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Chickpea: A Potential Crop for Southwestern Colorado

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Chickpeas (*Cicer arietinum* L.) better known in the United States as garbanzo beans are an important source of protein in human diets. It is believed that chickpeas originated in southeastern Turkey. They have been cultivated in the Middle East, India, the Mediterranean, and Ethiopia since antiquity and were brought to the New World through trade and conquests (Duke 1981). Chickpea is an important crop in the US, Mexico, and Australia. Commercial production of chickpea in the US is concentrated in the central and coastal valleys of California and the Palouse region in eastern Washington and northern Idaho (Brick et al. 1998).

Chickpea is a deep-rooted (up to 2 m), self-pollinated, annual legume crop. Its stems are branched, erect or spreading, and leaves are either pinnately compound with 3 to 8 leaflet pairs or less commonly unifoliate. Leaf color is olive, dark green, or bluish. There are two groups of chickpea, depending on seed size, shape, and color. The large-seeded chickpeas (in excess of 26 g/100 seeds) are called *kabuli* and the smaller ones are called *desi*. Almost all of the chickpeas grown in the US are of the kabuli type. Kabuli chickpea often have rounded and pale-cream seeds. Their plants are tall (up to 1 m), have white flowers and no anthocyanin pigmentation. Desi plants are shorter, more prostrate, and have smaller leaflets. Their flowers and stems usually have anthocyanin pigmentation. Flowers can be white, pink, purplish, or blue and seeds can be irregularly shaped and yellow, brown, black, or green. Desi types are traditionally grown in India, other parts of Asia, and in Ethiopia and account for more than 80% of the world production of chickpea (Muehlbauer et al. 1982).

Chickpea seed contains 13% to 33% protein, 40% to 55% carbohydrate, and 4% to 10% oil (Stallknecht et al. 1995). Fatty acid composition varies with chickpea type but is approximately 50% oleic and 40% linoleic (Duke 1981). Chickpea seeds are consumed “fresh as green vegetable, parched, fried, roasted, and boiled; as snack bar, sweet, and condiments” (Muehlbauer and Tullu 1997). They are also ground into flour and used to make soup, bread, and sweetmeats. Chickpeas are commonly found in salad bars in the US and are extensively used for making dishes such as “couscous,” “hummus,” and “falafel” in the Mediterranean region, the Middle East, and parts of Asia.

Chickpea production was introduced to southwestern Colorado in the early 1980s but was short-lived due to agronomic, processing, and marketing constraints. Renewed interest in chickpea in recent years has been prompted by the release of more adapted cultivars and the need for alternative crops. Research on chickpea at the Southwestern Colorado Research Center (SWCRC) in 1994–1998 included cultivar yield trials, gradient irrigation experiments, and planting date trials. Elevation at the research center is 2128 m. The number of days with minimum temperature > –2.2°C is 143 in 8 out of 10 years (Colorado Climate Center). The average annual precipitation is 40.5 cm with June being the driest month. The predominant soil series is Wetherill silty clay loam (fine-silty, mixed, superactive, mesic Aridic Haplustalf).

The main objectives of the studies conducted at the SWCRC have been to evaluate the adaptation and yield potential of new cultivars of chickpea in southwestern Colorado; to determine the response to irrigation and N rate; and to identify challenges and opportunities that may arise from chickpea production.

YIELD POTENTIAL OF CHICKPEA IN SOUTHWESTERN COLORADO

Cultivar Differences

In 1995, five chickpea cultivars and eight advanced lines from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) were tested at the SWCRC (Tables 1 and 2). The Kabuli-type chickpeas ‘UC27’, ‘UC15’, ‘Dwelley’, and ‘Sanford’ were planted with a White 3407 air planter. ‘Myles’ (desi-type) was planted with a hand-push Precision Garden Seeder due to its smaller seeds. Row spacing was 76.2 cm and planting rate 6.6 seeds/m of row. The plate used with the White planter was not adequate for planting large-seeded chickpea such as ‘Dwelley’, which resulted in numerous skips. ‘UC15’ and ‘UC27’ are cultivars released by the University of California-Davis for production in the coastal areas and central valleys of California, respectively (Helms et al. 1992a,b). Both cultivars produce seed with desirable canning quality but are susceptible to Ascochyta blight caused by *Ascochyta rabiei* (Pass.), a serious chickpea disease that spreads rapidly under cool moist conditions and is difficult to control (Wiese et al. 1995). ‘Dwelley’ 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 (Muehlbauer et al. 1998a; Muehlbauer et al. 1998b) and both have good resistance to Ascochyta blight. ‘Sanford’ matures 3 to 4 days earlier, has slightly smaller seed, and is more productive than ‘Dwelley’ (Muehlbauer et al. 1982). ‘Myles’ is a desi-type chickpea that was developed by USDA-ARS and released in 1994 based on its resistance to Ascochyta blight (Muehlbauer et al. 1998c).

Dryland cultivar Trial 1 averaged 2238 kg/ha in above ground dry matter (DM) and 1088 kg/ha in seed yield (Table 1). ‘Dwelley’ had the lowest plant population, dry matter, and seed yield at harvest. ‘Myles’ was the first to mature. It started to flower in late June and was ready to harvest by the third week of August. ‘Myles’ is easily recognizable from the kabuli-type seed due to its purple flowers and smaller leaflets (fern-type). There were no significant differences in DM or seed yield among the ICRISAT lines (Table 2). Yield

Table 1. Results of the 1995 chickpea cultivar trial 1 at Yellow Jacket, Colorado[z].

Cultivar	Type	No. plants/m^2 at harvest	Dry matter[y] (kg/ha)	Seed yield (kg/ha)	100-seed weight (g)	Diseased plants (%)
Myles	Desi	7.5	2088	1265	18.6	6.4
UC27	Kabuli	5.8	2293	1211	50.3	11.9
UC15	Kabuli	4.8	2382	1210	47.6	8.0
Sanford	Kabuli	8.4	2633	1178	42.8	8.8
Dwelley	Kabuli	2.9	1796	578	51.5	11.3
Mean		5.9	2238	1088	42.2	9.3
LSD (5%)		1.5	335	201	1.5	--
CV (%)		16.6	10	12	2.3	--

[z]Planting date: May 3, 1995; Harvest: Aug. 23, 1995 (Dwelley Aug. 29)
[y]Total above ground dry matter (DM)

Table 2. Results of the 1995 chickpea cultivar trial 2 at Yellow Jacket, Colorado[z].

Entry (Kabuli)	No. plants/m^2 at harvest	Dry matter[y] (kg/ha)	Seed yield (kg/ha)	100-seed weight (g)	Diseased plants (%)
ICCV95301	5.6	2213	1278	39.2	6.5
ICCV94305	6.1	1987	1119	42.7	24.0
ICCV95401	5.6	2108	1115	39.3	11.8
ICCV94304	5.5	2216	1081	38.5	12.5
ICCV92328	5.7	2126	1074	39.7	10.6
ICCV92310	5.8	2053	1073	40.4	12.1
ICCV95402	7.3	2056	1065	51.0	4.6
ICCV95501	5.4	1992	1064	37.8	14.5
Mean	5.9	2094	1109	41.1	12.1
LSD (5%)	NS[x]	NS	NS	2.5	--
CV (%)	8.1	8	7	3.4	--

[z]Planting date: May 3, 1995; Harvest: Aug. 23, 1995
[y]Total above ground dry matter (DM)
[x]Not significant

levels in cultivar Trials 1 and 2 were similar with the exception of ‘Dwelley’. All the entries in the two trials were infested with Pea Enation Mosaic Virus (PEMV) and possibly other unidentified diseases. Infestation was 6% to 12% in Trial 1 and 5% to 24% in Trial 2. Leafminer (*Liriomyza sativa* Blanchard) was observed on a small number of chickpea plants. The effect of PEMV or leafminer on DM and seed yield was not quantified.

‘Myles’ had the lowest seed weight as was expected and dark-cream to brownish seeds. Among the kabuli-type cultivars, ‘UC27’ had the most marketable seeds. It had very few cracked or stained seeds, good seed size (50.3 g/100 seeds), and attractive seed shape (round) and color (light cream). Both ‘UC27’ and ‘UC15’ had round seeds with smooth edges compared to the seeds of ‘Dwelley’ and ‘Sanford’, which were somewhat wrinkled. ‘Dwelley’ and ‘UC15’ had similar seed size to that of ‘UC27’ but had more stained seeds. ‘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 stained seeds than ‘UC27’ (data not shown).

Irrigation and Nitrogen Management

Most of the chickpea crop in the world is produced on residual moisture but supplemental irrigation can enhance production. Irrigation during the pre-flowering period and at early pod fill resulted in increased yield at several locations in India (Saxena 1980). Irrigation prolonged the reproductive period of chickpea and produced higher total biomass and more pods per plant. Conversely, 100-seed weight and harvest index were reduced (ICRISAT 1987).

Line-source irrigation experiments were conducted at Yellow Jacket to test the response of ‘Dwelley’ (1994) and ‘Sanford’ (1994–1996) to irrigation amount and N rate. The irrigation system used was similar to the one described by Hanks et al. (1976). Planting dates were 2 June 1994, 5 May 1995, and 21 May 1996. Metolachlor (Dual 8E) was applied pre-plant at 2.2 to 2.8 kg a.i. ha^{-1} and incorporated with a field cultivator. The granular rhizobial inoculant (Implant Plus, LiphaTech) was broadcast at 20 kg ha^{-1} shortly before planting. Row spacing was 76.2 cm and seeding rate 13.2 seeds/m of row. Phosphorus and/or K rates were based on soil tests.

Table 3. Seed yield and size of ‘Dwelley’ and ‘Sanford’ chickpea as influenced by irrigation and nitrogen in 1994 at Yellow Jacket, Colorado.

	Dwelley				Sanford			
	Check		56 kg N/ha		Check		56 kg N/ha	
Irrigation amount[z] (cm)	Seed yield (kg/ha)	100 seeds (g)	Seed yield (kg/ha)	100 seeds (g)	Seed yield (kg/ha)	100 seeds (g)	Seed yield (kg/ha)	100 seeds (g)
0.0	888	48.4	1042	56.6	990	45.5	889	44.8
3.6	857	--	1260	--	1085	--	1096	--
7.1	879	46.1	1734	59.8	1146	45.2	1432	48.3
10.7	904	--	1994	--	1335	--	1889	--
14.2	803	39.6	2373	58.5	1264	39.8	2289	48.9
17.7	917	--	2388	--	1374	--	2473	--
21.3	892	38.2	2467	52.4	1445	37.3	2488	42.4
24.8	936	--	2362	--	1580	--	2498	--
28.3	972	38.5	2051	46.6	1624	36.0	2500	37.2
Mean	894	42.1	1963	54.8	1316	40.8	1951	44.3
LSD (5%)	271	2.0	271	2.0	277	1.9	277	1.9

[z]Derived from the regression equation, irrigation amount (cm) = 31.88 – 1.93X, where X = distance from the sprinkler line in m. $R^2 = 0.99$

Irrigation, nitrogen fertilization, and their interaction all had a highly significant effect on seed yield and size of 'Dwelley' and 'Sanford' in 1994 (Table 3). The seed yield of 'Dwelley' more than doubled with the application of 56 kg N/ha and that of 'Sanford' increased by about one-half compared to the zero N treatment. There was no significant increase in seed yield of either 'Dwelley' or 'Sanford' in the N treatment beyond 14.2 cm of cumulative irrigation. In addition, a uniform irrigation of 5.0 cm before planting and 2.5 cm after planting was applied to ensure adequate stand establishment. Total rainfall from planting to harvest was 5.8 cm. The increase in yield due to irrigation was more pronounced where nitrogen was applied, particularly in the case of 'Dwelley'. Nitrogen and/or less irrigation water applied resulted in larger and/or heavier seeds of 'Dwelley' and 'Sanford'. A composite sample of 'Sanford' seeds from the 1994 harvest had few defects, good seed color, and excellent imbibing quality (Stan Murray, Klein-Berger Co., pers. commun.).

'Sanford' seed yield increased significantly with increasing amounts of irrigation in 1995 (Table 4). A maximum of approximately 2000 kg/ha was reached with 28.7 cm of water (irrigation plus precipitation). Hundred-seed weight averaged 48.2 g with no significant differences among irrigation levels. Nitrogen fertilization did not influence seed yield or size despite low soil test levels in 1995 (data not shown). Much cooler conditions prevailed during and following planting in 1995 than in 1994 or 1996 (Colorado Climate Center). 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 15 to 25 kg N/ha of starter fertilizer in soils low in organic matter. Murray et al. (1987) recommended the application of 22 to 34 kg N/ha at planting on soils with less than 22 kg N/ha of residual nitrogen. Starter nitrogen may be beneficial for stand establishment or until chickpea plants are able to fix their own nitrogen.

The period from Oct. 1995 through May 1996 was extremely dry. Consequently, the pre-irrigation in 1996 was barely enough to ensure adequate seed germination and plant emergence. The soil profile below 20 cm 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 5). Seed yield and 100-seed weight increased significantly with 56 kg N/ha and greater amounts of irrigation water.

Table 4. Seed yield and size of 'Sanford' as influenced by irrigation in 1995 at Yellow Jacket, Colorado.

Irrigation[z] amount (cm)	Seed yield (kg/ha)	100 seeds (g)
0.0	1248	46.6
2.0	1248	--
4.2	1394	47.8
6.2	1567	--
8.6	1583	49.2
10.8	1780	--
13.0	1877	48.8
15.2	2054	--
17.3	2027	48.7
Mean	1642	48.2
LSD (5%)	125	NS

[z]Derived from the regression equation, Irrigation amount (cm) = 19.54 – 1.19 X, where X = distance from the sprinkler line in m. $R^2 = 0.99$

Table 5. Seed yield and size of 'Sanford' as influenced by irrigation and nitrogen in 1996 at Yellow Jacket, Colorado.

	Check		56 kg N/ha	
Irrigation amount[z] (cm)	Seed yield (kg/ha)	100 seeds (g)	Seed yield (kg/ha)	100 seeds (g)
0.0	595	42.7	680	43.0
2.9	570	--	743	--
6.6	682	44.0	870	44.3
10.3	802	--	1114	--
14.0	853	44.2	1296	47.8
17.7	1079	--	1557	--
21.5	1066	43.8	1674	46.2
25.2	1122	--	1772	--
28.9	1179	44.6	1756	45.5
Mean	884	43.8	1273	45.4
LSD (5%)	177	1.3	177	1.3

[z]Derived from the regression equation, Irrigation amount (cm) = 32.64 – 2.03 X, where X = distance from the sprinkler line in m. $R^2 = 0.97$

Planting Date

Chickpea should be planted when soil temperature is above 5°C although "some cultivars can tolerate temperatures as low as –9.5°C in early stages or under snow cover" (Muehlbauer et al. 1982; Muehlbauer and Tullu 1997). Chickpea is a quantitative long-day plant but flowers in every photoperiod (Smithson et al. 1985). A 1984 chickpea planting date study at SWCRC showed no significant difference in seed yield between 1 May, 15 May, and 1 June planting dates (unpublished data). Additional studies (Table 6) were conducted in 1997 and 1998 to determine the effects of chickpea cultivar, planting date, and their interaction on seed yield and quality. A new release 'Evans' from the USDA-ARS, Washington State University, and the University of Idaho was included in this study. 'Evans' is a kabuli-type chickpea with good resistance to Ascochyta blight. Its seed size is larger than 'Sanford' but smaller than 'Dwelley' and matures 2 to 3 days earlier than 'Sanford' or 'Dwelley'.

The effect of planting date and cultivar on seed yield and 100-seed weight was highly significant in 1997 and 1998. Seed yield increased substantially when planting was delayed until 20 or 22 May. Further yield increase occurred in 1997 when chickpea was planted as late as 16 June. Seed yields were generally higher in 1997 than in 1998 due to more favorable moisture conditions. Most chickpea cultivars evaluated at SWCRC exhibited a somewhat indeterminate growth habit. For example, 'UC27' and 'Evans' planted in April or early May were ready to harvest by mid- to late-Aug. in 1997 and 1998. However, frequent rain events in late July and Aug. induced new vegetative growth leading to a flush of flowering and pod formation. 'Sanford' and 'Dwelley' showed similar characteristics but their maturity appeared to be more uniform for the late May and early June plantings than at the other planting dates.

'UC27' had the highest average seed yield in 1997 and 1998. 'Dwelley' outperformed 'Evans' and 'Sanford' in 1997 due to the higher yield at 2 June and 16 June planting dates, but had similar yield in 1998. The effect of planting date by chickpea cultivar on seed yield was significant in 1997 at $\alpha = 0.05$. Seed weight was influenced by both the cultivar and planting date. 'Dwelley' produced the largest and/or heaviest seeds at all planting dates followed by 'UC27' in 1997 and 1998. Based on 100-seed weight, the seeds of 'Dwelley' and 'UC27' would be suitable for canning. 'Evans' and 'Sanford' did not produce seeds of canning quality,

Table 6. Planting date effect on seed yield of four chickpea cultivars in 1997 and 1998 at Yellow Jacket, Colorado.

	Dwelley		Evans		Sanford		UC27		Mean	
Planting date	Seed yield (kg/ha)	100-seed weight (g)	Seed yield (kg/ha)	100-seed weight (g)	Seed yield (kg/ha)	100-seed weight (g)	Seed yield (kg/ha)	100-seed weight (g)	Seed yield (kg/ha)	100-seed weight (g)
					1997					
22 Apr.	902c[z]	54.81c	683b	44.98d	843c	46.78c	832c	50.51b	815	49.26
5 May	1019c	59.23a	731b	46.61c	1008c	50.00b	885c	51.22b	911	51.76
20 May	1462b	57.08ab	1407a	53.02a	1482ab	53.53a	1897b	56.01a	1562	54.91
2 June	1671b	55.47bc	1504a	51.40ab	1256b	49.02bc	2228b	54.91a	1665	52.70
16 June	2127a	54.12c	1529a	49.67b	1844a	47.46bc	2596a	56.23a	2024	51.88
Mean	1436	56.14	1171	49.14	1287	49.36	1687	53.78	1395	52.10
					1998					
1 May	999	56.14ab	1028	46.26b	1158	49.30ab	1140	49.33d	1081b	50.26
8 May	982	56.44a	1071	47.99a	1076	50.51a	1370	51.09c	1125b	51.51
22 May	1346	54.68bc	1033	48.45a	1112	49.14ab	1769	53.66ab	1315a	51.48
3 June	1398	53.51c	1197	46.89ab	1325	48.53b	1585	52.14bc	1376a	50.27
16 June	1137	57.31a	1191	47.45ab	1244	47.76b	1867	54.94a	1360a	51.86
Mean	1172b	55.62	1104b	47.41	1183b	49.05	1546a	52.23	1251	51.10

[z]Mean separation within cultivars and years by Duncan's Multiple Range Test, 5% level.

Table 7. United States chickpea production 1992 to 1997. Source: NASS, USDA

State	Production (t)						
	1992	1993	1994	1995	1996	1997	Average
California	8,573	10,070	12,519	13,063	15,966	6,169	11,060
Idaho	680	771	408	2,858	1,678	4,627	1,837
Oregon	862	454	590	907	154	2,994	993
Washington	1,860	2,359	1,996	4,627	3,674	3,493	3,001
Total	11,975	13,654	15,513	21,455	21,472	17,283	16,892

except at 5 May ('Sanford') and 20 May/2 June ('Evans') in 1997. Only mature seeds were used for 100-seed weight.

When marketing chickpea, seed lots with a high percentage of stained or green seeds may be rejected or sold as animal feed. On this basis, all the production from 2 June 1997 would be discarded since it had approximately 49% immature seeds (data not shown). Above average precipitation and frequent rains prolonged the vegetative and reproductive stages of the chickpea cultivars planted on or after 20 May 1997. There were less immature (green) seeds in 1998 than in 1997 due to drier conditions in 1998. Visual observations showed that with the exception of the early harvested chickpea cultivars, the early June plantings had the most uniform maturity and the least percentage of green and stained seeds. When seed maturity is delayed due to irrigation and/or weather conditions, 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 (Gramoxone) have also been used to hasten chickpea maturity.

MARKET CONSIDERATIONS

The US imports approximately $12 million chickpea each year, compared to domestic production valued at $2 million (Yarris 1984). World chickpea production from 1992 to 1996 averaged 7.3 million t, 90% of which was produced in Asia. India, alone, produces 4 to 5 million t of chickpea annually (Bean Market News, 1997 Summary). Other major chickpea producing countries are Pakistan, Turkey, Iran, Australia, Mexico, and Ethiopia. US production represents less than 1% of world production with California leading the way (Table 7). Almost all the chickpeas produced in the US are of the kabuli type, while over 80% of world production is of the desi type (Muehlbauer et al. 1982).

Chickpeas are graded as a miscellaneous bean under US standards in which damaged and defective seeds and foreign material are considered in determining grades (Muehlbauer et al. 1982). Most chickpeas grown in the US are sold for canning. The rest, about 10%, is sold for dry packaging or as animal feed. Desirable qualities for canning are medium seed size (50.6 to 52.5 g/100 seeds), golden color, rough texture, high water intake, and a seed coat that does not fracture easily (Stan Murray, Klein-Berger Co., pers. commun.).

Chickpea can be processed with the same equipment used for pinto beans. Elevator legs, bins, conveyors, screw augers, air cleaners, and secondary equipment should provide sufficient separation to process a market grade product. Commercial processing includes seed conditioning, sizing, and packaging or canning of the product (Brick et al. 1998). A minimum of 100 t is required to make processing of chickpea in southwestern Colorado economically feasible. In 1998, at least one-half of the chickpea production in southwestern Colorado was shipped in bulk to a bean dealer in Kansas.

Table 8. Dealer pinto bean and chickpea prices. Source: USDA Bean Market News, 1996 and 1997 summaries.

Year/ commodity	Price ($/t)	
	Pinto[z]	Chickpea[y]
1992–1993	524.77	916.86
1993–1994	733.49	714.98
1994–1995	470.11	932.95
1995–1996	567.31	1,018.03
1996–1997	607.42	711.01
1997–1998	563.56	726.66
Mean	577.78	836.75

[z]Northern Colorado
[y]California

Available markets for chickpea include dry packers, canners, dehydrated products, and livestock feed (inferior quality seeds). Southwestern Colorado would be ideal for a dry packer or canner. The lack of railroad or waterways may reflect higher freight rates, depending on product destination.

ADVANTAGES OF CHICKPEA OVER PINTOS IN SOUTHWESTERN COLORADO

Southwestern Colorado is traditionally a dry bean (primarily pinto) producing area. From 1990 to 1997, the harvested crop area of dry bean averaged 12500 ha of which 87% was dryland. Seed yields averaged 1750 kg/ha with irrigation and 360 kg/ha dryland (without irrigation) during the same period (Colorado Agricultural Statistics). Evaluation of chickpea at the SWCRC in the early 1980s and in 1994–1998 showed that average yields of at least 2000 kg/ha with irrigation and 500 to 1000 kg/ha dryland are feasible in southwestern Colorado. Limited on-farm testing and commercial production has confirmed these results (Bruce Riddell pers. commun.).

In addition to seed yield, chickpea prices have been consistently higher than those of pinto beans (Table 8) although seed quality appears to have more effect on chickpea prices. Acceptable seed quality for dry packaging with ‘Sanford’ and for canning with ‘UC27’ and ‘Dwelley’ has been produced in southwestern Colorado. Marketing may be the biggest obstacle for chickpea production in southwestern Colorado.

Chickpea planted early i.e. before mid-May at high elevation seem to produce smaller seeds than later planted chickpea. If chickpeas are planted late i.e. after the first week of June, the incidence of immature seeds increases. Above normal precipitation, particularly in Aug. and Sept., tends to prolong the vegetative and reproductive growth of chickpea in southwestern Colorado, which could lead to lower seed quality. Ideally, chickpea should be planted in mid-May (or earlier at lower elevations) and harvested by early Sept. Pinto beans are more sensitive to frost damage than chickpea and are usually not planted in southwestern Colorado until early June. An early frost will damage the seeds of both chickpea and pinto beans, although chickpea plants will continue to grow if the frost is not too severe.

Unlike pintos, chickpea can be direct-combined which would speed up the harvest operation and reduce costs. Swathing should be considered if maturity is delayed due to late planting or wet conditions, to allow sufficient time for the seeds to dry. Dry beans are usually undercut with knives in early to mid-Sept., windrowed and left to dry in the field for at least 10 days depending on the weather. They are then threshed with a combine equipped with a pickup attachment that lifts the windrow into the header (Berrada et al. 1995a). This practice often delays winter wheat planting that was shown to reduce wheat yield (Brengle et al. 1976). Other production practices for chickpeas are similar to pinto beans, reducing the need for new equipment investment (Berrada et al. 1995b).

CONCLUSION

The results of the chickpea trials at Yellow Jacket from 1994 to 1998 show good yield potential and adaptability of several cultivars. Comparable seed yields to pinto bean under irrigation and higher yields under dryland conditions were achieved. Both crops can be grown and processed using similar equipment and management practices. Chickpea can be planted and harvested earlier than pintos, which would allow for a more optimum planting date of winter wheat. Southwestern Colorado is well suited to dry packers and canners. The freight availability may create some problems in timely deliveries and transportation expenses. Good seed quality has been produced in southwestern Colorado but late planting and/or frequent rains can delay maturity and increase the incidence of stained seeds. More research is needed to identify cultivars and management practices that will enhance the marketability of chickpea produced in southwestern Colorado.

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