

Effect of Seeding Rate, Rowspacing and Seed Size on Chickpea Yield and Seed Size¹

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ABSTRACT

Recommended seeding rates of large-seeded Kabuli chickpeas (*Cicer arietinum* L.) range from 16 to 224 kg ha⁻¹, depending on location. At the higher seeding rates, seed costs alone can be 180 U.S. dollars ha⁻¹ because of high seed costs (1.32 dollars kg⁻¹ and relatively few seed per kg⁻¹ (1600-1900). This study was undertaken to determine the influence of seeding rate, rowspacing and size of planted seed on seed yield and seed size of 'UC-5' chickpea in the inland northwest. Field trials were conducted in 1981 and 1982 at Moscow and Grangeville, Idaho. Soils were a Southwick silt loam and a Palouse silt loam at Moscow in 1981 and 1982, respectively, and a Shebang silt loam at Grangeville in both years. In 1981, seed yield averaged over all seeding rates increased 48% as rowspacing decreased from 45.7 to 15.2 cm at Moscow and increased 26% as rowspacing narrowed from 30.5 to 15.2 cm at Grangeville. Similar seed yield responses were noted in 1982 trials at both locations. Optimum within-row plant population was 6 plants m⁻¹ in three out of four trials. At Moscow in 1981, optimum within-row plant population was 3.3 plants m⁻¹. Weight per 100 seed declined as rowspacing increased because plants tended to set two seeds per pod instead of one per pod. Planting seed 14% smaller than the largest sized seed of UC-5 chickpea seedlots reduced seeding costs by 30%, without sacrificing seed yield and weight per 100 seed. Repeated screening of seedlots to obtain smaller seed for planting should be limited to a few cycles to prevent production of seed with lower average weight per 100 seed than that found in original seed lots.

Additional index words: seed weight, yield components, stand establishment, sizing seed, *Cicer arietinum* L.

INTRODUCTION

Chickpeas, (*Cicer arietinum* L.), are the third ranking pulse crop produced in the world (Singh, 1978). India and Pakistan produce 74 and 10%, respectively, of the

world's crop with the remaining production found in the Middle East, Ethiopia and Mexico (Auckland and van der Maeson, 1980; Auckland and Singh, 1977; Singh, 1978). In the U.S.A., only the coastal areas of central California have a history of chickpea production.

Recent changes in farm programs and low prices for traditional crops have increased interest in production of adapted alternative crops. Chickpeas have shown adaptation to climatic and agricultural conditions of northern Idaho, eastern Washington, and western Montana (Auld et al., 1982; Welty et al., 1982). However, chickpeas, especially the large-seeded Kabuli types, can cost between 100 and 180 U.S. dollars per hectare for establishment based on seeding rates and rowspacing recommendations from traditional production areas. Most of these recommendations were developed in areas that have longer growing seasons and drier climates than those of the inland Pacific Northwest. Saxena (1979) indicated that moisture was an important determinant of optimum plant population with 33 plants m⁻² adequate for good yields in congenial environments of Syria. Work from the coastal area of California with 30 to 51 cm of precipitation suggests planting rates of 15.7 to 39.2 kg ha⁻¹ in rows 76.2 to 86.4 cm apart (Smith et al., 1950). Preliminary studies in Idaho (Auld et al., 1982) and Montana areas with 51 to 58 cm of precipitation (Welty et al., 1982) suggest planting rates of 134 to 168 kg ha⁻¹ and 168 to 224 kg ha⁻¹, respectively. Highest seed yields were attained at both locations as rowspacings narrowed to 15.2 or 17.8 cm.

Size of harvested seed is an important factor for marketing of large-seeded 'Kabuli' chickpeas. Seed that weighs 48.4 grams or more per 100 seed is necessary to satisfy these markets. Thus, both seed weight and seed yield must be monitored in response to plant populations.

These studies were conducted to determine seeding rates, rowspacings, and seed size needed to obtain acceptable yield and size of seed harvested from large-seeded chickpea. Rowspacings were restricted to those available from commercial drills.

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MATERIALS AND METHODS

Seeding Rate and Rowspacing Trials

Field studies were conducted near Moscow, Idaho on a Palouse silt loam (fine-silty, mixed, mesic Pachic Ultic Haploxerolls) and a Latahco silt loam (fine-silty, mixed, frigid Argiaquic Xeric Agrialboll) in 1981 and 1982, respectively. Studies near Grangeville, Idaho were placed on a Shebang silt loam (fine, montmorilonitic, mesic Xeric Argialboll) in 1981 and 1982.

Chickpea cultivar UC-5, a 'Kabuli' type with large seeds was used in both years at both locations. The cultivar UC-5 is a pure-line selected from a self-pollinated landrace grown in California for nearly 10 years. All seed was treated with Captan [n-(trichloro-methylthio) 4-cyclohexene-1, 2-dicarboximide] prior to planting. Planting depths were 4 cm. *Rhizobium* inoculum³ with a peat carrier was mixed with the seed just prior to planting in 1981. Granular inoculum was mixed with the seed just prior to planting in 1982 trials. Rowspacings, seeding rates, seeding dates, seeding equipment and locations used are listed in Table 1. Individual plots were 6.1 m in length with 0.9 m spacing between plots. A border plot was planted 0.9 m from the last plot in each replication to reduce edge effect.

Weeds were controlled at all locations by preplant incorporation of 0.42 kg ha⁻¹ profluralin⁴ [n-(cyclopropylmethyl) α, α, α trifluoro-2, 6-dinitro-n-propyl-p-toluidine] and 1.4 kg ha⁻¹ triallate⁴ [S-(2, 3, 3, trichlorallyl) diisopropylthio-carbamate]. Immediately after planting, 6.7, and 3.4 kg ha⁻¹ of dinoseb amine⁴ (2-sec-butyl-4, 6-dinitro-phenol) was applied over the seedbed in 1981 and 1982, respectively.

³ Inoculum provided by Nitragin Company.

⁴ Non-registered herbicide.

Plant populations at Moscow in 1981 were counted on 15 June from 0.9 m of each of 6 rows in the center of each plot. Plant populations at Grangeville in 1981 and at all other trial locations in 1982 were obtained by counting seedlings for a length of 0.9 m in the center two rows of each plot. Dates of seedling counts were 2 June, 25 May, and 2 June, at Grangeville 1981, Moscow 1982, and Grangeville 1982, respectively.

Plant material 0.6 m in length was removed from each end of the plots to provide a harvested length of 4.9 m. Chickpeas were harvested with a Hege, Model B1 or B2, small plot combine. Seed yields were calculated on a per unit area basis to allow comparisons of yields from plots with different row numbers and plot areas. Three representative sub-samples from the harvested seed were used to determine 100 seed weights.

Seed Size Trials

A 27 kg sample of registered 'UC-5' chickpea seed was sieved through 0.87 and 0.95 cm round-holed seed screens to obtain three seed lots which differed in both size and weight (Table 2). The seed of these three lots were planted 4 cm deep at Moscow, Idaho on 5 May 1981 on a Palouse silt loam (fine-silty, mixed, mesic, pachic Ultic Haploxeroll). Seeding rate was adjusted by seed count so that 13 seeds m⁻¹ were planted in each of the four rows of the plot. Rows were spaced 18 cm apart and were 4.8 m in length. Plots were spaced 0.46 m apart to allow separation at harvest. Seeds had been commercially treated with Captan and were covered with a commercial *Rhizobium* inoculum immediately prior to seeding. Weed control methods were the same as described for plant population and rowspacing trials in 1981.

Table 1. Rowspacings, seeding rates, seeding dates, seeding equipment and locations used in rowspacing by seeding rate experiments.

Experimental detail	Location			
	Moscow		Grangeville	
	1981	1982	1981	1982
Drill	International 5100		four row cone seeder	
Rowspacings (cm)	15.2, 30.4, 45.6	15.2, 30.4	17.8, 35	15.2, 30.4
Seeding rates (m ⁻¹)	3.3, 5.9, 7.5, 8.9	3.3, 6.6, 9.9, 13.1	3.3, 5.9, 7.5, 8.9	3.3, 6.6, 9.9, 13.1
Seeding dates	3 May	27 May	30 Apr.	6 May

Table 2. The relative size distribution and average seed weight obtained by screening 27 kg of registered UC-5 garbanzo seed through 0.87 and 0.95 cm round holed screens.

Seed		Size distribution	Seed weight
Sieve size	Class		
-cm-		%	seeds kg ⁻¹
>0.95	Large	46.9	1661
0.87-0.94	Medium	45.4	1962
0.79-0.86	Small	7.7	2563

Approximately 6 weeks after planting the number of plants in 2 m of the center two rows of each plot were counted. The plots were harvested on 3 September in a manner similar to that described for seeding rate and rowspacing trials. Harvested seed was cleaned over a 0.79 cm round-holed screen prior to weighing. A random sample of 100 seeds from each plot was weighed to determine relative seed size and then 800 ml of seed was sieved through a 0.87 and 0.95 cm screen to determine the distribution of relative seed size.

In 1982, seed harvested from chickpeas grown from large, medium and small seed classes were each sized into the same three size classes used in the 1981 study. On 22 April 1982 the nine sized seedlots were planted at Moscow on the same Palouse silt loam soil using the same procedures as previously described. The plots were harvested on 24 September and indices of yield, seed weight, and seed size distribution were determined as previously described.

Rowspacing and seeding rate trials and seed size studies were conducted as randomized complete block designs with four replications. Data were subjected to analyses of variance and means were separated using an LSD test at $P \leq 0.05$ when the F test was significant. The indices of stand establishment, seed yield, seed weight, and relative seed size from the 1982 seed size study were subjected to simple linear correlations to determine if associations existed.

RESULTS AND DISCUSSION

Seeding Rate and Rowspacing Trials

Established plant populations of 3.3 to 4.6 plants m⁻¹ of row had no influence on seed yield when averaged over all row spacings at Moscow in 1981, but seed yields increased 53% as plant populations increased from 3.3 to

8.2 plants m⁻¹ at Grangeville (Table 3). The lack of seed yield response to within row plant populations at Moscow was likely due to the narrow range of plant populations established. Seeding rates of 4.3 to 8.9 plants m⁻¹ established 3.3 to 4.6 plants m⁻¹, respectively. Seed cracking and lack of precision metering of seed by the commercial grain drill appeared responsible for the narrow range of plant populations established at Moscow in 1981. Cone planters used in the 1982 studies eliminated seed cracking problems encountered with commercial drills at Moscow in 1981.

The proportion of plants established decreased from nearly 100% at planting rates of 6.6 seed m⁻¹ to 68% at planting rates of 13.1 plants m⁻¹ at Moscow in 1982 (Table 3). Similar responses were noted at Grangeville. Since plant counts were made shortly after emergence, it is doubtful that plant competition reduced stands at higher plant populations. Reasons for reduced plant establishment at higher planting rates are unknown.

In 1981, the highest seed yields at each location was obtained when chickpeas were planted at the narrowest row spacings (Tables 1 and 4). Wider row spacings significantly reduced seed yields. The within-row plant population-rowspacing interaction was not significant for seed yield at either location.

Weight per 100 seed was not influenced by plant population or rowspacing at Moscow in 1981 (Tables 3 and 4), but weight per 100 seed increased at Grangeville in 1981 as within row plant population increased and rowspacing decreased. These data contrast with the accepted concept that individual seed weight declines with increasing plant numbers per unit area. Large-seeded chickpeas usually set one seed per pod, but in our trials, as plant population decreased the tendency to set two seed per pod was increased. Apparently individual seed weights were lighter when two seed were set per pod than individual seed weights when of one seed was set per pod. Data were taken on these parameters in 1982 for verification of this hypothesis. The within row plant population-rowspacing interaction was not significant for weight per 100 seed at either location in 1981.

In 1982 the highest seed yields were again attained at the narrowest row spacings (15.2 cm) at both locations when averaged over all planting rates (Table 4). Because of the large increase in yield as rowspacing narrowed, one could speculate that yields may have been even higher at row spacings less than 15.2 cm.

At Moscow in 1982, seed yield increased 52% as plant population established within the row increased from 3.6 to 8.9 plants m⁻¹ (Table 3). A similar increase in plant population at Grangeville improved seed yield 37%, but seed yield at Grangeville did not increase significantly in response to plant populations above 6.6 plants m⁻¹.

Table 3. Effect of within-row planting rates on plant establishment and seed yield of UC-5 chickpea at Moscow and Grangeville, ID in 1981 and 1982.

	Moscow				Grangeville			
	Within-row		Seed		Within-row		Seed	
	Planting rate	Plants established	yield	weight	Planting rate	Plants established	yield	weight
	seed m ⁻¹	m ⁻¹	kg ha ⁻¹	g 100 seed ⁻¹	seed m ⁻¹	m ⁻¹	kg ha ⁻¹	100 seed ⁻¹
1981								
	4.3	3.9	2138	47.8	4.3	3.3	1985	48.8
	5.9	3.3	2241	47.9	5.9	6.6	2892	50.2
	7.5	4.6	2270	48.1	7.5	8.2	3037	50.1
	8.9	4.3	2270	48.9	--	--	--	--
	LSD (0.05)	NS	NS	NS		1.1	284	1.1
1982								
	3.3	3.6	2432	45.9	3.3	3.6	3323	48.6
	6.6	5.9	3098	46.9	6.6	6.6	4236	48.6
	9.9	6.2	3357	46.9	9.9	7.9	4446	49.2
	13.1	8.9	3688	48.2	13.1	9.8	4553	49.2
	LSD (0.05)	1.6	430	1.0		1.6	382	NS

Table 4. Effect of rowspacing on seed yield and seed weight of UC-5 chickpea at Moscow and Grangeville, ID in 1981 and 1982.

	Moscow			Grangeville		
	Rowspacing	Seed		Rowspacing	Seed	
		Yield	Weight		Yield	Weight
	cm	kg ha ⁻¹	g 100 seed ⁻¹	cm	kg ha ⁻¹	g 100 seed ⁻¹
1981						
	15.2	2632	48.5	17.8	2943	50.2
	30.4	2282	48.3	35.6	2332	49.2
	45.6	1775	47.8	--	--	--
	LSD (0.05)	327	NS		232	0.9
1982						
	15.2	3506	47.9	15.2	4650	48.7
	30.4	2781	46.0	30.4	3628	49.1
	LSD (0.05)	305	0.7		270	NS

At Moscow in 1982, the number of seeds per plant, pods per plant and seeds per pod significantly declined and weight per 100 seed significantly increased as space between rows decreased from 30.5 to 15.2 cm (Table 5). The reduced number of seed per pod appeared responsible for increased weight per 100 seed observed in 1982 trials. Seeds per pod and weight per 100 seed showed no change as rowspacing changed at Grangeville.

Seeds per plant and pods per plant, showed 47 and 44% reduction, respectively, as within row populations increased from 3.6 to 8.9 plants m^{-1} of row at Moscow (Table 5). Similar results were obtained at Grangeville. Seeds per pod did not change as within row population changed at either location, but weight per 100 seed increased 5% as plant population increased at Moscow.

At each location in 1981 and 1982, most of the seed yield increase appeared to be due to an increased number of plants per unit area. The small increase in seed weight observed at Grangeville in 1981 and Moscow in 1982 as rowspacing narrowed and within row plant population increased could not account for observed seed yield increase.

Our data indicate that chickpeas should be planted in narrower row spacings than recommended in California (Smith et al., 1950) and agrees with preliminary studies in Montana (Welty et al., 1972) and Idaho (Auld et al., 1982). Optimum yields and weight per 100 seed were attained with either 15.2 or 17.8 cm between rows, respectively, compared to the 76.2 to 86.4 cm between rows used in California areas with comparable precipitation (Smith et al., 1950). Row spacings narrower than 15.2 cm may provide further increases in seed yield in the inland northwest and deserves additional study. Response of chickpeas to narrower row spacing in our area may be related to the shorter growing season. In California and other longer growing season areas, chickpeas may take five months or longer to mature. The longer growing season allows plants grown at wider row spacings to become larger and set more pods per plant than is possible in our three-month growing season.

The best seeding rate for optimum yield and seed size was about 6 plants m^{-1} of row, except at Moscow in 1981 where no yield response to seeding rate was found because of seed cracking by the commercial grain drill. Seeding rates of 6 plants m^{-1} are lower than those in Montana (Welty et al., 1982) and about equal to the highest rates suggested in Idaho and California (Auld et al., 1982). However, in California the spacing between rows is 5 to 6 times wider than that needed in our area, making the seeding rate per hectare 5 to 6 times lower in California than seeding rates in Idaho and Montana.

Hastened maturity and better weed control because of faster row closure are additional advantages of narrower row spacings. Narrower row spacings enhanced maturity

for soybeans produced in short growing season areas (Hume et al., 1979) and appear to also enhance maturity of chickpeas. Crop competition is especially important for weed control in the rolling topography of the Palouse where cultivation is not possible after chickpea emergence.

Seed Size Trials

Only 7.7% of the original seed lot passed through the 0.79 cm screen while equivalent proportions of 45.4 and 46.9% stayed on top of the 0.87 and 0.95 cm screens, respectively (Table 2). The registered seed had been previously screened over a 0.79 cm round-holed screen which, along with the large size of UC-5, accounts for the small proportion of small seed in the original seedlot.

Stand establishment, seed yield, and seed weight were not influenced ($p \leq 0.05$) by size of planted seed when evaluated in the field in 1981 (Table 6). Size of planted seed also had no effect on relative size of seed harvested from the plants (Table 7). The proportions of seed in each of the three size classes in the 1981 harvested crop was nearly the same as that observed in the original seedlot.

In 1982, plant establishment from the nine seed classes sized from 1981 seed varied from 250.0 to 555.6 thousand plants ha^{-1} (Table 6). The small- and medium-sized seed lots obtained from the 1981 plots when planted in 1982 produced stands equal to or better than those from the large seed lots. Stands established from the smallest seed produced seed yields that averaged 16% higher than yields established from the largest seed. The larger seeds apparently suffered more physical damage during harvest and cleaning than the medium and small sized seed size which may account for the reduced stand establishment and subsequent performance of the large seed.

The proportion of small and large seed produced by plants established from the nine size classes of 1981 seed differed (Table 7). The proportion of small seed produced was negatively correlated with both stand ($r=0.37^*$) and seed yield ($r=0.51^{**}$) (Table 8). Plants in thinner stands produced more but smaller seeds. Because of the reduced weight of individual seeds, these plants generally produced lower yields. Plants established in 1982 from the smaller seed class obtained after two cycles of seed screening, produced only 5.5% of the smaller seed class. Over 94% of the seed harvested from plots established with this smaller seed would have been acceptable for commercial marketing.

Seed yield of chickpea was significantly influenced by seed weight (seeds kg^{-1}) of harvested seed ($r=0.37^*$) (Table 8). Increased ** seed yields were associated with large seeds ($r=0.43^*$) and subsequent declines in the

Table 5. Effect of rowspacing and plants established on yield components of UC-5 chickpea at Moscow and Grangeville, ID in 1982.

Location	Row-spacing	Seeds	Pods	Seeds	Seed weight	Plants est.	Seeds	Pods	Seeds	Seed weight
	cm	--no. plant ⁻¹ --		no. pd ⁻¹	g 100 seed ⁻¹	no. m ⁻¹	--no. plant ⁻¹ --		no. pd ⁻¹	g 100 seed ⁻¹
Moscow	15.2	37	36	1.0	47.9	3.6	73	68	1.1	45.9
	30.5	76	70	1.1	46.0	5.9	56	52	1.1	46.9
						6.2	57	54	1.0	46.9
						8.9	40	38	1.0	48.2
LSD (0.05)		19	17	0.08	0.7		12	11	NS	1.0
Grangeville	15.2	36	33	1.1	48.7	3.6	72	66	1.1	48.6
	30.5	64	60	1.1	49.1	6.6	52	49	1.1	48.6
						7.9	41	38	1.1	49.2
						9.8	35	32	1.1	49.2
LSD (0.05)		14	13	NS	NS		9	8	NS	NS

Table 6. The effect of sizing seed of UC-5 chickpea on stand establishment, seed yield, and seed weight at Moscow, ID in 1981 and 1982.

Seed Class		Stand establishment		Seed yield		Seed weight	
1981	1982	1981	1982	1981	1982	1981	1982
		1000 plant ha ⁻¹		kg ha ⁻¹		seeds kg ⁻¹	
Large	Large	444.0	375.0	2436	3778	2027	1903
	Medium	--	500.0		4447	--	1989
	Small	--	416.6		3899	--	1926
Medium	Large	--	388.8		3848	--	1875
	Medium	453.0	500.0	2326	3805	2052	1960
	Small	--	500.0		4272	--	1991
Small	Large	--	250.0		3627	--	1876
	Medium	--	527.8		3993	--	1927
	Small	502.4	555.6	2459	4366	2061	1932
	LSD (0.05)	NS	10.5	NS	399	NS	24
	CV (%)	17.4	18.6	13.8	5.6	2.1	2.2

Table 7. The effect of planting differential sized seed of UC-5 chickpea on the size distribution of subsequent seed crop at Moscow, ID in 1981 and 1982.

Seed class	1981 Seed size class (cm)			1982 Seed size class (cm)		
	0.79-0.87	0.87-0.94	>0.95	0.79-0.87	0.87-0.94	>0.95
	-----%-----					
Large	6.8	52.3	40.9			
Large				4.5	27.7	67.8
Medium				4.7	29.3	66.0
Small				5.4	34.4	60.2
Medium	7.8	53.9	38.3			
Large				7.7	31.4	60.9
Medium				6.5	37.2	56.3
Small				4.5	27.4	68.1
Small	9.0	53.6	37.4			
Large				10.9	36.6	52.5
Medium				7.0	35.5	57.5
Small				5.5	32.4	62.1
LSD (0.05)	NS	NS	NS	2.7	NS	11.9
CV (%)	19.6	6.2	10.2	24.5	17.3	11.0

Table 8. Correlation coefficients of seed yield, seed weight, and seed size distribution of nine seed classes of sized UC-5 chickpeas at Moscow, ID in 1982.

	Seed yield	Seed weight	1982 Harvested seed size distribution (cm)		
			0.79-0.86	0.87-0.94	>0.95
	-----r values df = 36-----				
Stand	0.46**	0.49**	-0.37*	-0.07 ns	0.17 ns
Seed yield	--	0.37*	-0.51**	-0.36*	0.43**
Seed weight		--	-0.31 ns	-0.05 ns	0.14 ns

ns, *, ** = non-significant and significant at the 0.05 and 0.01 level of probability, respectively.

proportions of intermediate ($r = -0.36^*$) and small ($r = -0.51^{**}$) seed. The seed size distribution observed in 1982 indicated that the first cycle of sizing planted seed resulted in a slight increase in the proportion of small seed (0.79-0.86 cm) (Table 6). However, the plants established with the smaller seed still produced an average of 92.2% marketable seed compared to 93.8 and 95.2% for the medium (0.87 to 0.94 cm) and larger seed (>0.95 cm), respectively.

The result of these studies agrees with earlier work (Biderbost, et al., 1980) which indicates that small seed from pure line cultivars of large-seeded chickpeas can be used for planting without sacrificing subsequent seed yield. Establishment of a stand of chickpeas would require a minimum of 195 kg ha⁻¹ of the small seed class compared to 255 and 301 kg ha⁻¹ for the medium and large seed classes, respectively, representing an average savings of 30% on seed costs. In both years of this study the smaller UC-5 seed produced stands, yields, seed weights and seed size distributions comparable to larger seed. A trend towards slightly smaller seed detected in this study could have been caused by genetic drift and indicates that even in pure line cultivars, repeated seed screening could eventually result in the production of smaller seed. Limiting screening to a few cycles would offer a significant reduction in seeding cost while maintaining the size and relative value of the remaining seed lot. The use of smaller sized seed would also allow growers to plant seed which had less mechanical damage during harvest, storage and handling. The smaller seed would also receive less damage during commercial planting operations than large seed. These advantages would help insure better emergence under field conditions.

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