GROWING CHICKPEAS IN EASTERN OREGON.

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IMPORTANCE OF CHICKPEAS

Chickpea (*Cicer arientinum* L.) is a cool-season annual pulse crop that belongs to the *Leguminosae* family. It is an ancient crop that is believed to have been first grown in Turkey 7500 years ago (Oplinger et al., 1990). It is the third most important pulse crop after dry beans and dry pea (Singh and Saxena, 1999). Chickpea is grown in wide range of environments comprising about 44 countries in tropical, subtropical, and temperate regions of the world (Muehlbauer and Tullu, 1997; Singh and Saxena, 1999). Chickpea is used in a variety of food preparations that are rich in protein. Seeds are about 20% protein, 5% fat, and 55% carbohydrate. It is consumed as a dry pulse crop or as a green vegetable (Oplinger et al., 1990). In the United States chickpea is used in soups, vegetable combinations, or as part of fresh salads in restaurant bars (Oplinger et al., 1990).

Chickpea benefit agricultural production by fixing atmospheric nitrogen and adding it to the soil for its use and for use by subsequent crops. It benefits cereal crops in rotation by breaking up disease and insect cycles. Also it provides the opportunity to clean-up grassy weeds that are problematic in cereal monocropping. Chickpea is a deep rooted crop that is believed to be the most drought-resistance among cool-season pulses and produces reasonable yields under low-precipitation conditions.

Chickpeas are classified based on seed size, shape and color. Two types are common: the small, angular, and colored seeds are classified as *desi* and the large, ram-head shaped and beige-colored seed are called *kabuli* (Oplinger et al., 1990; Singh and Saxena, 1999). The *desi* types predominate in the Indian subcontinent while the *kabuli* types predominate elsewhere. *Kabuli* types dominate the American production because of their high value for use as an ingredient in salad bars; however, there is a small but steadily increasing production of desi types. The small amount of *desi* beans produced is currently marketed to ethnic communities in the large cities; however, there are prospects, yet to be explored, of developing expanded production suitable for export (Muehlbauer et al., 1982). The transfer of favorable traits from one type to the other is easy because the beans cross easily with each other (Singh and Saxena, 1999).

AGRONOMIC RESEARCH AND RECOMMENDATIONS FOR GROWING CHICKPEAS IN EASTERN OREGON

The reduction of green peas due to the closure of Agrifrozen Foods, Inc. in Walla Walla, WA and the decline in contract acres by Chiquita Processed Foods, LLC in Milton-Freewater, OR has led to a search for a new legume crop. Chickpea have the potential to replace peas in the traditional wheat pea rotation but being a relatively new commercial legume crop to northeastern Oregon, there is limited information on chickpea agronomy.

Although research on chickpea (garbanzo) in eastern Oregon dates back to the 1940's and 1960's, it is a relatively new commercial legume crop to northeastern Oregon and limited information on chickpea agronomy exists for this region. At a recent grower meeting, many questions on chickpea production were raised. Areas of greatest concern included varieties, seeding dates, plant density and inoculation among other topics. The goal of this work was to address these concerns.

The Pacific Northwest has a Mediterranean type climate that is characterized by wet winters and dry summers. Thus, chickpea, planted in the spring, matures on decreasing water supply and residual moisture. The date the crop is seeded determines how much water will be available for the crop with more water being available for the early-seeded crops than the late seeded crops. Therefore, seeding early in the spring ensures adequate moisture for optimum plant growth and high yield. The earliest seeding date is dictated by soil temperatures and field conditions such as wetness. Chickpea is a cool season crop and seedlings are frost tolerant. Chickpea generally germinates when soil temperature is above 41°F (5°C) (Muehlbauer et al., 1982). However, some varieties can tolerate colder temperatures and therefore can be seeded earlier in spring. Seeding can be delayed when the soil is too wet. Late seeding result in shorter plants, late-formed flowers and pods and reduced grain yield. Flower and pod abortion increase if flowering and pod set coincide with hot, dry weather. Should late seeded chickpeas be seeded at a higher seeding rate to compensate for pod abortion? The use of a higher seeding rate to compensate for a late seeding date comes with the risk of plant population being negatively impacted by limited soil moisture. Optimum row spacing may alleviate water stress caused by high plant populations. It is clear that there are more questions on chickpea agronomy than answers. Research was conducted to answer these questions. Specifically we needed to understand the relationships between seeding dates and seeding density for different chickpea varieties. With this new information growers will be able to make appropriate decisions on seeding density whenever they are able to seed.

The objectives of this study were to:

1. determine the optimum seeding dates
2. determine the optimum seeding density
3. determine the adaptable varieties
4. determine whether inoculation is required for nitrogen fixation

in low and high yield environments of eastern Oregon.

SEEDING DATE, ROW SPACING AND SEEDING RATE

To determine the optimum seeding date and seeding density of chickpeas, two *kabuli* varieties, namely Dwelley and Sinaloa, were sown at the Columbia Basin Agricultural Research Center (CBARC) at Sherman Experiment Station in Moro (11-in. precipitation), CBARC at Pendleton Experiment Station (16-in. precipitation), and at the Nibler Farm (20 inch precipitation) in Milton-Freewater in early April, mid-April, and at the end of April in 2002. The plants were sown in rows 6 and 12 inches apart and at 1.5, 3, and 4.5 seeds/ft^2 (equivalent to 75, 160, and 240 lb/a, respectively for Dwelley and 81, 162, and 243 lb/a, respectively for Sinaloa). The experimental design was a split, split, split plot design with seeding dates as main plots, row spacing as sub plots and a variety and seeding rate factorial in the sub, sub plots. In

2003, the experiment was repeated only at Pendleton and Moro and another seeding date was added in mid-March to make four seeding dates.

Chickpeas were grown under different conventional tillage methods that are representative of practices in regions where the experimental sites were located in 2002 and 2003 crop years. Chickpeas were grown after winter wheat in Pendleton and Milton-Freewater where crop year precipitation is above 16 inches. Chickpeas were planted after fallow in Moro where crop year precipitation is 11 inches and below. Seeding was done by a Hege® plot seeder in 5ft x 20ft plots. Data on plant stand, phenology, plant height, grain yield, and grain size were obtained in 2002 and yield components were included in 2003. A Hege® plot combine was used to harvest whole plots.

Results and Discussion

Overall grain yields were influenced by precipitation and available soil moisture. In 2002, a year where moisture was 77-83% of normal, highest grain yields of chickpeas were produced in Milton-Freewater, followed by Moro, and the lowest yields were produced in Pendleton in 2002. Milton Freewater, Pendleton and Moro received a total of about 16.6, 13.03, and 8.43 inches of precipitation, respectively. Although Pendleton received higher precipitation than Moro, soil available water was probably higher in Moro where chickpeas were grown after fallow (two season's precipitation) than at Pendleton where the chickpeas were grown after wheat. The advantages of fallow disappeared in 2003, a year where moisture was closer to normal at 84-96% of average with precipitation at Pendleton and Moro increased to 15.42 and 9.29, respectively. In this year, chickpea grain yields were higher in Pendleton than in Moro. No chickpeas were grown in Milton Freewater in 2003. Results and discussion will be limited to treatments that significantly influenced grain yields.

Seeding date

In both years, the highest grain yields were obtained when seeding was done early in the spring at all sites except at Moro in 2003 where problems associated with plant stand were encountered in the first 3 seeding dates (Figs 1-5).

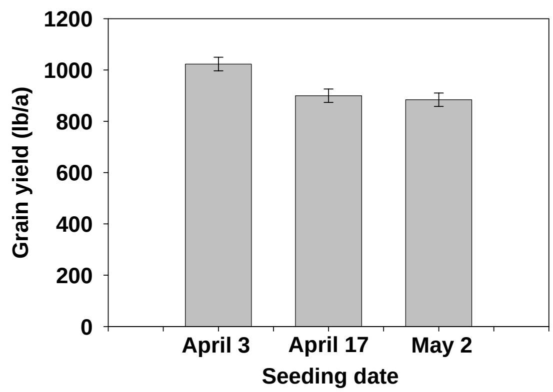

Fig 1. Seeding date effects on chickpea grain yield at Nibler's Farm, Milton-Freewater, 2002

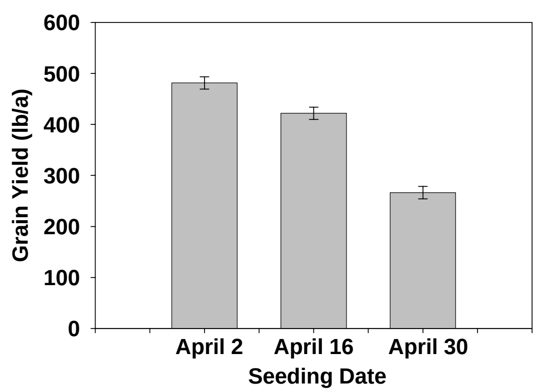

Fig. 2 Seeding date effects on chickpea grain yield at CBARC, Pendleton, 2002

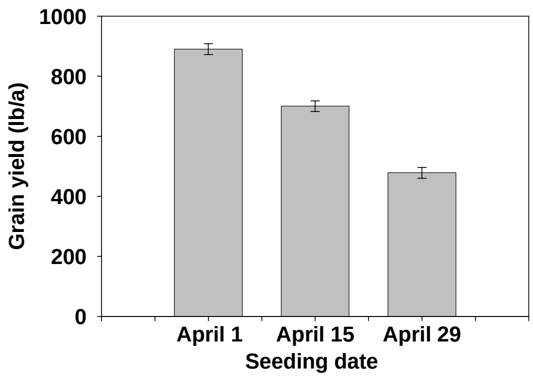

Fig 3. Seeding date effects on chickpea grain yield at the CBARC, Moro, 2002

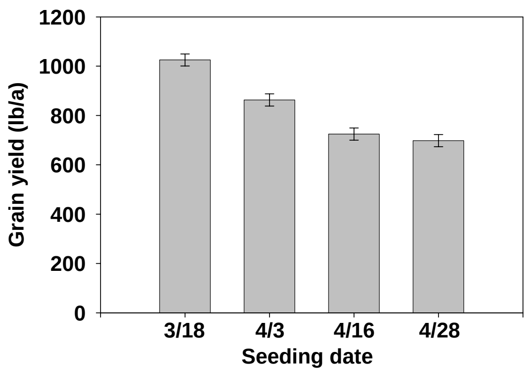

Fig. 4. Seeding date effects on chickpea grain yield at CBARC, Pendleton, 2003

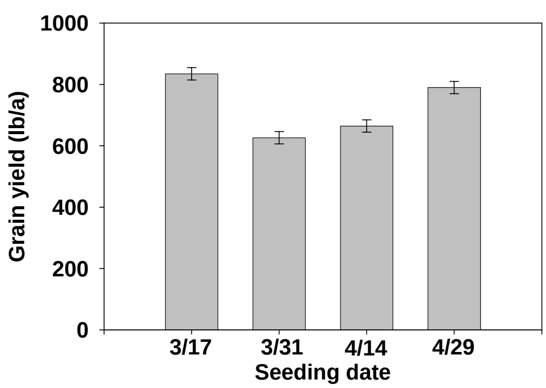

Fig. 5. Seeding date effects on chickpea grain yields at CBARC, Moro, 2003

Despite the reduced plant population, the crop seeded early in mid-March still produced the highest yield.

Diseases

In 2002, plants that were seeded on April 3 were attacked by a combination of fungi and viruses more so than those planted in mid April and early May. Fungi isolated in Dr. Smiley's lab (CBARC, Pendleton) included *Fusarium solani* and *F. oxysporum*. Viruses isolated from the plants in Dr. Larsen's lab (USDA-ARS, Prosser, WA) included the bean leafroll and alfalfa mosaic viruses. *Fusarium solani* causes cortical root rot resulting in dark lesions and ultimately sunken areas of the root. This root rot damages plants slowly, causing them to become unthrifty and chlorotic but generally not killing them directly. Fusarium root rot can be easily seen by digging or pulling plants in most fields. *Fusarium oxysporum* is a pathogen that causes vascular discoloration and rapid wilting of entire plants. The vascular symptom can only be observed by slicing roots diagonally and looking for discoloration of vascular tissue without necessarily causing any discoloration of the center of the root, or of the cortical or epidermal tissues. The wilt caused early stunting of plants that were randomly scattered through the field. Affected plants became very yellow while still small in June, and they had died by July. Despite the disease incidences, the highest grain yields were produced when seeding was done in early April 3. This is probably because there was more water available for plants seeded early in April than those seeded later. Plants seeded after the first week of April probably experienced both water and disease stresses. The disease incidences were very low in 2003.

Based on these results, it is **recommended to seed as early in March when it is practical to do in areas with similar climatic conditions to the sites used in this study.** Plants seeded early can take advantage of longer growing period under favorable temperatures and higher available soil moisture (Table 1). Seeding late reduces the growing period and exposes plants to high temperatures that can rise up to more than 90ºF in June and July. Temperatures above 86ºF affect growth and heat stress can cause drop of buds, flowers, and young pods (Singh and Saxena, 1999)

Table 1. Seeding date effect on length of growing period and precipitation amounts in 2003

	Pendleton		Moro	
Seeding date	Days to maturity	Precipitation received (in)	Days to maturity	Precipitation received (in)
March 18	125a†	4.25	135a	1.53
April 3	113b	2.42	127b	1.21
April 16	104c	1.98	116c	0.9
April 28	94d	1.08	104d	0.28

† means with the same letter within a column are not significantly different (p<0.05

Seeding date and variety

In both years (2002,2003), there was an interaction between seeding date and variety. Dwelley produced higher grain yields than Sinaloa when seeded early in the spring (Table 2, 3). These conditions ensure a long growing season and adequate soil moisture for growth and development. Sinaloa also yield high when seeded early but continues to yield well at later seeding dates even under limited water supply. Based on these results, **it is therefore recommended to plant either Dwelley or Sinoloa when seeding early and Sinaloa when seeding late or in locations that have limited water supply**.

Table 2. Seeding date effects on grain yield (lbs/a) of chickpea varieties at different sites in 2002

Seeding date	Milton Freewater		Pendleton		Moro	
	Dwelley	Sinaloa	Dwelley	Sinaloa	Dwelley	Sinaloa
Early April	1119 a†	927a	400a	562a	819a	961a
Mid April	913b	886a	367b	476b	626b	775b
Late April	853b	914a	107c	425c	363c	594c

† means with the same letter within a column are not significantly different (p<0.05)

Table 3. Seeding date effects on grain yield (lbs/a) of chickpea varieties at different sites in 2003

Seeding date	Pendleton		Moro	
	Dwelley	Sinaloa	Dwelley	Sinaloa
Mid March	1036a†	1014a	823a	845a
Early April	794b	932b	591c	661c
Mid April	721c	728c	642b	686c
Late April	652d	744c	822a	758b

† means with the same letter within a column are not significantly different (p<0.05)

Seeding rate

Increasing seeding rates generally increased grain yields at all the sites and in both years (Fig 6-10). The effect of seeding rate on grain yield was, however, influenced by seeding date. Increasing seeding rates significantly increased grain yield when seeding was done early in the spring. The magnitude of the increase in grain yield with increase in seeding rates was significantly reduced when seeding was done later in the season (Fig 6-10). The results at Moro, although confounded with plant population problems, still showed the same response. **It is therefore recommended that higher seeding rates be used when planting is done early in the spring.** Although high grain yields were produced at high seeding rates late in the season, the yield increase was small relative to early seeded crop and profitability may not justify the use of high seeding rate late in the season.

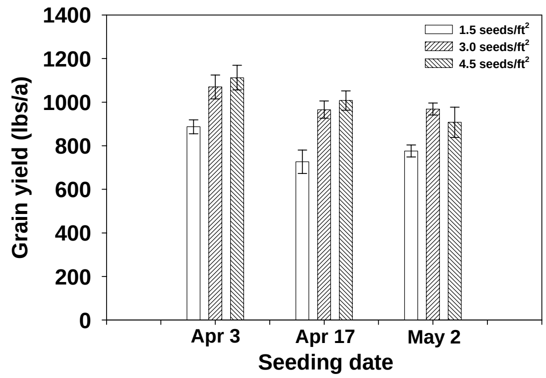

Fig 6. Seeding date and seeding rate effects on chickpea grain yield at Nibler's Farm, Milton Freewater, 2002

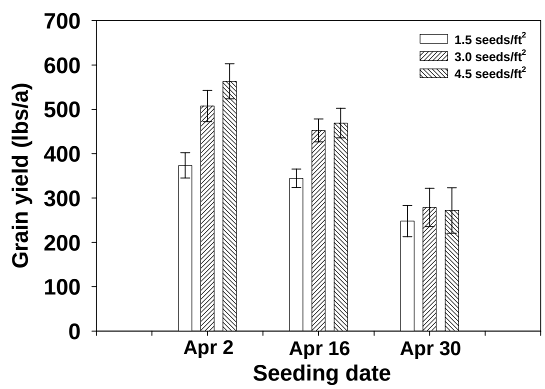

Fig. 7. Seeding date and seeding rate effects on chickpea grain yield at CBARC, Pendleton, 2002

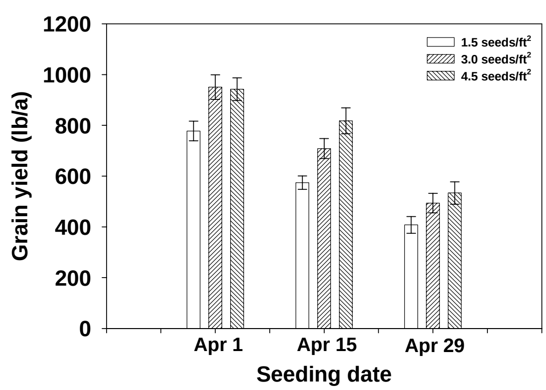

Fig 8. Seeding date and seeding rate effects on chickpea grain yield at CBARC, Moro, 2002

Seeding rate and variety

Tables 4 and 5 show yield responses of Dwelley and Sinaloa to seeding rates. Based on these results, the optimum seeding rate for Dwelley is 3.0 seeds/ft^2. Increasing seeding rate to 4.5 seed/ft^2 did not result in significant yield increase and could be uneconomical. In contrast the optimum seeding rate for Sinoloa is 4.5 seeds/ft^2.in both years under both low and high soil moisture conditions. **It is therefore recommended to seed Dwelley at 3.0 seeds/ft^2 and Sinaloa at 4.5 seeds/ft^2 if it is economical to do so.**

Row spacing had no significant effect on grain yield of both varieties.

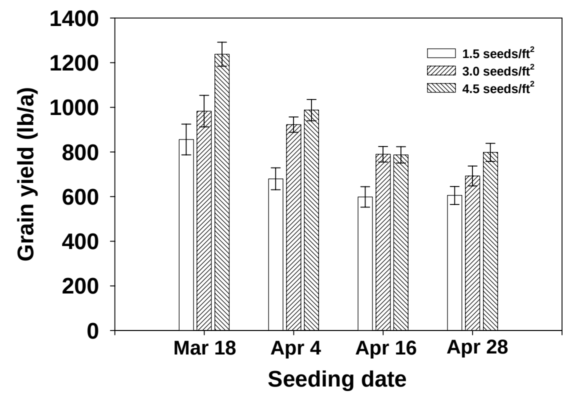

Fig. 9. Seeding date and seedrate effects on chickpea grain yield at CBARC, Pendleton, 2003

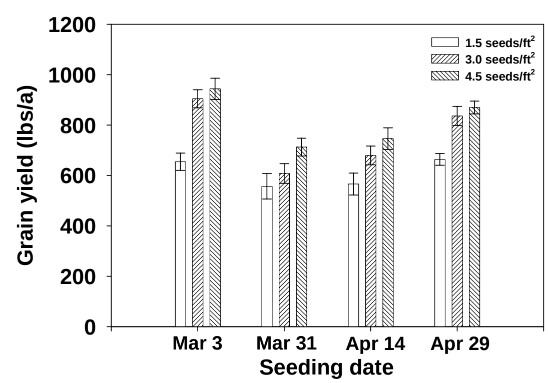

Fig 10. Seeding date and seeding rate effects on chickpea grain yield at CBARC, Moro, 2003

Table 4. Seeding rate effects on grain yield (lbs/a) of chickpea varieties
at different sites in 2002

Seeding rate (seeds/ft^2)	Milton Freewater		Pendleton		Moro	
	Dwelley	Sinaloa	Dwelley	Sinaloa	Dwelley	Sinaloa
1.5	806c †	786c	256b	388c	534b	640c
3.0	1071a	931b	313a	513b	633a	802b
4.5	1008b	1010a	306a	563c	641a	888a

† means with the same letter within a column are not significantly different ($p<0.05$)

Table 5. Seeding rate effects on grain yield (lbs/a) of chickpea
varieties at different sites in 2003

Seeding rate (seeds/ft^2)	Pendleton		Moro	
	Dwelley	Sinaloa	Dwelley	Sinaloa
1.5	689c	680c	591b	659c
3.0	821b	872b	769a	745b
4.5	893a	1012a	799a	838a

† means with the same letter within a column are not significantly different ($p<0.05$)

Grain quality

While it is important to produce high grain yields, it is equally important to pay attention to bean size. Chickpeas are sold based on bean size. Larger beans command high premium. The beans were graded by passing them through sieves. In 2002, chickpeas that did not pass though “22/64” sieve were considered “A” grade and those that passed “22/64” sieve but did not pass through the “18/64” sieve were considered “B” grade. In 2003 we adopted a more stringent grading system. Chickpeas that did not pass through a 22/64 are "A" beans, those that did not pass though a 20/64" are "B" beans, those that did not pass though a 18/64" sieve are "C" beans, and those that pass through the 18/64 sieve are “feed” grade. On average grade A sell for 18-23c/lb and B beans sell for 10-15c/lb. The C and feed grade can sell for $60-70/ton.

In 2002, Dwelley and Sinaloa produced >80% grade A seed when seeded in the first week of April (Fig. 11,12). The percentage of grade A peas decreased significantly when Dwelley was seeding after the first week of April (Fig. 11). The opposite was true for grade B peas. Delaying the seeding of Sinaloa from the first of April to mid-April, however, did not affect the percentage of grade A peas (Fig 12). Grain size of Sinaloa decreased when seeding was delayed to the last week of April but the percentage of grade A peas did not decrease below 80% (Fig 12). Available soil moisture decreased with delay in seeding. The ability of Sinaloa to produce a high percentage of grade A peas when seeded late, therefore, may indicate that Sinaloa is better adapted to limited soil moisture conditions than Dwelley.

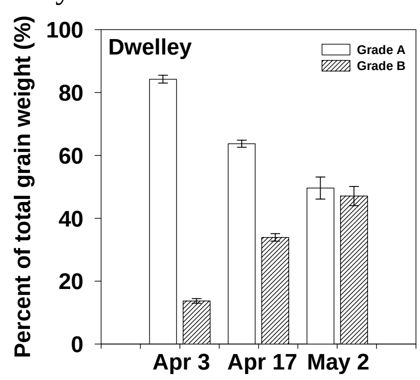

Fig 11. Seeding date and variety effects on grain size of chickpeas at Nibler's Farm, Milton-Freewater, 2002

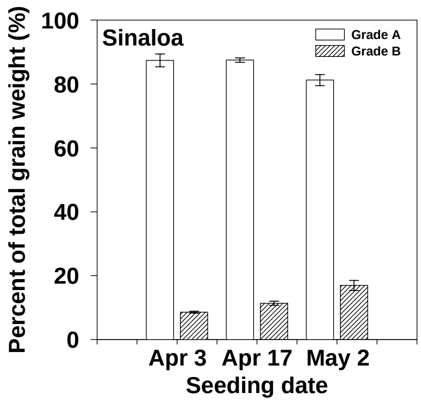

Fig 12. Seeding date and variety effects on grain size of chickpea at Nibler'f Farm, Milton-Freewater, 2002

At Pendleton, Dwelley and Sinaloa produced about 70% and 90% grade A seed, respectively, when seeded in the first week of April (Fig. 13,14). Delaying seeding significantly decreased the amount of grade A seed in both varieties. The decrease in the amount of grade A seed was, however, much greater for Dwelley than for Sinaloa (Fig. 13,14). The percentage of grade A seed decreased significantly to 25 and 60 when seeding of Dwelley and Sinaloa, respectively, was delayed to the end of April (Fig. 13,14). Given that less soil water was available at Pendleton, this result supports the conclusion that Sinaloa is better adapted to limited soil moisture conditions than Dwelley.

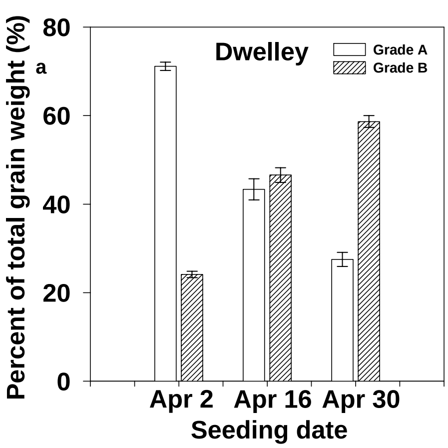

Fig. 13. Seeding date and variety effects on chickpea grain size at CBARC, Pendleton, 2002

At Moro, grain size was not affected by seeding date in both varieties (Fig. 15,16). However, >80% of grain from Sinaloa was A grade compared to about 60% from Dwelley (Fig. 15,16). This result further confirms that Sinaloa consistently produces bigger grain than Dwelley in different environments.

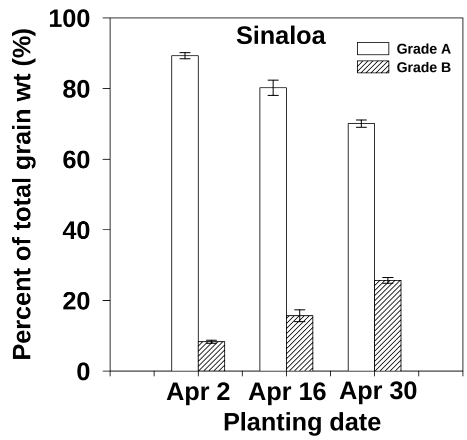

Fig 14. Seeding date and variety effects on chickpea grain size at CBARC, Pendleton, 2002

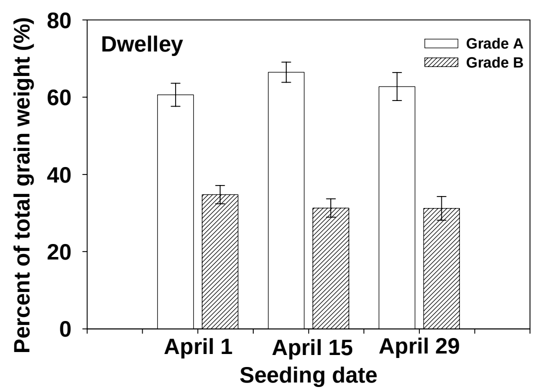

Fig 15. Seeding date and variety effects on chickpea grain size at CBARC, Moro, 2002

In 2003, both varieties produced the highest percentage of grade A beans when seeding was done in mid March and early April at Pendleton (Fig 17). Delaying seeding to mid- and late-April reduced the percentage of grade A beans more in Dwelley than in Sinaloa. The percentage of grade B, and C beans increased when seeding was delayed (Fig 17). Row spacing had no effect on grain size at Pendleton.

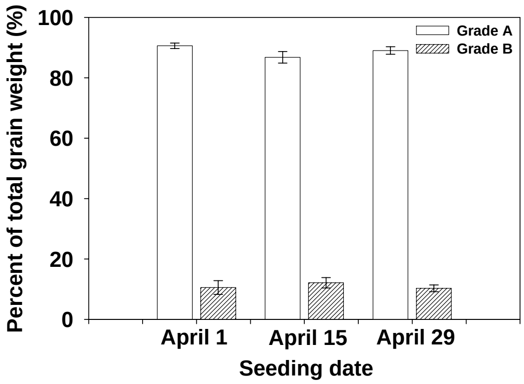

Fig 16. Seeding date and variety effects on chickpea grain size at CBARC, Moro, 2002

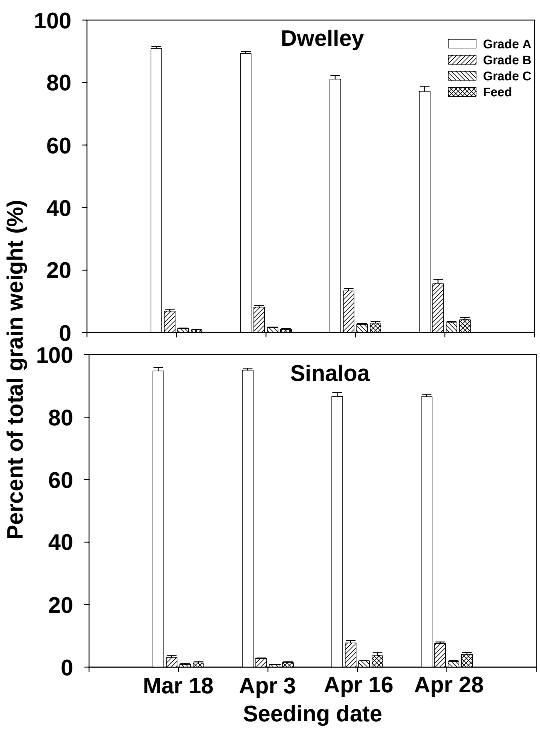

Fig 17. Seeding date and variety effects on chickpea grain quality at CBARC, Pendleton, 2003

In contrast to results obtained at Pendleton, the percentage of grade A beans was not reduced as seeding was delayed from mid-March to the end of April in 2003 at Moro (Fig 18). The percentage of grade A beans was significantly higher in Sinaloa than in Dwelley (Fig 18). These results confirm

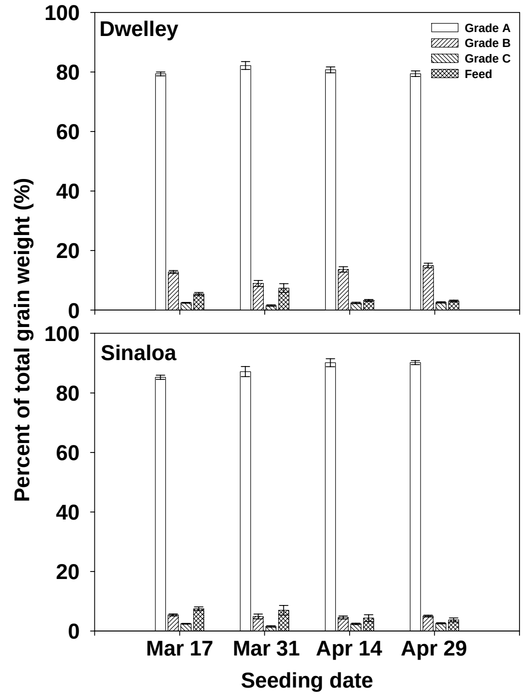

Fig 18. Seeding and variety effects on grain quality of chickpeas at CBARC, Moro, 2003

the results obtained in 2002. It is not clear why grain size does not decrease when seeding is done in late April or early May at Moro. The longer growing season brought about by cooler temperatures at this location may play a role in ensuring the production of larger beans. **To obtain the highest percentage of grade A beans, it is recommended to plant early in the spring. If seeding is delayed it is recommended to seed the variety Sinoloa to maintain a high percentage of grade A beans. At Moro seeding late does not seem to reduce the percentage of grade A beans produced.** However, the reduction in grain yield when seeding is delayed may more than offsets the returns due to high percentage of grade A seed produced.

VARIETY EVALUATIONS

To determine chickpea varieties adapted to eastern Oregon, seven varieties: Dwelley, Sinaloa, Evans, Myles, Sanford, Sierra, and CA99901604W were sown around mid April at CBARC, Moro (11-in rainfall) and at CBARC, Pendleton (15-in rainfall) at a seeding rate of 3 seeds/ft^2 in 2002 and 2003. With the exception of Myles, a *desi* type, all varieties that were evaluated were *kabuli* types. The chickpeas were grown after wheat and after fallow at Pendleton and Moro, respectively, in both years.

Results and Discussion

The yields and grain size of the varieties from the two sites and two years were combined and analyzed for trends using regression analysis.

Grain yield

Figure 19 shows variety yield performance compared to the mean yield of all varieties evaluated in the same experiment at Moro and Pendleton in 2002 and 2003. The Moro and the Pendleton sites are representative of the low and high yielding environments of eastern Oregon. Dwelley responded poorly under low yielding environments and yielded slightly above average in Pendleton. Although below average, Sinaloa responded better at the lower yielding site and above average at the high yielding environment. Evans expressed poor response to both low and high yielding environments. Myles demonstrated wide adaptability to low and high yield environments and maintained similar yield levels under both environments. Sanford and Sierra represents varieties that responded poorly to low yield environments and produced yield equal to the mean at high yielding environments. CA99901604W yielded above average at low yielding environments and responded poorly at the high yield environment.

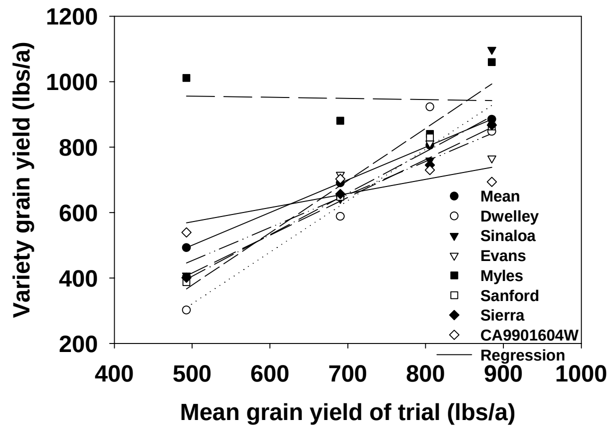

Fig 19. Yield response of chickpea varfieties relative to mean of yield trials

As mentioned earlier, the profit margin can be increased by producing high yields with high percentage of grade A beans. A suitable variety, therefore, should posses both attributes. Figure 20 shows grain size of each variety regressed against the mean grain size of all the varieties evaluated at Moro and Pendleton in 2002 and 2003. The percentage of grade A beans of Dwelley equaled the average (<50%) at the low yield environment and was >80% at the high yielding environment. Sinaloa expressed wide adaptability and produced >80% grade A beans at both low and high yield environments. Evans and Sanford responded

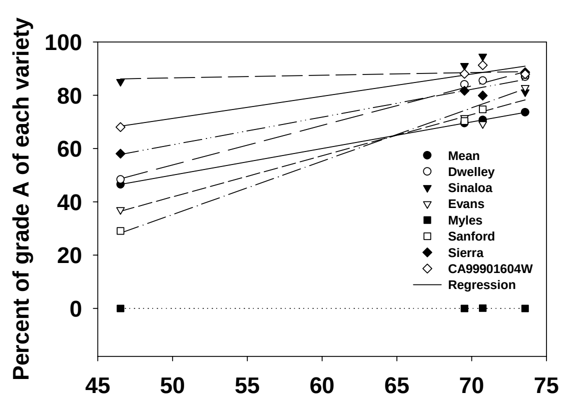

Fig 20. Grain size response of chickpea varieties relative to mean of grain size trials

poorly at the low yield site and slightly above average at high yield site. Being a *desi*, Myles did not produce any grade A beans. Sierra and CA99901604W responded better than average at both sites but the percentage of grade A beans at the low yield site was lower than at the high yield site.

To obtain both high grain yield and a high percentage of grade A beans in low and high yield environment it is recommended that Sinaloa be grown. **Dwelley should be grown only in high yield environments. If grain yield is the only important factor, then Myles should be grown in both low and high yield environments. Myles produces exceptionally high yields in low yield environments.** There is a big market for *desi* type chickpeas in India, Pakistan and North Africa that need to be explored. Currently, the Canadians and Australians have a big share of this market.

GERMINATION STUDY

A germination experiment was also conducted to determine how different chickpea varieties germinate under different soil temperatures. Information derived from this work will be used to determine which varieties are adaptable to seeding in early spring conditions. The varieties evaluated in this study include Dwelley, Sinaloa, Evans, Myles, Sanford, Sierra and CA99901604W. 450 seeds of each variety (50/replication) were first germinated at 68/86ºF night and day temperature to determine germination percentage. The varieties were then germinated in growth cabinets set at 41, 46 and 52ºF constant temperatures. Sterile sand (0.1 lbs) was placed in petri dishes (0.36-inch-diamenter) and watered to saturation with 10 ml of distilled water. 50 seeds were placed in each petri dish on top of the sand and pressed to bury about ¾ of the seed (with the beak pointing sideways). The petri dishes were then placed in germination chambers set at different temperatures. Petri dishes were checked every day and water added as needed. The first count was done after 2 days and continued until it was certain all seeds that are expected to germinate have germinated.

Results and Discussion

Seeding date studies (discussed above) indicate that the highest grain yields are produced when seeding is done early in the spring. During this time soil temperatures are low and only chickpea varieties that have the ability to germinate under low temperatures can take advantage of the long growing season and more available soil moisture.

At the 68/68ºF night/day temperature Dwelley, Sinaloa and CA99901604W germinated rapidly and reached 100% germination in about 92 hours after incubation (Fig 21). Evans, Myles, Sanford and Sierra were slower and were fully germinated after 140 hours after incubation (Fig 21). Of these only Sanford reached 100% germination. Evans, Myles and Sierra reached 95, 93, and 80% final germination, respectively.

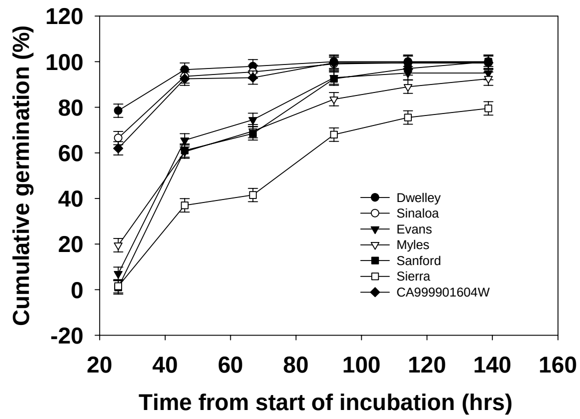

Fig 21. Cumulative germination of chickpea varieties at 20/30ºC (68/86ºF)

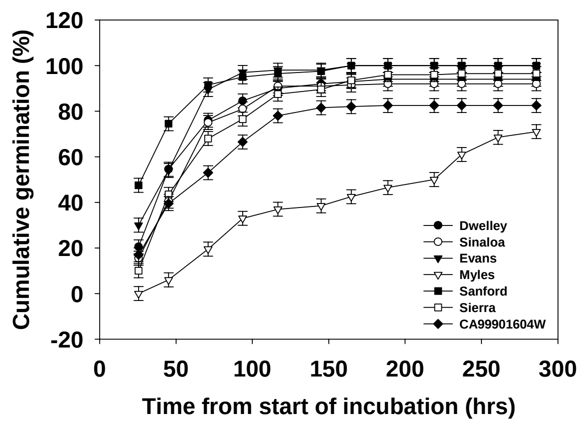

Fig 22. Cumulative germination of Chickpea varieties at 5ºC (41ºF)

When incubated at 41ºF, Sanford had the fastest rate of germination and reached a final germination of 100% (Fig 22). Evans was the second fastest, followed by Dwelley, Sinaloa, Sierra, CA99901604W and Myles. Final germination counts were 100, 94, 92, 97, 83, and 71%, respectively. Evans and Sierra increased their final germination counts when compared to

68/68ºF night/day temperature regime. The final germination counts of CA99901604W and Myles were reduced when compared to 68/68ºF night/day temperature regime.

When the varieties were grown at 46ºF, Sanford had the fastest rate followed by Evans, Dwelley and Sinaloa with final counts of 100, 94, 99, and 97%, respectively (Fig. 23). At this temperature regime, the rate of germination of CA99901604W and Sierra was slow and final germination for both varieties did not exceed 72%. Myles was the slowest to germinate but had steadily increased to 76% when the final count was done.

The response to germination of all the varieties at 52ºF was similar to that at 46ºF (Fig. 24).

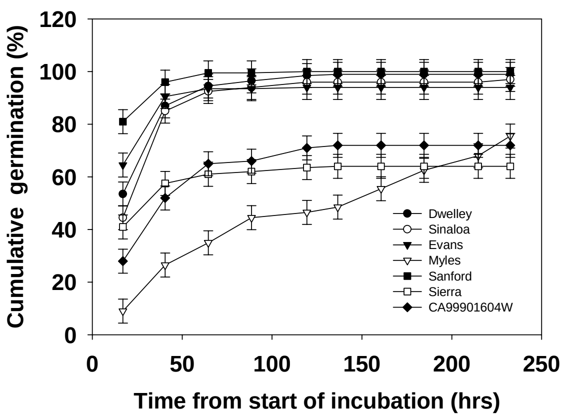

Fig 23. Cumulative germination of Chickpea varieties at 8ºC (46ºF)

Based on these results Dwelley and Sinaloa can germinate very well at all the temperatures from 41 to 77ºF with the germination rate being faster at temperatures above 46ºF. Sanford and Evans also

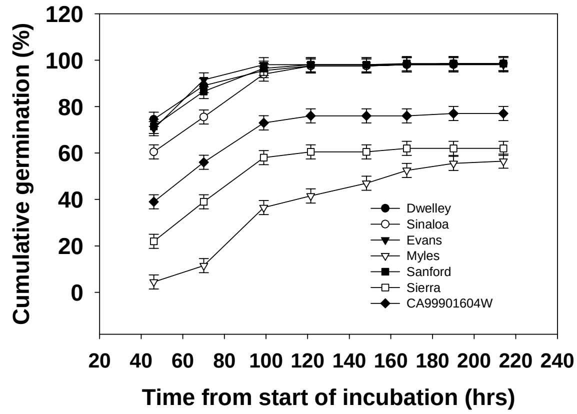

Fig. 24. Cumulative germination of Chickpea varieties at 11ºC (52ºF)

germinate fairly rapid at all temperatures from 41 to 77ºF but slower when germinated at 77ºF. Sierra germinates fairly rapid at lower temperatures than at high temperatures. The germination rate of CA99901604W is highest at warmer temperatures and slows downs at lower temperatures. This information is useful when determining which variety to grow at any given seeding date. Myles appear to germinate better only when temperatures are higher than 52ºF.

Based on these results Sanford and Evans can be planted very early in the spring when soil temperatures are about 41ºF. Dwelley and Sinaloa can be planted when soil temperatures reach 46ºF. CA99901604W can be planted late when soil temperature exceed 52ºF. Sierra had less than optimum germination at all test temperatures indicating that there may be problems with the quality of the seed lot evaluated in this experiment.

INOCULATION STUDY

Chickpea requires about 68 to 224 lbs/acre for growth and development. Nitrogen (N) applications are generally not necessary because it fixes atmospheric N through symbiosis with nitrogen fixing bacteria (*Rhizobium ciceri*). The bacteria, however, should be present in the soil for N fixation to occur. This experiment was conducted to determine if inoculating chickpea seed at seeding is necessary and if so what inoculation method would be the most effective. This experiment was conducted only at Pendleton.

Humus inoculant containing *Rhizobium ciceri* (Urbana Laboratories, St. Joseph, Mo) was applied to seeds of Sinaloa just before planting. There were six treatments: 1.) no inoculant, 2.) dry inoculant at recommended rate (1lb/300 lb seed), 3.) recommended rate x2, 4.) wet seed with 10% sugar solution and sprinkle recommended rate of inoculant, 5.) as in 2 plus starter fertilizer (16-20-0 NPK), and 6.) as in 4 plus starter fertilizer (16-20-0 NPK). At the beginning of anthesis, five plants from each replication were dug out to obtain roots in the first foot of top soil using shovels. The soil was washed away and the dry weight of nodules was determined by separating the nodules and sun-drying them in a greenhouse. The temperature in the greenhouse ranged from 70ºF at night to 100ºF during the day.

Results and Discussion

Applying inoculant stimulated nodulation (Fig 25). The highest weight of nodules was produced when inoculant was applied at twice the recommended rate and when applied to seed wetted by 10% sugar solution. These marked differences in nodule weights did not translate to significant differences in yield. Any treatment with inoculant, however, yielded more than the control treatment (Fig 26).

Based on these results, it is advisable to inoculate seed before planting. This work needs to be repeated in different seasons to determine whether *Rhizobium ciceri* can survive in our soils and the role of inoculation in chickpea production under eastern Oregon conditions

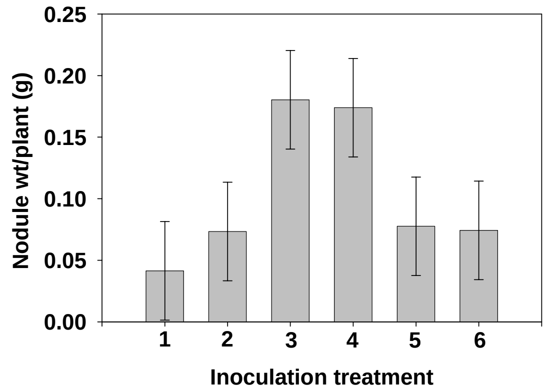

Fig 25. Seed inoculation effects on chickpea nodulation, CBARC, Pendleton, 2003

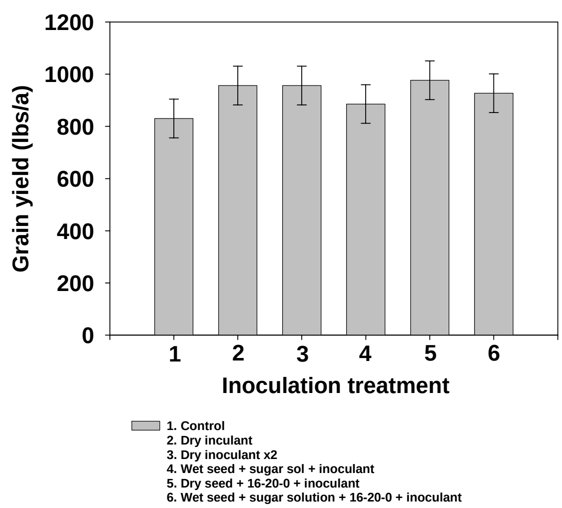

Fig 26. Seed inoculation effects on chickpea grain yield at CBARC, Pendleton, 2003

SUMMARY

Based on these results the following conclusions and recommendations have been drawn:

Seeding date, seeding rate, row spacing and variety studies

1. **Seed early in March when it is practical to do so in both low and high yield environments.**
2. **Seed either Dwelley or Sinoloa when seeding early and Sinaloa when seeding late or in low yield environments.**
3. **Seed at higher seeding rate when seeding early in spring (March) and at low seeding rate when seeding late (May).**
4. **The optimum seeding rate for Dwelley is 3.0 seeds/ft^2 and for Sinaloa is 4.5 seeds/ft^2 (if it is economical to do so).**
5. **Seed early in the spring to obtain the highest percentage of grade A beans. If seeding is delayed it is recommended to seed the variety Sinoloa to maintain a high percentage of grade A beans. At Moro seeding late does not seem to reduce the percentage of grade A beans produced.** However, the reduction in grain yield when seeding is delayed may more than offsets the returns due to high percentage of grade A seed produced.

Variety evaluations

1. **Grow Sinaloa in low and high yield environment to obtain both high grain yield and a high percentage of grade A beans**.
2. **Grow Dwelley in high yield environments only.**
3. **If grain yield alone is important, then Myles should be grown in both low and high yield environments. Myles produces exceptionally high yields in low yield environments.**

Germination studies

1. **Sanford and Evans can be seeded very early in the spring when soil temperatures are about 41ºF.**
2. **Dwelley and Sinaloa can be planted when soil temperatures reach 46ºF.**
3. **CA99901604W can be planted late when soil temperature exceed 52ºF**.

Inoculation studies

1. **It is advisable to inoculate seed before planting**
2. **Applying inoculant at twice the recommended rate or at the recommended rate with 10% sugar solution were the most effective inoculation methods on nodulation, but had no significant impact on grain yield.**

ACKNOWLEDGEMENTS

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