-

[1] Aboveground dry matter including seeds

No significant effect at alpha = 0.05

* Bean (pea) leaf roll virus

Seed yield and size of Dwelley and Sanford as influenced by seasonal irrigation and nitrogen in 1994 at Yellow Jacket, CO.

		Dwelley				SANFORD			
	Seasonal Amount (inches)	0 N/acre				0 N/acre		50 lb N/acre	
			Seeds /oz		Seeds /oz		Seeds /oz		Seeds /oz
2	1.4	765	-	1125	-	969	-	979	-
3	2.8	874	61.6	1548	47.5	1023	62.9	1279	58 .6
5	5.6	717	71.7	2119	48.8	1129	71.2	2044	58.0
6	7.0	819	-	2132	-	1227	-	2208	-
8	9.8	836	-	2109	-	1411	-	2230	-
9	11.2	868	73.7	1831	60.8	1450	78.6	2232	76.6
		808	68.0		52.3	1175		1742	64.6
	(0.05)	242		242	3.6		4.4	247	

[1] Derived from the regression equation, Irrigation amount (inches) = 12.55 – 0.23X,

[2] = 0.99

Table 9. Seed yield and size of Sanford as influenced by irrigation in 1995 at Yellow Jacket,

Irrigation Level	Seasonal Amount (inches)	(lb/acre)	Seeds/oz
2	0.8	1114	-
3	1.7	1245	59.3
5	3.4	1413	57.7
6	4.3	1589	-
8	6.0	1834	-
9	6.8	1843	58.2
		1470	58.8
(0.05)		112	

[1] Derived from the regression equation, Irrigation amount (inches) = 7.69 – 0.14 X,

[2] = 0.99

Table 10. Seed yield and size of Sanford as influenced by irrigation and nitrogen in 1996 at Yellow Jacket, CO.

Irrigation		0 N/acre		50 lb N/acre	
Level	Seasonal Amount[1] (inches)	lb/acre	Seeds /oz	lb/acre	Seeds /oz
1	0.1	531	66.9	607	66.1
2	1.1	509	-	663	-
3	2.6	609	64.5	777	64.1
4	4.1	716	-	995	-
5	5.5	762	64.3	1157	59.4
6	7.0	963	-	1390	-
7	8.5	952	65.1	1495	61.4
8	9.9	1002	-	1582	-
9	11.4	1053	63.9	1568	62.4
Average		789	64.9	1137	62.7
$LSD_{(0.05)}$		158	2.6	158	2.6

[1] Derived from the regression equation, Irrigation amount (inches) = 12.85 – 0.24 X,
Where X = distance from the sprinkler line in ft. $R^2 = 0.97$

Planting date: 21 May; Harvest date: 29 August to 10 September.

Garbanzo Yield and Adaptation Trials at Torrington, WY

James Krall, and Jerry Nachtman

Methods

The study was conducted in 1996 at the University of Wyoming Research and Extension Center near Torrington, WY. The site is located 2 miles west of Torrington on the north side of US Highway 26. The soil at this site is classified as Valentine series sandy loamy, mixed, mesic Typic Ustipsamment with 1.3% organic matter and pH 7.5. The study was designed to compare production levels of four commercial chickpea varieties with the objective to obtain baseline production information on garbanzo bean production in southeastern Wyoming. The cultivars were kabuli seed types and included 'UC-15' and 'UC-27' from the University of California-Davis, and 'Sanford' and 'Dwelley' from Washington State University. Seed for these cultivars were supplied by Dr. Mark Brick of Colorado State University as part of a regional cultivar evaluation program.

The trials were planted with a cone planter on 4 April, 1996. Seed was placed in 9-inch rows to a depth of 1 inch below the soil surface. Bulk seeding rates under this irrigated environment were 120 lb seed/acre, which provided a pure live seed (PLS) planting rate of 102,000 seeds/acre. A granular form of *Rhizobium* (Implant Plus, Nitragin-Brand Inoculant for Garbanzo) was mixed with the seed in the seeder box at planting and delivered to the seed furrow.

The first irrigation was applied in early June, consequently the effects of irrigation did not influence stand establishment. Supplemental irrigation water was applied with an overhead sprinkler irrigation system. The irrigated plots received approximately 7 inches of supplemental water. As the plots were located in an area where other annual legumes such as pea and vetch were being evaluated, they received the same weed management practices. This consisted of Treflan E.C. applied at the rate of 0.5 lbs/acre with incorporation before planting, then hand weeding on two separate occasions to remove any weed escapes from the plots.

Seed production was evaluated from four replicates of six rows 25 feet in length. The plots were cut by hand on 14 August with a sickle and the plants allowed to air dry in the field for 7 days. Seeds were threshed from the plant debris with a stationary plot thresher. Yield levels reported herein are likely to be 10 to 20% higher than what would be obtained on a farmer's field.

Results

Seedling emergence and stand establishment were delayed by cool, wet weather during April. Seedling emergence and establishment was variable and provided a plant density of 61,000 to 116,000 plants/acre among plots. Regardless, ultimate yield levels were similar to those obtained in Colorado. The combination of 14.2 inches of moisture from precipitation along with

supplemental sprinkler irrigation during the growing season produced conditions conducive to optimizing yields given the environment.

Mean yield ranged from 1128 lb/acre for UC-27 to 1431 lb/A for UC-15 (Table 11). This compares similarly to irrigated yields in Colorado of 1050 lb/acre for irrigated production and comparable planting date in 1995 (Tables 1). Seed size ranged from a mean of 52.3 seeds/oz for UC-15 to 59.0 seeds/oz for Dwelley (Table 11). The overall trial mean was 55.5 seeds/oz compared to the Colorado irrigated overall trial mean of 72.7 seeds/oz for the comparable planting date in 1996.

Maturity was measured in Wyoming by assessing the proportion of "brown pods" at harvest. Percent brown pods ranged from 68% for UC-15 to 46% for UC-27 (Table 11). This measure does not relate well to the DTF and DTM methods employed in Colorado which indicated that UC-27 matured earlier than UC-15.

Summary

The results from the research suggest that garbanzo bean can be produced in southeastern Wyoming. The research demonstrates that based on seed size, high quality market class beans can be produced. This does not imply similar results under dissimilar environmental conditions. Multiple location and year testing is needed before making projections of how chickpeas will perform across environmental conditions.

Table 11. Yield, seed size and percent brown pods at harvest of four chickpea varieties in 1996 under sprinkler irrigation at Torrington, WY.

Variety	Yield	Seed Size	Brown Pods at Harvest
	lb/acre	seeds/oz	%
UC-15	1431	52.3	68
UC-27	1128	55.0	46
Sanford	1267	59.0	66
Dwelley	1208	55.8	48
Mean	1258	55.5	57
$LSD_{(0.05)}$	NS	5.2	NS

Planting date: 4 April; Harvest date: 14 August.

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