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Comparing Single-Row and Twin-Row Corn Production in the Mid South

H. Arnold Bruns, Crop Production Systems Research Unit, USDA-ARS, Stoneville, MS 38776; **M. Wayne Ebelhar,** Mississippi State University Delta Research and Extension Center, Stoneville, MS 38776; and **Hamed K. Abbas,** Biological Control of Pests Research Unit, USDA-ARS, Stoneville, MS 38776

Corresponding author: H. Arnold Bruns. arnold.bruns@ars.usda.gov

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Abstract

Twin-row corn (*Zea mays* L.) has increased in the Mid South but with limited research. Comparisons of single- vs. twin-row irrigated corn stands of 25,700, 30,700, 35,000, and 39,200 plants/acre grown at N fertilizer rates of 180, 220, and 260 lbs N/acre were made at Stoneville, MS, in 2007 and 2008. Leaf area index (LAI) was greater (6.3) in twin rows than single rows (6.1) but was not affected by N fertilizer. LAI was greater in all stands in 2007 than 2008 due to more plants/acre and rainfall in July vs. drought in July 2008. Greater yields also occurred in 2007 than 2008. No yield differences occurred between row types except twin rows at 30,700 (238 bu/acre) and 35,000 (244 bu/acre) plants/acre in 2007 were greater than single rows (224 and 227 bu/acre, respectively). Row type nor N fertilizer affected 100-kernel weights, though they did decline in 2007 as stands increased from 25,700 (1.37 oz) to 30,700 (1.28 oz) plants/acre. In 2008, 100-kernel weights were less, with the two lower stands not differing (1.08 and 1.11 oz) and the two higher stands (1.05 oz) less than the 30,700 stand. Lodging occurred in 2007 and was greatest at 39,200 plants/acre. Aflatoxin and fumonisin were higher in 2008 (901.8 ppb and 8.6 ppm) than 2007 (0.4 ppb and 0.6 ppm) but unaffected by row type and N fertilizer. N fertilizer above 180 lbs/acre did not affect yield or other measured data.

Current Knowledge About Stand Density and Row Types

Increased corn grain yields resulting from higher stand densities have encouraged producers to attempt growing their crops in ever-decreasing row widths. In most areas limits on modifying planting and harvesting equipment have been an obstacle to growing corn profitably in single rows spaced less than 30 inches apart. The concept of twin-row planting evolved as a means of increasing stand densities and still being able to use harvesters designed for conventional row widths. Planters have been designed that plant two (twin) rows 6 to 10 inches apart with the mid-points of two sets of twin rows spaced at conventional row centers of 30 inches to 40 inches. Popular press articles and sales brochures have promoted the idea that increased crop yields are possible with twin-row configurations compared to single-row plantings at the same plant densities (2,8,14). On the other hand, some extension and research reports are more conservative and do not note significant yield differences between the two configurations when the plant populations are the same (12,15).

Twin-row production of some crops has shown profitable increases over single-row production in some experiments. Grichar (10) found that, averaged over cultivars and seeding rates, twin-row planted soybean planted 4 to 6 inches apart on 38-inch centers produced greater seed yields than single-row conventional plantings 38 inches apart in southern Texas. Bruns (5,6) however, reported that in the Mississippi Delta no consistent increases in yields were observed for soybean grown in twin-row configurations, compared to single rows with different seeding rates or planting dates for either a MG IV or MG V cultivar. Cotton (*Gossypium hirsutum* L.) lint yields have been observed to increase when planted in twin-row configurations compared to single rows (11). Peanut (*Arachis hypogaea* L.) has been found not only to have increased pod yields when grown in twin rows, but also to have reduced losses due to *Tomato spotted wilt virus* (genus *Tospovirus*, family *Bunyavirdae*) (3).

Though twin-row corn production has not been well researched in the lower Mississippi River Valley, the practice is becoming increasingly popular among the region's farmers who are increasing their acreage of twin-row soybean to nearly 80% of the total production (P. Giachelli, *personal communication*, 2011). Twin-row corn is being produced in order to increase the utilization of the planters used to grow soybean. Also, no modifications of corn pickers are required to harvest twin-row corn verses conventional single rows.

Nitrogen is one of the most essential elements to corn growth and development and is often the key to production of profitable yields. It is a primary element of all amino acids and thus proteins which make up the bulk of all living matter. Bruns and Ebelhar (7) determined that harvest of corn grain in the lower Mississippi River Valley permanently removed 124 to 237 lbs N/acre and replacing this loss would require 172 to 287 lbs/acre of fertilizer N to achieve 200 bu/acre yield goals. Costs of N fertilizers though have increased over the past decade due higher natural gas prices and doubled for urea:NH_4NO_3 during this experiment from $12.00 per cwt in 2007 to $24.00 per cwt in 2008 (S. Martin, *personal communication*, 2011). This strongly emphasizes the need to manage N fertilizer rates on corn for maximum economic yields rather than just total grain yield.

Pre-harvest contamination of corn with aflatoxin is a constant threat in the Mid South. Aflatoxin is a secondary metabolite of the fungus *Aspergillus flavus* and along with fumonisin which is a secondary product of the *Fusarium* spp. of fungi are potent carcinogens in humans and serious health threats in livestock (9). In 1998, pre-harvest aflatoxin contamination of corn grown in Arkansas, Louisiana, Mississippi, and Texas is estimated to have resulted in a loss of $85 million (US dollars) (18). Stressful environmental conditions, especially drought and heat stress during kernel development in corn grown in the Mid South and Southeastern United States are conducive to mycotoxin contamination (9).

The objectives of this study were to: (i) determine if twin-row planted corn yields more grain than single-row plantings at comparable seeding and/or N fertilizer rates; (ii) determine if these treatments affect LAI at anthesis; and (iii) note if row configuration, seeding rate, and/or N fertilizer rate combinations have an effect on aflatoxin and/or fumonisin contamination of the grain at harvest.

Plant Populations, Row Configuration, and N rates

The experiment was conducted at Mississippi State University's Delta States Research and Extension Center Experiment Station at Stoneville, MS, in 2007 and 2008 in two adjacent fields at one site that were previously planted to soybean each year. Soil types at the experimental site were a Bosket fine sandy loam (Mollic Hapludalfs) mixed with some areas of a Beulah fine sandy loam (Typic Dystrudepts). The experimental design was a split-plot of a randomized complete block replicated four times. Whole plots were either a single-row or twin-row planting configuration. Sub-plots were a combination of one of four seeding rates (28,750, 34,500, 40,250, or 46,000 kernels/acre to achieve final stands of at least 25,000, 30,000, 35,000, or 40,000 plants/acre) and N fertility rates of 180, 220, and 260 lbs/acre.

The field was prepared both years by sub-soiling in the fall before planting, then disking and hipping in late winter into 24-inch ridges spaced 40 inches apart. Soil tests prior to winter tillage indicated no supplemental P or K fertilizer was required for a yield goal of 200 bu/acre of corn. Each year the experiment received 120 lbs N/acre as a urea:NH_4NO_3 solution prior to planting with the remainder of the N fertilizer side-dressed at growth stage V6 (six fully extended leaves) as defined by Ritchie et al. (17). Individual experimental units were eight 40-inch rows, 60 ft long, for the single-row plantings or eight twin-row pairs with each pair planted 8 inches apart on 40-inch centers and 60 ft long. Single-row plots were planted using a John Deere model 7100 vacuum planter (Moline, IL) while twin-row plots were planted using a Monosem model NG-3 planter (Edwardsville, KS).

The corn hybrid used in the experiment in 2007 was DeKalb brand DKC 66-23 RR/Bt and in 2008 was DeKalb brand DKC 63-42 RR/Bt (Monsanto, St. Louis, MO). Choice of hybrids used in the experiment was based on availability of seed at planting. Planting was completed on 27 March 2007 and 30 March 2008. Weed control was accomplished with a pre-emergence application of 2.4 qt/acre of BICEP II Magnum (Syngenta, Greensboro, NC) [33.0% Atrazine (2-chloro-4-ethylamine-6-isopropylamino-s-triazine) + 26.1% s-Metolachlor (Acetamide, 2-chloro-N-(e-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)-(S)]. Plots both years of the study were furrow irrigated beginning at or shortly after anthesis. Leaf area index (LAI) at anthesis was estimated using an AccuPAR LP-80 PAR/LAI ceptometer (Decagon Devices, Pullman, WA). Six individual measurements were taken at random in the interior of the two middle rows of each plot between 9:00 and 12:00 CST and the mean LAI determined.

The four center rows or row pairs of each plot were machine harvested when random pre-harvest samples indicated the grain to be near 15.5% moisture. The harvested grain was weighed and a sample taken for determining moisture, grain test weight, and 100-kernel weight. All plot weights were adjusted to 15.5% moisture on a dry weight basis. Final stand counts and relative lodging per plot were estimated by counting the two rows adjacent to the four harvested rows for yield immediately upon completion of harvesting. Sub-samples of the grain collected at harvest were later dried at 160°F for 24 h, ground, and analyzed for mycotoxin contamination using procedures previously described by Abbas et al. (1). Data were analyzed using PROC MIXED (SAS Institute Inc., Cary, NC). Year was considered a fixed effect. Means separation was performed calculating Fisher's protected LSD (0.05).

Summary of Weather Conditions for the Experiment

One irrigation was applied to the experiment on 11 June 2007. Though some water stress may have been experienced by the plants in the early part of that growing season, beginning 19 June 2007, and continuing for the remainder of the summer sufficient rainfall occurred to negate the need for further irrigations (Table 1). Maximum temperatures during the 2007 growing season equaled or exceeded 90°F a total of 45 days with no maximums at or above 100°F until August (*data not shown*), well after the plants acquired physiological maturity (growth stage R6).

By contrast, the first two months of the 2008 growing season were above average in rainfall while June was very deficient (Table 1). Irrigation equipment did not become available for use on the experiment until 1 July 2008 and the plants likely suffered some drought stress prior to this time. Temperatures in 2008 were similar to 2007 during most of the season until July. July 2007 had 18 days of temperatures above 90°F and none above 100°F. July 2008 on the other hand had 31 days of temperatures above 90°F with four of those days above 100°F.

Table 1. Days per month with temperatures ≥ 90°F and 100°F, rainfall totals, irrigations, and total water received on corn planted in single- or twin-rows, at different mean stands (25,700, 30,700, 35,000, 39,200 plants/acre) and N fertility rates (180, 220, and 260 lbs N/acre) for 2 years at Stoneville, MS (13).

Year	**Month**	**Days ≥ 90°F**	**Days ≥ 100°F**	**Rainfall** (inches)[x]	**Irrigation** (inches)[y]	**Total water** (inches)
2007	April	0	0	3.4 (-2.0)	0	3.4
	May	4	0	1.3 (-3.7)	0	1.3
	June	23	0	3.9 (-0.1)	1	4.9
	July	18	0	7.7 (+4.3)	0	7.7
2008	April	0	0	8.0 (+2.6)	0	8.0
	May	4	0	6.9 (+2.0)	0	6.9
	June	25	0	0.4 (-3.6)	0	0.4
	July	31	4	1.6 (-1.8)	2	3.6

[x] Values in ( ) represent the departure from the monthly average.

[y] Irrigation dates 14 June 2007, 1 July 2008, and 30 July 2008.

Few Differences Found Among Single-row and Twin-row Corn

Numbers of established plants were greater in the four seeding rates in 2007 than in 2008 in both single- and twin-row plantings (Table 2). At planting, seeding rates were increased approximately 15% above the desired plant population to compensate for potential stand losses during the growing season. A greater seedling survival rate in 2007 is likely responsible for most of the higher final plant populations observed that year. No heavy rainfall occurred in 2007 until 20 day after planting (13). In 2008 within 24 h after planting, 6 days of rain totaling 5.7 inches occurred which may have facilitated damping-off of some seedlings and reduced final stands below levels observed in 2007. However, the desired final plant populations were achieved in 2008.

With exception of the 34,500 and 40,250 kernels/acre seeding rates in 2008, twin-row plantings had more plants per acre than single-row configurations (Table 2). Bruns (5,6) reported similar findings in furrow irrigated soybean grown in the Mid South using the same model of twin-row planter. Further study would be needed to determine if these differences are due to possible differences in seed damage during planting between the single-row vs. twin-row planters, possible differences in intra-row competition between the two row configurations, slight differences in seeding rates between the two planters, or a combination of any of these factors. The planters used in this experiment were not the same two implements used in studies reported by Bruns (5,6).

Table 2. Final plant populations of a comparison of irrigated single- vs. twin-row planted corn at different seeding rates and N fertility rates at Stoneville, MS, in 2007 and 2008.[x]

Seeding rate (kernels/acre)	**Plant population** (plants/acre)				
	2007		**2008**		**Mean stand**[y]
	Single-row	**Twin-row**	**Single-row**	**Twin-row**	
28,750	26,220	27,300	24,200	25,020	25,700
34,500	31,230	33,380	29,680	28,560	30,700
40,250	35,670	36,870	33,900	33,600	35,000
46,000	38,850	41,960	37,500	38,400	39,200

[x] Means of 4 reps and three N fertility rates (180, 220, and 260 lbs N/acre). To compare means within a column or a row LSD @ $P \leq 0.05$ = 500.

[y] Means across both row configurations and years.

Twin-row plantings had a greater ($P \leq 0.05$) average LAI (6.3) at anthesis than single-row plantings (6.1). Nitrogen fertilizer rate though had no significant effect on LAI either year. Average LAI across N fertilizer rates was 6.2. Increased average stands did tend to increase LAI in 2007 but a significant ($P \leq 0.05$) increase was only noted between the 25,700 plants/acre average stand and all other average stands in 2008 (Table 3). Values for LAI of comparable average stands were significantly ($P \leq 0.05$) greater for 2007 than 2008. This difference is likely due in part to a greater number of established plants per acre in all seeding rates in 2007 as previously noted.

Table 3. Leaf area index (LAI) of irrigated corn at anthesis grown at different seeding rates in Stoneville, MS, in 2007 and 2008.[x]

Mean stand (plants/acre)	**LAI**	
	2007	**2008**
25,700	5.8	5.1
30,700	6.7	5.6
35,000	7.1	5.7
39,200	7.5	6.0

[x] Means for 4 reps, single- and twin-row planting schemes, and three N fertility rates (180, 220, and 260 lbs N/acre). To compare means within a row or a column LSD @ $P \leq 0.05 = 0.5$.

Overall grain yields were greater in 2007 than 2008 in comparable average stands and row configurations (Table 4). With the exception of average stands of 30,700 and 35,000 plants/acre in 2007, no differences in grain yield were observed between single-row and twin-row plantings. Twin-row plantings at those average stands in 2007 did have significantly ($P \leq 0.05$) greater yields than comparable single-row plantings. Separate analysis of yield data for individual N fertilizer rates in 2007 showed these differences to only be statistically significant ($P \leq 0.05$) at the 180 lbs N/acre rate (224 bu/acre vs. 231 bu/acre and 221 bu/acre vs. 248 bu/acre for single vs. twin rows at 30,700 and 35,000 plants/acre respectively) and not at the higher N fertilizer rates. No consistent yield increases or decreases between average stands were observed for any particular row configuration either year.

Table 4. Yields from a comparison of irrigated single- vs. twin-row corn at different seeding rates and N fertility rates at Stoneville, MS, in 2007 thru 2008.[x]

Mean stand (plants/acre)	**Yield** (bu/acre)			
	2007		**2008**	
	Single-row	**Twin-row**	**Single-row**	**Twin-row**
25,700	230	222	168	172
30,700	224	238	182	179
35,000	227	244	175	184
39,200	225	222	184	187

[x] Means of 4 reps and three N fertility rates (180, 220, and 260 lbs N/acre). To compare means within a column or a row LSD @ $P \leq 0.05 = 12$.

Varying rates of N fertilizer were not observed to affect yield ($P > F = 0.30$) (202, 205, and 205 bu/acre for 180, 220, and 260 lbs N/acre respectively). Neither were statistically significant interactions, as they related to yield, of N fertilizer rates with year ($P > F = 0.33$), row type ($P > F = 0.30$), seeding rate ($P > F = 0.38$) nor any significant three way or the four way interaction observed. The lack of statistical significance among these data demonstrate that

N fertilizer rates above 180 lbs/acre will likely not produce the maximum economic yield and that row configuration will not be a factor in N fertilizer management, regardless of planting density.

Data on grain test weights had statistically significant ($P \leq 0.05$) interactions between the variables of N fertilizer rates × year and row type × year. However, from a practical stand point these interactions were inconsequential as the range of values in the N fertilizer × year interaction was 56.9 to 57.6 lbs/bu and for the row type × year interaction between 56.1 to 58.1 lb/bu. All of these test weights are well within the limits required for the corn to grade No. 2 Yellow, the most common grade traded in the market which has a minimum test weight requirement of 54 lb/bu.

Row configuration and N fertilizer rates had no impact on 100-kernel weights. In 2007 100-kernel weights steadily declined with increases in average stands to 35,000 plants/acre with no difference being observed between 35,000 and 39,200 plants/acre (Table 5). In 2008 the 30,700 plants/acre average stand had 100-kernel weights significantly greater ($P \leq 0.05$) than the 35,000 and 39,200 plants/acre average stand with no other significant differences being noted. Data on 100-kernel weights shows kernels produced in 2007 were significantly heavier than comparable average stands in 2008. This would have contributed to the overall greater yields observed in 2007 compared to 2008 as previously noted (Table 4).

Table 5. 100 Kernel weight of irrigated corn grown at different seeding rates in 2007 and 2008 at Stoneville, MS.[x]

Mean stand (plants/acre)	**100 kernel wt.** (oz)	
	2007	**2008**
25,700	1.37	1.08
30,700	1.28	1.11
35,000	1.20	1.05
39,200	1.20	1.05

[x] Means for 4 reps, single- and twin-row planting schemes, and three N fertility rates (180, 220, and 260 lbs N/acre). To compare means within a row or a column LSD @ $P \leq 0.05 = 0.04$

Significant lodging (combined root and stalk) occurred in 2007 (Table 6). According to official weather records (16) two thunderstorms occurred in the area at 2:05 CDT and 11:53 CDT on13 July 2007 producing northerly winds of 28 and 36 mph, respectively, which resulted in the observed lodging. Lodging in 2007 was greater than all other populations in mean stands of 39,200 plants/acre within a row configuration (Table 6). Lodging was significantly less (1.6%) in 2007 in the single-row plots of 25,700 plants/acre than all other populations of that row configuration. Average stands of 30,700 and 35,000 plants/acre of the single-row configuration that year did not differ from each other in relative lodging. In the twin-row plantings no differences in relative lodging were observed between any of the stands below 39,200 plants/acre. Lodging was not a problem in 2008 (Table 6). The lodging in 2007 occurred late in the season when the plants were at or near physiological maturity (growth stage R6) and likely had little or no impact on kernel development. Also, considerable care was exercised in harvesting that probably minimized grain losses as reflected by the yields obtained in that year (Table 5).

Table 6. Percent lodging of irrigated corn planted in single or twin rows at different seeding rates and N fertility rates at Stoneville, MS, in 2007 and 2008.[x]

Mean stand (plants/acre)	**% lodging**			
	2007[y]		**2008**[z]	
	Single-row	**Twin-row**	**Single-row**	**Twin-row**
25,700	1.6	9.6	<1.0	<1.0
30,700	32.9	6.3	<1.0	<1.0
35,000	22.5	17.5	2.1	2.3
39,200	59.6	40.2	<1.0	3

[x] Means of 4 reps and three N fertility rates (180, 220, and 260 lbs N/acre).

[y] For comparing means within a column or a row LSD @ $P \leq 0.05$ = 15.0.

[z] Means are not significantly different.

Aflatoxin and fumonisin were unaffected by any of the variables in the experiment except year. Both of these mycotoxins were greater in 2008 than 2007. Aflatoxin levels were 0.4 and 901.8 ppb in 2007 and 2008, respectively. Fumonisin contamination was 0.6 and 8.6 ppm in 2007 and 2008, respectively. The levels of both aflatoxin and fumonisin found in 2007 are well below the action levels of 20 ppb and 5.0 ppm for the two mycotoxins, respectively, but not so in 2008 (9). Grain contamination by both of these mycotoxins are known to increase during growing seasons marked by excessive heat stress and aflatoxin particularly by both heat and drought stress during the later reproductive growth stages (4). Such stresses were likely present during 2008 as is indicated by temperature and rainfall data presented in Table 1.

Based on these data, twin-row corn production will not necessarily result in greater grain yields compared to single-row plantings at similar populations but, neither is there any indication of a reduction in yield with the twin-row configuration. These findings are similar to those reported by Kratochvil and Taylor (12) and Nelson and Smoot (15). Neither configuration appears to have an advantage in N utilization, LAI, or mycotoxin contamination. Data from this experiment suggest that N fertilizer rates above 180 lbs N/acre, regardless of row configuration or stand density, do not increase grain yields and would unnecessarily increase production costs and reduce economic yield.

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