Planting date and furrow-irrigation effects on cowpea for edible dry beans, Southern High Plains, USA

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ABSTRACT

Producers in the irrigated Southern High Plains, USA need crops to replace hail-damaged cotton (*Gossypium hirsutum* L.). Cowpea (*Vigna unguiculata* [L.] Walp.) has similar inputs as cotton. The objective of this study was to assess the suitability of cowpea as an alternative to cotton when the cotton is damaged by environmental factors early in its stand life. From 1998 to 2000, at New Mexico State University's Agricultural Science Center at Tucumcari, dry bean yield was measured of blackeye and pinkeye cowpeas planted mid-May and mid-June and irrigated 1 dap then every 14 d (ALT-14) or 1 dap and every 28 d thereafter (ALT-28). The mid-May 1999 planting was destroyed by hail, precluding that year from the analysis. Blackeye yields were greater than pinkeye yields under more optimum precipitation. There was, however, no difference when precipitation was less optimum leading to a year x cultivar interaction. An irrigation regime x planting date x cultivar interaction also existed due to a difference between varieties in when a 33% yield reduction was caused by late planting and/or reduced irrigation. In that interaction, blackeye yields were reduced only under ALT-28 planted mid-June while either later planting or ALT-28 decreased pinkeye yields. Blackeye cowpeas may be used to replace failed cotton in the Southern High Plains. Planting in mid-June likely will avoid hail and take advantage of higher precipitation periods. Irrigation water conserved during vegetative stages can be used to supplement precipitation as needed to provide water regularly during reproductive stages.

Abbreviations:

ALT-14: *Alternate furrows irrigated every 14 days.*
ALT-28: *Alternate furrows irrigated every 28 days*
Dap: *Days after planting*

Cotton (*Gossypium hirsutum* L.) is well adapted to the irrigated Southern High Plains, USA. Planting occurs in early to mid-May when the 10-d average minimum soil temperature is 15ºC. Cotton seedlings are susceptible to damage until they reach the 4-leaf stage, which normally occurs 20-30 days after planting (dap). May and June weather patterns in the region are characterized by a high incidence of crop-damaging hail (Kirksey et al., 2003). Pea-sized or larger hail has occurred between mid-May and mid-June in 23 of the 40 years from 1964 to 2003, at Tucumcari, NM, which is in the Southern High Plains. Stripper cotton yields at Tucumcari averaged 1285 kg ha^{-1} in 1998, 2000, and 2001 (R.E. Kirksey, unpublished data). In 1999, cotton was destroyed by hail on 29 May at Tucumcari. Replanting took place on 4 June with average yields being 699 kg $^{ha-1}$ for 1999 (R.E. Kirksey, unpublished data). Cotton plantings after the end of May in the Southern High Plains are not economically feasible due to reduced yields, so producers in the region need replacement crops in the event of an early-season cotton crop failure. Many of the production practices and inputs, including pre-plant fertilizers and herbicides, used for cotton also can be used for cowpea (*Vigna unguiculata* (L.) Walp.), making it a prime candidate to recover inputs for hail-damaged cotton.

Cowpea is a versatile crop having value as fresh or dried beans for human consumption (Fery, 1990; Muleba et al., 1991). It is well adapted to the climate and soils of the Southern High Plains. Being deep-rooted, cowpea performs well in sandy soils and is more tolerant to drought than soybean (Dadson et al., 2003), although irrigation is essential to maximize yield (Fery, 1990; Turk et al., 1980). Production still is possible without irrigation in semiarid regions during periods of low precipitation when other drought-resistant crops fail, such as grain sorghum (*Sorghum bicolor* (L.) Mo-

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ench.) and pearl millet (*Pennisetum americanum* (L.) Leeke, Syn: P. glaucum, P. spicatum, P. typhoides) (Turk et al., 1980). Soil moisture availability, either deficit (irrigated to replenish 60% of PET, Pandey et al., 1984a) or surplus, during the vegetative stage has little effect on seed yield if conditions improve and sufficient moisture is present during flowering and pod-filling (Gwathmey and Hall, 1992; Muleba et al., 1991; Pandey et al., 1984a). Thus, if water for irrigation is limited, it is possible to withhold irrigation during the vegetative stage with negligible effects on seed yield (Ziska and Hall, 1983). Patel and Hall (1990) in southern California used weekly alternate-furrow irrigation to maintain active growth during the vegetative stage and conserve water for use during flowering and pod-filling.

The precipitation pattern in the Southern High Plains is continental, in that, approximately 83% of the total annual precipitation occurs as intermittent, relatively intense rainfall events during the growing season (April-October) (Kirksey et al., 2003). July and August historically have the highest precipitation, averaging 67 and 69 mm per month, respectively (Kirksey et al., 2003). By scheduling planting dates so that flowering and pod-filling occur in July and August, water can be conserved, especially if irrigation can be reduced in the first 28 d of growth during the vegetative period. However, if cowpea is to follow a hailed-out cotton crop, producers need to know how late they can plant and still maintain acceptable yields.

The purpose of this research was to determine if cowpea could be a replacement crop for failed cotton plantings in the Southern High Plains of the USA, and if so, to determine the effect of a later planting date and commonly used furrow irrigation regimes on edible dry bean yield.

MATERIALS AND METHODS

Tests were conducted in the same field at New Mexico State University's Agricultural Science Center at Tucumcari (35.20°N, 103.69°W; elev. 1247 m) during the 1998 to 2000 growing seasons. Pea-sized hail fell on 25 and 29 May 1999 and golf ball-sized hail fell on 3 June 1999, destroying the test that year. Thus, only the 1998 and 2000 tests will be described and discussed. Each test was a randomized complete block replicated three times with a strip-split plot treatment arrangement (Littell et al., 1996). The strip plot was irrigation regime, which included: alternate furrows irrigated 1 day after planting (dap) and every 14 d thereafter (ALT-14) and alternate furrows irrigated 1 dap and every 28 d thereafter (ALT-28). Irrigation treatments were delivered through gated pipe and were of sufficient duration to completely wet the center of the beds for their full length. It was estimated (Ziska et al., 1985) that 100 mm water was applied during each alternate-furrow irrigation (Table 1). The same furrows were irrigated each time. Subplot treatments were planting date (mid-May and mid-June). Sub-subplots were variety: CB5 (blackeye) and Charleston Greenpack (pinkeye). Seed was not inoculated.

The soil was a Canez fine sandy loam (fine-loamy, mixed, thermic Ustollic Haplargid) with initial soil test levels in 1998 of 23 and 201 ppm P and K, respectively, and a pH of 8.3 in the surface 20 cm. Uniform broadcasts of pre-plant incorporated fertilizer and Trifluralin each year were 125-117-0 kg N-P_2O_5-K_2O ha^{-1} and 0.56 kg a.i. ha^{-1}, respectively. Each test was sown into a conventionally tilled seedbed formed into 0.91 m beds for furrow irrigation. Planting dates were 20 May and 17 June 1998 and 17 May and 14 June 2000. Plots (4 beds x 7.62 m) were planted on a 0.91-m row spacing with a conventional four-row flex-planter fitted with a seed-metering cone on each planter unit. The planting rate, 144-thousand seeds ha^{-1}, was chosen because other research at this location indicated that edible dry bean yields were not different at seeding rates of 72- to 216-thousand seeds ha^{-1}, but they were depressed at lower seeding rates (L.M. Lauriault, unpublished data). The two center rows of each plot were harvested, leaving the outside rows as borders. An additional 2-bed border was sown between irrigation treatments to prevent lateral movement of water into the adjacent plot as described by Ziska et al. (1985).

Insecticides (Carbaryl, 1.68 kg a.i. ha^{-1} and Malathion 1.35 kg a.i. ha^{-1}) were used to control armyworms (*Noctuidae* sp.) and grasshoppers (*Orthoptera* sp.) both years. Fungicides (Copper hydroxide, 1.12 kg a.i. ha^{-1} and Chlorothalonil, 1.76 kg a.i. ha^{-1}) were sprayed weekly each year beginning 14 dap and continuing for 6 weeks for both planting dates to protect against bacterial blight (*Xanthomonas campestris pv. vignicola* (Burkh.)).

Shortly after first bloom (30 dap), leaf senescence began in all plots, except the mid-May 1998 planting. By 42 dap 50% of leaves had senesced and senescence was nearly 100% by 56 dap. The onset of senescence in the pinkeye cultivar was slightly later than the blackeye variety. Analysis of whole plant samples indicated that the causative agent of senescence was Fusarium wilt (*Fusarium oxysporum* Schlecht. *f. tracheiphilum* (E.F. Sm.) Synd. & Hans.) (Natalie Goldberg, pers. comm.). On

Table 1. Approximate dates of furrow-irrigations (X) and significant precipitation events, by year, irrigation treatment, and planting date for cowpea studies conducted at the NMSU Agricultural Science Center at Tucumcari in 1998 and 2000.

Irrigation Treatment	Planting date	May				June				July				August				September				Total mm
Alt-14	Mid-May			X		X		X		X		X		X		X		X				800
	Mid-June							X				X		X		X		X				600
Alt-28	Mid-May			X				X				X				X						400
	Mid-June							X				X				X						300
1998 Precipitation (mm)											16		39	50	21		49				60	204‡
2000 Precipitation (mm)					21	10			29	29	7		21									197‡

† Alt-14 and Alt-28 signify alternate rows irrigated 1 dap and every 14 days thereafter and alternate rows irrigated 1 dap and every 28 d thereafter, respectively.

‡ Precipitation totals include individual isolated events of <3 mm not otherwise shown, which totaled 13 mm in 10 events in 1998 and 12 mm in 15 events in 2000.

all occasions where the disease occurred, a vegetative regrowth occurred, but there was no second flush of flowers, as there had been for the mid-May 1998 planting.

Cowpeas from the center two rows were cut and threshed with an Allis-Chalmers Model 66 All Crop B series harvester on 16 Sep. 1998 and 16 Oct. 2000, when pods had dried sufficiently for threshing. The combine was fitted with lifting fingers to collect vines from furrows because it was observed that, while the blackeye variety (CB5) had an upright growth habit, the pinkeye variety (Charleston Greenpack) was more decumbent and viny, trailing along the ground between rows.

Threshed material was cleaned using a Clipper Office Tester (Bluffton Agri/Industrial Corp.) fitted with a #21 top screen and a #14 bottom screen and full air. Scalpings and screenings were inspected to recover escaped seed and portions except seed coats. All remaining noticeable stems, hulls, weed seed (*Cenchrus* sp.; *Tribulus* sp.) and mineral fragments were removed after cleaning. Clean seed weights were recorded and an aliquot of up to approximately 500 g was weighed prior to drying for 24 h at 100°C and reweighing. Seed moisture was calculated and clean seed yields were converted to 14% moisture for statistical analysis (Pandey et al., 1984a).

Weather data were collected from a National Weather Service cooperative station located at the center, within 1 km of the study area. There was very little variation in mean monthly temperatures between years and all were typical of the Southern High Plains region (data not shown). The long-term (1905-2002) mean annual temperature at Tucumcari is 14.4°C; annual temperatures during the years of this study were 15.6 and 16.1°C for 1998 and 2000, respectively (Kirksey et al., 2003). The annual precipitation each year during the study period was 450 and 310 mm for 1998 and 2000, respectively, while the long-term average for Tucumcari is 404 mm (Kirksey et al., 2003). Marble-sized hail fell on 26 May 1998 (2 mm total precipitation) and pea-sized hail fell 25 May 2000 (trace precipitation), before most plants of the mid-May planting had emerged.

Edible dry bean yield data collected in 1998 and 2000 were subjected to analysis of variance and SAS PROC MIXED techniques (SAS Inst., 2001) for all effects and interactions. Rep x year, rep x year x irrigation regime, rep x year x irrigation regime x planting date, and residual error were considered random and used as denominators for tests of significance (Littell et al., 1996). Protected least significant differences ($P < 0.05$) were calculated using standard deviation for differences between main effects and within interactions generated by the PDIFF option of the LSMEANS statement (SAS Inst., 2001). All differences reported were significant at $P < 0.05$.

RESULTS AND DISCUSSION

Edible dry bean yields at Tucumcari were similar to those reported earlier (Kwapata and Hall, 1990; Muleba et al., 1991; Pandey et al., 1984a). The year x cultivar interaction was significant because there was a difference between cultivar yields in 1998, but not 2000 (Table 2). The difference in 1998 was much greater than the 20% expected between blackeye and pinkeye cultivars (Leo Thrasher, pers. Comm.), while the difference in 2000 was less than expected (Table 2). Other research from this location indicated that the yield difference between blackeye and pinkeye varieties was due to differences in seed yield per plant (29.64 vs. 23.07 g $plant^{-1}$ for blackeye and pinkeye varieties, respectively, L.M. Lauriault,

Table 2. The effect of year and cultivar on edible dry bean yield (kg ha^{-1}) of cowpea in the Southern High Plains, U.S.†.

	Year‡	
Cultivar	**1998**	**2000**
Blackeye, CB5	2665[a]	763[c]
Pinkeye, Charleston Greenpack	1660[b]	716[c]

† Data are the means of three replicates, two irrigation treatments (alternate furrows irrigated 1 dap and every 14 d thereafter and alternate furrows irrigated 1 dap and every 28 d thereafter), and two planting dates (mid-May and mid-June).

‡ The mid-May planting in 1999 was destroyed by hail, so that year was not analyzed.

abc Means followed by different letters are significantly different at the 5 percent level based on a least significant difference (= 285 kg ha^{-1}) calculated from the standard deviation from the SAS LSMEANS analysis of the interaction.

unpublished data). Seed yield plant^{-1} is determined by seed size, seed number plant^{-1}, and seed weight, among other factors, all of which are environmentally affected (Pandey et al., 1984; Turk et al., 1980). The other Tucumcari research also suggested that the pinkeye variety used in the present studies (Charleston Greenpack) does not perform as well at Tucumcari as Coronet (1663 vs. 2142 kg ha^{-1} edible dry beans ha^{-1} for Charleston Greenpack and Coronet, respectively, L.M. Lauriault, unpublished data).

Plant growth in semiarid regions is often limited by variations in the amount and duration of precipitation (Pandey et al., 1984b). While there was little measurable precipitation from planting until early July 1998 (Table 1), 113 mm fell between 1 January and 1 May, compared to the long-term average of 67 mm for the same period (Kirksey et al., 2003). This likely provided more soil moisture for stand establishment and vegetative growth in 1998 compared to 2000, when only 64 cm of precipitation fell before planting. Still, timely precipitation in May and June 2000 (Table 1) also probably promoted establishment and vegetative growth. Muleba et al. (1991) attributed depressed yields in cowpea to frequent severe and protracted drought during the reproductive stages. Turk et al. (1980) found that drought induced during the vegetative stage followed by weekly irrigations initiated just prior to flowering and continuing until 50% senescence, maximized cowpea seed yields compared to drought induced during either flowering or pod-filling, regardless of irrigation intensity.

The pod-filling period for cowpea is relatively short (17 to 24 d) (Kwapata et al., 1990; Turk et al., 1980). Flowering and pod-filling (35-70 dap, Gwathmey and Hall, 1992; Kwapata et al.,1990; Pandey et al., 1984b; Patel and Hall, 1990) for cowpea planted mid-May and mid-June, was from mid-June to late July and mid-July to late August, respectively, in Tucumcari. It is likely that the distribution of precipitation from late June through August coincident to the alternate-furrow irrigations provided a regular, sufficient supply of water (approximately every 7 to 14 d) during the reproductive stages to sustain yields across planting dates in 1998 (Table 1) (Turk et al., 1980). The blackeye cowpeas may have benefited more from this uniform availability of water than the pinkeye cowpeas (Table 2).

The irrigation treatment x planting date x cultivar interaction was significant (Table 3). As expected, yield of blackeye cowpeas sown mid-May and irrigated every 14 d (ALT-14) were numerically higher by 20% pinkeye cowpeas for the same irrigation regime-planting date treatment combination (Leo Thrasher, pers. Comm.); but, those yields were not significantly different between cultivars (Table 3). The interaction occurred because blackeye yields were reduced only when planted in mid-June and irrigated every 28 d while pinkeye yields were decreased either by later planting or less frequent irrigation. Thus, although there are higher yielding pinkeye varieties than that used in the present study, pinkeye varieties may not be well enough adapted to this region to be used for later planting dates following hail-damaged cotton. Kwapata and Hall (1990) concluded that a later sowing date reduced time for vegetative development, including branching that would produce more pods, thereby reducing seed yield. Kwapata et al. (1990) observed dry pods 90 days after emergence in southern California when cowpeas were provided sufficient water to meet maximum crop requirements. This is consistent with the present study in which cowpeas planted in mid-June were threshed in September. Other research in eastern New Mexico (L.M. Lauriault, unpublished data) indicates a dramatic decline in yield when cowpea is planted after mid-June, regardless of irrigation regime or harvest date, which is consistent with Kwapata and Hall (1990).

Table 3. The effect of irrigation treatment, planting date, and cultivar on edible dry bean yield (kg ha^{-1}) of cowpea in the Southern High Plains, U.S.†.

Irrigation treatment‡	Planting date: Mid-May	Planting date: Mid-June
Blackeyes		
ALT-14	1878^{ab}	1964^{a}
ALT-28	1688^{abc}	1327^{cde}
Pinkeyes		
ALT-14	1518^{bcd}	1128^{de}
ALT-28	1058^{e}	1048^{e}

† Data are the means of three replicates in two years (1998 and 2000; the mid-May planting in 1999 was destroyed by hail, so that year was not analyzed).

‡ ALT-14 and ALT-28 signify alternate furrows irrigated 1 dap and every 14 d thereafter and alternate furrows irrigated 1 dap and every 28 d thereafter, respectively.

abcde Means followed by different letters are significantly different at the 5 percent level based on a least significant difference (= 430 kg ha^{-1}) calculated from the standard deviation from the SAS LSMEANS analysis of the interaction.

Continued irrigation after flowering can cause flushes of vegetative growth in cowpea (R.B. Dadson, pers. comm., 2003) that could lead to higher yields if there is sufficient time for flowering and pod-filling on those branches. It also could lead to reduced yield if the vegetative growth interferes with reproduction (R.B. Dadson, pers. comm.). Fusarium wilt caused senescence in the present study, preventing continued vegetative growth after initial bloom. The mid-May planting in 1998 did undergo a second flush of blooms that might have increased yields for that planting, although the year x planting date interaction was not significant.

Because there was no yield loss when blackeye cowpeas were planted in mid-May and irrigated every 28 d or planted in mid-June and irrigated every 14 d, compared to mid-May ALT-14 (Table 3), as much as 400 mm of water could have been saved to be applied in weekly 100 mm increments in August 2000 (Table 1) during the flowering and pod-filling periods. Further water savings might be feasible by withholding irrigation during the vegetative stage until visible signs of drought stress occur (Turk et al., 1980). That water also could be used to supplement precipitation during the reproductive stages in August or conserved for later use.

CONCLUSIONS

Cowpea is well adapted and can be productive in the Southern High Plains of the USA. Like cotton, cowpea is susceptible to hail damage, which has a high incidence of occurrence in the Southern High Plains of the USA. Producers, however, can use blackeye varieties, particularly CB5, to replace hail-damaged cotton or other crops with similar inputs, by planting as late as mid-June without a yield sacrifice if sufficient water is provided. In addition to narrowing the window for possible hail damage to the cowpeas, irrigation requirements for cowpea production can be reduced by delaying planting, using deficit irrigation until approximately 30 dap, and using alternate-furrow irrigation as needed only to supplement precipitation to provide moisture approximately every 7 to 14 d during bloom and pod-filling (35-70 dap).

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Notes

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