Plant Stand Density and Row Configuration Effect on Production of Texas Pinkeye Hull Cowpea

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ABSTRACT

In the Texas Rolling Plains (northwest Texas), cowpea [*Vigna unguiculata* (L.) Walp.] is often considered a replacement crop following early-season cotton (*Gossypium hirsutum* L.) failure. A 3-yr field experiment using a 6x2 factorial in a randomized complete block design was conducted to determine the optimum row spacing and planting density for maximum production of Texas Pinkeye Purple Hull Cowpea. Factor A consisted of six plant stand densities: 0.5, 0.6, 0.8, 1.1, 1.5 and 1.8 plants/sq ft whereas, factor B consisted of 1 or 2 rows (spaced 40 inches or 12 inches apart, respectively) on beds formed 40 inches apart. Seed yield was higher with 2 rows per bed than one row per bed and was highest (754 lbs/ac) at 1.5 plants/sq ft. This was significantly higher than at 1.1 plants / sq ft or lower densities. Seed yield was closely related to pods/sq ft. Pods per plant were higher with 2 rows per bed than with 1 row per bed and decreased with increasing plant stand density. Seeds per pod were not affected by either row spacing or plant stand density. Pea weight was only slightly affected by plant stand density. This study found that a yield of about 900 pounds per acre may be achieved with 70,000 plants per acre, planted in 2 rows per bed and an average within row spacing of 5 inches. Pod density or pods/sq ft was an important regulator of seed yield, whereas seeds per pod and seed weigtremained relatively constant.

KEY WORDS: seed yield, pods per sq ft, row spacing, and plant population

Cowpea has been shown to produce more acceptable yields than many other leguminous crops under many diverse climatic conditions, soils, and cultural practices (Fery, 1981). Cowpea breeding is well documented in the literature for such factors as disease resistance (Hare and Thompson, 1989; Fery, 1985; Kuhn, 1989; Patel, 1985; Pathak, 1988), heat tolerance (Hall and Patel, 1989), nitrogen fixation (Miller, 1989), and mineral nutrition (Marsh, 1989). Limited precise information is available for the southern U.S. and in the Rolling Plains of Texas on the effect of in-row or between-row spacing and plant stand density on cowpea yield. Conflicting results exist for cowpea response to various spatial arrangements. Ezedinma (1974) and Nangju et al. (1975) found no relationship between within-row and between-row spacings, whereas Haizel (1972) found that bunch type cowpea yield increased when a square planting arrangement was practiced rather with a rectangular planting arrangement. Nangju (1979) reported a seed yield decline for leafy cowpea cultivars at high plant densities. He postulated that the yield decline was due to more vegetative than reproductive growth because of excess leaf area resulting from plentiful rainfall and good soil fertility. Smittle (1989) reported that erect, early, and determinate cultivars are more suited to high density planting while semi-erect or vining, indeterminate, and high branching cultivars are more suited to low density planting. Grantz and Hull (1982) reported that widely spaced plants accumulated greater proportions of shoot dry matter in reproductive parts at mid-season than did closely spaced plants. A stronger association between yield and planting density was seen for determinate bean types (ACanyon and ABlue Lake 274) than for indeterminate types because the latter has more yield component compensation for the increased area/plant at lower planting densities (Crothers and Westerman, 1976). Chambliss and Turner (1972) reported increased seed yield of southern peas with increasing plant stand density. However, increasing the plant population from 20,000 to 30,000 plants per acre offered only a slight yield response. Herbert and Baggerman (1983) reported decreased cowpea seed yield with increased row spacing. They attributed this to the interaction of row width and plant stand density to available water.

In the Rolling Plains of northwest Texas cowpeas are grown as a catch crop either after wheat (*Triticum aestivum* L.) harvest or after loss of a primary crop, such as cotton. In general, a catch crop is a quick and fast growing crop grown between harvest or planting of two main crops, or as a substitute crop after a crop failure. Recently, producers have considered cowpea as an alternate crop in an attempt to diversify their farming operations. Sustaining soil productivity and fertility presents a serious challenge in the warmer southern U.S.A. (Doran and Smith, 1987) because of low soil organic matter, fragile soils, high evapotranspiration, low plant available water, and crust formation (Clark et al., 1993). The objective of this research was to determine the optimum plant stand density and row spacing for maximum cowpea yield. Treatment effects were evaluated on seed yields, pods per plant, seeds per pod, pods per sq ft, and pea weights.

MATERIALS AND METHODS

This experiment was conducted on a Miles fine sandy loam (fine loamy, mixed, thermic Typic Paleustalfs) in 1992, 1995, and 1996 at the Texas A&M University Experimental Farm near Munday, TX (33°27' N, 99°38' W, and ground elevation of 1460 ft). A 6x2 factorial experiment was conducted using a randomized complete block design with four replicates (Gomez and Gomez, 1984). Factor A consisted of six levels of successive desired plant stand densities: 0.5, 0.6, 0.9, 1.2, 1.8, and 2.4 plants / sq ft. Factor B consisted of 1 row (40 inches apart) and 2 rows (12 inches apart) per bed on raised beds formed 40 inches apart (Fig. 1). Because of yearly weather fluctuations (Table 1) actual plant stand densities differed from year to year. The 3-yr average plant stand densities were 0.5, 0.6, 0.8, 1.1, 1.5, and 1.8 plants / sq ft (Table 3). Texas Pinkeye Purple Hull was used as the experimental cultivar. This determinate, pinkeye, purple hull cultivar has an erect bush growth habit,

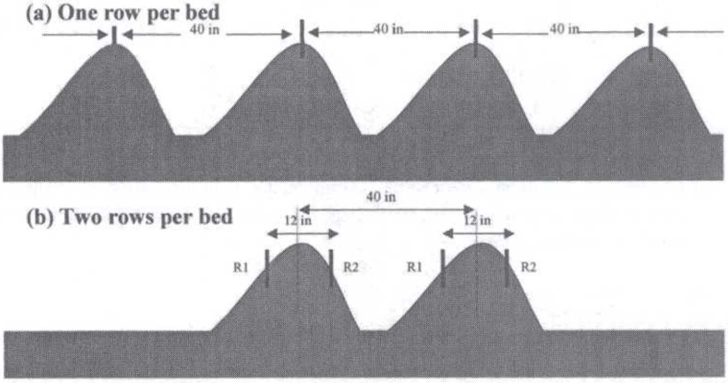

Figure 1. Planting pattern: (a) one row per bed, between row spacing 40 inches; (b) two rows per bed, between row spacing 12 inches, R1 is row 1 and R2 is row 2, dotted lines (....) indicate center of the bed 40 inches apart.

and concentrated pod set at or above the foliage level (Miller and Scheuring, 1994). The plot size was 4 rows by 20 ft long. Planting was done with a hand planter (Precision Garden Seeder, Model 1001B, Earthway Products Inc., Bristol, IN). Plants in the single row per bed treatment were established in the center of each bed, whereas plants in the two rows per bed treatment were established 6 inches to each side of the bed center (12 inches apart). Plots were over seeded and thinned immediately after emergence to obtain the desired plant stand density.

A post-plant application of 2 lbs / ac metolachlor [(2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl) acetamide)] was used for weed control. Plots received no fertilizer and were irrigated as needed to maintain adequate soil moisture in the root zone. Malathion [(0,0-dimethylphosphorodithioate of diethyl mercaptosuccinate) and diazinon (0,0-diethyl 0-(6-methyl-2-(1-methylethyl)-4-pyrididyl) phosphorothioate)] were applied twice during bloom to control aphid infestations. In 1992, 1995, and 1996 cowpeas were planted on 7 July, 11 July, and 18 June, respectively, and were harvested approximately 90 days after planting on 2 October, 13 October, and 15 September, respectively.

Plant count was taken approximately 7-d before harvesting from 5 ft of row length. Seed yields were determined by harvesting a 30 sq ft area. Seeds per pod and pods per plant were determined at harvest. Average pea or seed weight was based on 100 seeds.

Data were analyzed using the SAS computer program (SAS Institute Inc., 1989). Combined analyses of variance were run on 3 years data. Mean separation was done using orthogonal contrasts.

Table 1. Seasonal rainfall and daily maximum mean temperature data at the Munday, TX test site.

Month	Rainfall				Daily max. mean temperature			
	1992	1995	1996	30-yr Avg.[a]	1992	1995	1996	30-yr Avg.[a]
	inches				°F			
June	7.83	3.46	1.42	2.99	88	93	86	93
July	3.98	2.99	3.58	2.32	96	102	90	98
August	1.65	6.02	4.77	2.05	92	100	84	98
September	2.36	5.08	4.45	2.87	91	88	76	90
October	0.00	0.55	1.06	2.52	85	84	67	80
Season total	15.83[b]	18.11[c]	15.28[d]	12.76	-	-	-	-

[a]Source: Climatography of the United States No. 20-41, Climatological Summary, U. S. Department of Commerce, National Oceanic and Atmospheric Administration in cooperation with Cotton Economic Research and Bureau of Business Research of the University of Texas at Austin, December 1970.

[b] - From July 7 to October 2.
[c] - From July 11 to October 13.
[d] - From June 18 to September 15.

Table 2. Analysis of variance of seed yield and other plant paramenters.

Source of variation	df	Seed yield	Pods per plant	Seeds per pod	Pea weight
		---Probability (*P*)---			
Year	2	0.0001	0.0001	0.0023	0.0001
Reps within year	9				
Treatment	11				
Plant stand density	(5)	0.0001	0.0001	0.7188	0.0079
Row spacing	(1)	0.0001	0.0012	0.7460	0.2324
Plant stand density x row spacing	(5)	0.3392	0.0304	0.5560	0.2906
Year x Treatment	22				
Plant stand density x year	(10)	0.2863	0.0001	0.2544	0.8134
Row spacing x year	(2)	0.0015	0.0001	0.3338	0.0950
Plant stand density x row spacing x year	(10)	0.2479	0.1455	0.0416	0.7754
Error	99				
Total	143				
Contrast		Single degree of freedom contrasts (Pr>F)			
Plant stand density					
0.5 vx 0.6 plants / sq ft		0.1915	0.0001	0.1320	
0.6 vs 0.8 plants / sq ft		0.8592	0.0006	0.3612	
0.8 vs 1.1 plants / sq ft		0.1256	0.0001	0.1719	
1.1 vs 1.5 plants / sq ft		0.0243	0.0155	0.0137	
1.5 vs 1.8 plants / sq ft		0.0726	0.0421	0.4430	

Table 3. Effect of plant stand density and row spacing on seed yield at Munday, TX.

	Plant density			Within row spacing		Seed yield		
	1R/B	2R/B	Avg	1R/B	2R/B	1R/B	2R/B	Avg
	---Plants/sq ft---			---inches---		---lbs/ac---		
	0.4	0.5	0.5	8	15	504	677	591
	0.6	0.6	0.6	6	12	552	716	634
	0.8	0.9	0.8	5	8	597	660	628
	1.1	1.1	1.1	4	7	646	712	679
	1.4	1.6	1.5	2	5	689	820	754
	1.7	1.9	1.8	2	4	655	735	695
Avg	1.0	1.1	1.1	-	-	607	720	664
SED	0.1	0.1	0.1	-	-	47	47	34

SED = Standard Error of Difference between means.
1RB = one row per bed, between row spacing 40 inches.
2RB = two rows per bed, between row spacing 12 inches.

RESULTS AND DISCUSSION

Seed yield varied from year to year depending upon environmental conditions (Table 1 and Table 2). Pea yield was highest in 1992 (1054 lbs/ac) followed by 1996 (744 lbs/ac) and 1995 (196 lbs/ac) (data not shown). The low seed yield in 1995 was due to lower plant stand density (0.8 in 1995 vs 1.3 and 1.1 plants/sq ft in 1992 and 1996, respectively), lower number of pods per plant (4.1 in 1995 vs 9.1 and 9.2 pods per plant in 1992 and 1996, respectively), and lower number of seeds per pod (4.4 in 1995 vs 6.9 and 6 seeds per pod in 1992 and 1996, respectively). However, pea weight was slightly higher in 1995 (0.60 oz per 100 seed) than in 1992 (0.59 oz per 100 seed) and 1996 (0.55 oz per 100 seed). High temperatures in July 1995 resulted in poor emergence and high rainfall in August and September (Table 1) possibly resulted in poor stand and lower seed set in that year.

Overall, seed yield was higher with 2 rows per bed than 1 row per bed but it was higher only two out of three years (1992, $P < 0.0002$; 1996, $P < 0.0001$). This may have been due to less evaporation from the soil surface with two rows per bed (more soil shading). Bowers et al. (1976), Bradley and Baker (1974), and Stewart (1965) all concluded that yield increases could be expected with closer row spacings if more determinate varieties were used.

Although seed yield varied from year to year, the average seed yields were 591, 634, 628, 679, 754, and 695, lbs/ac at 0.5, 0.6, 0.8, 1.1, 1.5, and 1.8 plants/sq ft, respectively (Table 3). The seed yield was higher ($P < 0.0243$) only at 1.5 plants/sq ft compared with all other planting densities except at 1.8 plants/sq ft. Year x plant stand density interac was about 1.5 plants/sq ft. At plant populations below this the inputs probably were not tion did not affect seed yield. From our study we found that the optimum plant population efficiently was about 1.5 plants/sq ft. At a plant population above this probably resulted in crowding and severe competition for inputs. At a plant population of 1.8 plants/sq ft, yield was slightly decreased and seed cost was higher. Working on dry bean, Grafton et al. (1988) reported similar results with determinant varieties. Pods sq ft were calculated by multiplying number of plants / sq ft by the average number of pods per plant. Pods/sq ft seems to be an important parameter determining seed yield per unit area. In general pods /sq ft increased with plant population up to 1.5 plants / sq ft and then remained the same at 1.8 plants/sq ft. Pods / sq ft were 5.6, 5.9, 6.8, 6.6, 7.3, and 7.3 at 0.5, 0.6, 0.8, 1.1, 1.5, and 1.8 plants/sq ft, respectively (Fig. 2). Pods/sq ft followed a pattern similar to that of yield (Fig .2). Although pods/sq ft were similar on 1.5 and 1.8 plants/sq ft, seeds per pod was lower at 1.8 than at 1.5 plants/sq ft (Table 4). The lower seeds per pod may have resulted in slightly lower yields at 1.8 plants/sq ft than at 1.5 plants/sq ft. Similarly, pods/sq ft were higher for 2 rows per bed than 1 row per bed (8.6 vs 7.1 pods/sq ft). These findings were similar to the ones reported by Nangju (1979) and Herbert and Baggerman (1983).

Pods per plant were higher with two rows per bed than one row per bed (Table 2 and Table 4) and decreased with increasing plant stand density. Similar findings were reported by Grafton et al. (1988), Nangju (1979), Grantz and Hall (1982), and Herbert and Baggerman (1983). For determinate and indeterminate cowpea, Haizel (1972) found increasing number of pods per plant with decreasing plant stand density. Bennett et al. (1977) suggested that high seed yield could be achieved in high plant density conditions by the development and utilization of cultivars with few erect branches and a high number of nodes per branch. Pods per plant were affected by plant stand density x row spacing, plant stand density x year, and row spacing x year interactions (Table 2).

Seeds per pod were not affected by either row spacing or plant stand densities (Table 2 and Table 4). Working on a determinate dry bean cultivar, Grafton et al. (1988) reported that seeds per pod were not affected by stand density. A similar finding for a determinate cowpea cultivar was reported by Haizel (1972).

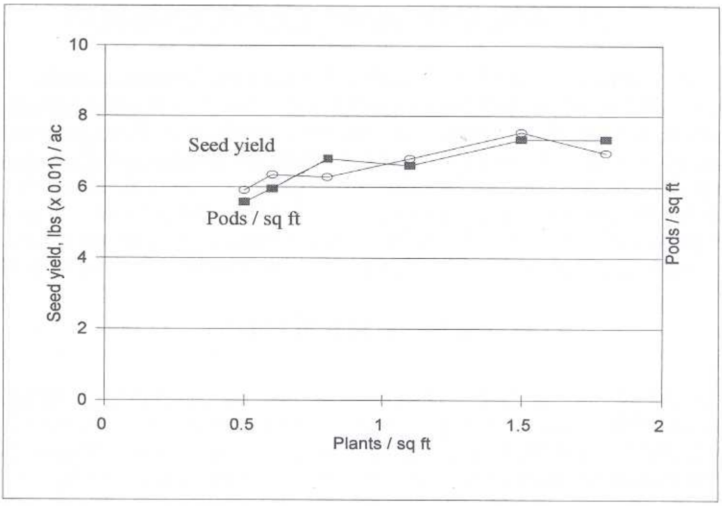

Figure 2. Seed yield (lbs x 10^{-2}/ac) and pod density (pods / sq ft) as affected by plant stand density (plants/sq ft).

Table 4. Effect of plant stand density and row spacking on pods per plant, seeds per pod, and pea weight at Munday, TX.

	Plant density			Pods per plant			Seeds per pod			Pea weight		
	1 R/B	2R/B	Avg	1 R/B	2R/B	Avg	1 R/B	2R/B	Avg	1 R/B	2R/B	Avg
	---Plants / sq ft--			-------------------Number-----------------------						--oz / 100 seed--		
	0.4	0.5	0.5	11.0	12.9	12.0	6.2	5.7	6.0	0.60	0.59	0.59
	0.6	0.6	0.6	8.4	10.9	9.7	5.5	6.2	5.9	0.58	0.58	0.58
	0.8	0.9	0.8	8.0	8.1	8.1	5.5	5.3	5.4	0.57	0.57	0.57
	1.1	1.1	1.1	5.9	6.1	6.0	5.5	5.8	5.7	0.57	0.60	0.58
	1.4	1.6	1.5	4.6	5.2	4.9	6.2	5.7	6.0	0.57	0.56	0.57
	1.7	1.9	1.8	4.0	4.0	4.0	6.0	5.6	5.8	0.57	0.58	0.57
Avg	1.0	1.1	1.0	7.0	7.9	7.4	5.8	5.7	5.8	0.58	0.58	0.58
SED	0.1	0.1	0.1	0.7	0.7	0.5	0.6	0.6	0.4	0.00	0.00	0.00

SED = Standard Error of Difference between means

1 RB = one row per bed, betrween row spacing 40 inches

2 RB = two rows per bed, between row spacing 12 inches

Overall, pea weight was not affected by plant stand density but it was significantly lower only at 1.5 plants/sq ft when compared with 1.1 plants/sq ft (Table 2 and Table 4). Grafton et al. (1988) did not find any differences in seed weight with increasing plant stand density either for determinate or indeterminate dry bean.

In this study the highest seed yield was obtained with the combination of a 12 inches between row spacing and 5 inches within row spacing that resulted in 1.6 plants/sq ft. Pod density or pods/sq ft (plant stand density x pods per plant) was the important regulator of seed yield, whereas seeds per pod and seed weight remained reasonably constant.

SUMMARY AND CONCLUSION

Seed yield for Texas Pinkeye Purple Hull Cowpea planted on raised beds 40 inches apart was greater with 2 rows per bed than 1 row per bed. Seed yield was greatest (754 lbs/ac) at 1.5 plants/sq ft. Seed yield was closely related to pods/sq ft. Pods per plant was higher with 2 rows per bed than 1 row per bed and decreased with increasing plant stand density. Seeds per pod were not affected by either row spacing or plant density. Pea weight was only slightly affected by plant stand density. Of the components of seed yield, pod density or pods/sq ft (plant stand density x pods per plant) was an important regulator of seed yield, whereas seeds per pod and pea weight remained somewhat constant.

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