Row-Spacing Effects on Corn in the Southeastern U.S.

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Abstract. Optimum row spacing for corn (*Zea mays* L.) is a controversial question throughout most of the U.S. This review summarizes a row-spacing survey that was mailed to commodity specialists throughout the southeast. The responses from seven southeastern states showed that narrow row spacing increased corn yield by 5–10%. It was not determined whether these yield increases are sufficient to warrant equipment changes necessary for reducing row spacing.

An alternative twin-row planting configuration that can increase yields by improving intrarow plant spacing without requiring major equipment changes is also evaluated and discussed. Nine hybrids, adapted for production between 25 and 45° N latitude, were planted in twin rows spaced 19-57-19 cm (7-23-7 in.) apart and in single rows spaced 76 cm (30 in.) apart. Plant density averaged 8.6 plants m^{-2} (34,830 plants/A) for all hybrids in an irrigated study conducted on Norfolk (fine-loamy, siliceous, thermic Typic Paleudult) loamy sand. Stem diameter and weight, and leaf area and weight at growth stage R4 (dough), were significantly greater (P = 0.10) for plants in twin rows than for those in single rows. The average grain yield was also significantly greater for the twin-row configuration. This research demonstrated that twin-row planting may offer a more practical alternative to narrow rows, because, with the exception of planter units, conventional wide-row equipment can be used.

Introduction

Profitable crop production systems must integrate all manageable components and optimize the use of natural resources. The amount of incident solar radiation (light) is a resource that cannot be changed, but its interception and utilization can be manipulated by changing row spacing or orientation [4, 5, 7, 22]. In soybean (*Glycine max* (L.) Merr.), row configuration has been shown to influence light quality and photosynthate partitioning [13], and for wheat (*Triticum aestivum* L.), row spacing has been shown to influence tiller formation and photosynthate partitioning [14].

Changing row spacing for corn or other crops is a controversial question, especially in the southeastern U.S. This controversy is not new or unique [5], but row spacing and plant population are the primary agronomic factors enabling growers to manipulate light interception, soil shading, and nutrient exploration through plant distribution. However, isolating the yield response to row spacing from the interacting effects of plant population, cultivar, and planting date is difficult.

Equidistant spacing of corn (*Zea mays* L.) is theoretically optimum [1] but is generally difficult to mechanically achieve and impractical to manage because of subsequent cultivation, fertilization, and harvest procedures. Broadcast seeding for corn was not successful in the U.S. Corn Belt [16], but an alternative row configuration that has increased grain and silage yield is a twin-row planting pattern [9, 10]. This system increases yield, because in theory the twin-row configuration, at comparable populations, decreases intrarow plant competition for water, nutrients, and light. Twin rows can accommodate in-row subsoiling where soil compaction problems occur because of traffic pans or genetic horizons. Twin rows can be fertilized and harvested using conventional equipment and therefore provide the advantages of narrow rows without requiring major equipment changes.

The purpose of this review is to summarize a row-spacing survey mailed to commodity specialists throughout the southeast and to present more comprehensive twin-row research results for

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Table 1. Row-spacing effects on corn yield in Virginia (Mg ha^{-1})[a]

Location	Year	Row spacing (cm)[b] 40	60	80	100
		Yield Mg ha^{-1}			
Blacksburg	1966	7.3a*	7.4a	7.3a	7.0a
Blacksburg	1967	6.0a	5.7a	5.6a	5.0b
Blacksburg	1968	7.2a	7.1a	6.8a	6.2b
Orange	1966	8.0b	7.6bc	8.7a	7.5c
Orange	1967	9.7a	9.2ab	9.2ab	8.8b
Orange	1968	9.3a	9.2a	9.1a	8.6b
Warsaw	1966	6.8a	6.8a	6.8a	7.0a
Warsaw	1967	9.1a	8.9a	8.4b	8.2b
Warsaw	1968	8.1a	8.0ab	7.8c	7.9bc
Average		8.0	7.8	7.7	7.3

Data from Lutz et al. [15].
* Means within a row followed by the same letter are not significantly different at P 0.05.
[a] Mg ha^{-1} × 890 = lb A^{-1}.
[b] cm × 0.4 = in.

Table 2. Row-spacing effects on corn yield in Tennessee (Mg ha^{-1})

Row width (cm)	4 year—4 location (2.2–4.4 plants m^{-2})[a]	3 year—3 location (4.4–6.4 plants m^{-2})	Mean
107	6.9	9.3	8.1
91	7.2	9.7	8.5
75	7.3	9.7	8.5
60	7.4	9.9	8.6
46	7.8	9.7	8.8

Data provided in personal communication by Joe Burns, University of Tennessee, Knoxville.
[a] Plants/m^2 × 4050 = plants/A.

nine commercial hybrids. This research expanded on previous studies [9, 10] by evaluating light interception, growth, development, and yield components.

Materials and Methods

A survey was mailed to commodity specialists throughout the southeast requesting comments and comparison data for current corn row spacing recommendations. Responses were received from Arkansas, Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. They are summarized in Tables 1–6.

Twin-row research was conducted near Florence, South Carolina, using nine corn hybrids ranging in maturity from 1,110 to 1,530 growing degree units (GDU). These hybrids are adapted for production between 25 and 45° N latitude and were selected to provide a broader genetic base than was used in previous studies [9, 10]. Initial soil pH (1:1, soil:water) averaged 6.3. Mehlich I [20]

Table 3. Row-spacing effects on corn yield in North Carolina (Mg ha^{-1})

Location	Year	Row spacing (cm) 53	106	LSD (0.05)
Plymouth	1965	7.7	7.8	NS
	1966	6.5	6.4	NS
Clayton	1965	8.9	8.7	NS
	1966	6.4	5.5	0.8
Mean		7.3	7.1	—

Data from Kamprath et al. [8].

Table 4. Corn yield as affected by plant population and row spacing when averaged for three growing seasons in Mississippi (Mg ha^{-1})

Population (plants m^{-2})	Row spacing (cm) 50	75	100
3.0	4.6	4.6	4.3
3.9	4.8	4.5	4.5
4.9	5.0	4.9	4.7
5.9	4.6	4.7	4.4
6.9	4.8	4.6	4.2
Mean	4.7	4.7	4.4

Data from Gill [6].

Table 5. Hybrid and row-spacing effects on irrigated corn in Alabama (Mg ha^{-1})

Hybrid	Year	Row spacing (cm) 46	68
Funks RA	1982	11.6	10.7
	1983	12.9	12.2
	1984	13.4	14.0
Funks RA	1982	11.3	10.0
	1983	12.9	12.9
	1984	11.9	14.6

Data provided in personal communication from Joe Touchton, Auburn University, Auburn, AL.

extractable P, K, Ca, Mg, Mn, and Zn averaged 75, 66, 305, 86, 16, and 1.6 mg kg^{-1} (67, 59, 272, 77, 14, and 1.4 lb/A), respectively. Soybean stubble and winter weeds were disked prior to broadcasting 56 kg ha^{-1} K (50 lb/A) and incorporating 3.4 kg ai ha^{-1} (3.0 lb ai/A) of butylate (S-ethyldiisobutylthiocarbamate) and 2.0 kg ai ha^{-1} (1.8 lb ai/A) of atrazine (2-chloro-4-ethylamino-6-isopropylamino-1,3,5-triazine).

Single- and twin-row configurations were planted on April 16, 1984, on Norfolk (fine, loamy, siliceous, thermic Typic Paleudult) loamy sand near Florence, South Carolina. Individual six-row plots were 4.6 m (15 ft) wide by 12.2 m (40 ft) long or 56 m^2 (600 ft^2) in area. The twin-row

Table 6. Summary of row-spacing effects on corn

State	Narrow vs. wide (cm)		Percent increase for narrow rows
Alabama	46	68	
Arkansas	75	96	10–15
Mississippi	75	100	6
Mississippi	50	100	7
North Carolina	63	106	4
North Carolina	75	100	5–10
South Carolina	75	96	5
South Carolina	96-twin	96	10
Tennessee	91	107	5
Virginia	80	100	5
Virginia	40	100	8
Virginia	38	76	4

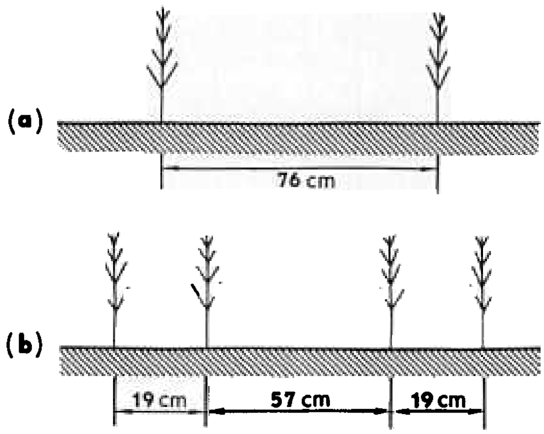

Fig. 1. Single- (a) and twin-row (b) planting configurations evaluated for improved maize production on a Typic Paleudult in the U.S. Southeastern Coastal Plains.

configuration was achieved using an experimental precision planter that alternately dropped seed in rows spaced 19 cm (7 in.) apart. This created row pairs that had the same plant density as single rows, but plants were distributed in a triangular pattern. Single-row configurations were achieved using John Deere Flex 71 planters. Center-to-center spacing was 76 cm (30 in.) for both systems, so rows were either 76 or 19-57-19 cm (7-23-7 in.) apart (Fig. 1). A 50 mm- (2-in.) wide subsoil shank, angled forward nonparabolically with a 125 mm- (4.9 in.) wide shoe, was centered between the twin rows or directly beneath the single rows. The shank penetrated to a depth of approximately 46 cm (18 in.) and thus disrupted a 20 cm- (8 in.) thick, root-restrictive E horizon [3]. Liquid fertilizer supplying 80, 35, and 1 kg ha^{-1} (71, 31, and 1 lb/A) of N, P, and B, respectively, was applied at planting in a zone approximately 5–15 cm (2–6 in.) deep behind each subsoil shank.

All hybrids were thinned to a population of 8.6 plants m^{-2} (34,830 plants/A) about 2 weeks after emergence. Supplemental irrigation water was applied when average soil-water tension at 20 cm (8 in.) exceeded 20 kPa (20 centibars). Seven applications of irrigation water totaling 172 mm (6.75 in.) were applied in addition to the 564 mm (22.2 in.) of rainfall received between April 15 and August 15, 1984. All plots were side-dressed with an additional 220 kg ha^{-1} (200 lb/A) N and 15 kg ha^{-1} (13 lb/A) S in split applications 4–6 weeks after emergence.

The effects of row configuration on light interception and quality within the canopies of four hybrids were determined by measuring spectral distributions at 5 nm intervals between 350 and 850 nm. Data were collected for DeKalb-Pfizer Genetics XL-8, DeKalb-Pfizer Genetics T1100, Pioneer Brand 3382, and Coker 21 hybrids at 1200 and 1800 h EDT on June 15. Weather conditions were clear and bright with 26.7 MJ m^{-2} (640 Ly) of total incoming solar radiation on that da. Measurements were made within the row, between the rows or row pairs, and between the individual rows forming each row pair in the twin-row configuration. Data were collected at the soil surface, 1.5 m (5 ft) above the soil (ear height), and above the canopy using a 1 cm- (0.4 in.) diameter collector connected by a fiber optic probe to a LiCor model 1800 Spectoradiometer. Measurements were made in two of four field replicates for each treatment both times.

Relative amounts of photosynthetically active radiation (400–700 nm) intercepted by the canopies were calculated as a percentage of the radiation in direct sunlight above the canopy. Spectral irradiances from 730 to 740 nm and from 640 to 650 nm were used to calculate far-red:red ratios, because these correspond to phytochrome action peaks in green plants [12].

Growth and development parameters measured to evaluate effects of row configuration included days to mid-silk, plant height, maximum stem diameter, stem weight, leaf area, leaf weight, ears plant^{-1}, and kernel weight. Plant height and stem and leaf parameters were measured at growth stage R4 [19] for all hybrids. Four replicates of six plants were collected from each row configuration. Plants were severed at the soil surface and divided into stems, leaves, and ear shoots (including shank and husks). Maximum stem diameter was measured with calipers and leaf area with a LiCor model 3200 area meter. Individual plant parts were dried at 65°C (117°F) for dry-matter determinations. Grain yield was measured by hand-harvesting four 5.3 m (17.4 ft) rows from the center of each 56 m^2 (600 ft^2) plot. Yield components were measured on 10 ears selected at random from each plot, near the area harvested for grain yield. Grain moisture was measured with a Steinlite model SS250 meter so that grain yield could be adjusted to a constant water content of 155 g kg^{-1} (15.5%).

The experimental design was a split plot with hybrid whole plots and row configuration as the split. Four replicates of each hybrid were arranged in randomized complete blocks. Analysis of variance (ANOVA), coefficients of variation (CV), and least significant differences (LSD) were calculated using procedures outlined by Steel and Torrie (21).

Results and Discussion

Survey Response

Survey data supportive of the trend toward narrow rows for corn are presented in Tables 1–6. Statistical significance is shown where provided by respondents. The most consistent response was that row-spacing effects could not be easily separated from the interaction effects of hybrid and plant population.

In Arkansas, yield increases were generally in the range of 10–15% (Don Adams, personal communication) when row width was reduced from 96 to 75 cm (38 to 30 in.). They have found that northern-type, single-ear hybrids responded to narrow rows better than southern prolific hybrids. If this hybrid difference can be substantiated, row-spacing data collected prior to the early 1970s, when southern prolifics predominated in this region, must be viewed accordingly. Likewise, data for current full-season (>1,625 GDU using a 10–30 C index) hybrids may show less response to narrow rows because of the large southern profile germplasm base in this group.

Average corn yields in the Tidewater area of North Carolina increased 5% to 10% [8] when row spacing was decreased from 100 to 75 cm (40 to 30 in.). However, in addition to a hybrid by row-spacing interaction, they also reported a row spacing by plant population interaction. Yields with "full-season" corn were highest in 100 cm (40 in.) rows at a population of 5.2 plants m^{-2} (21,000/A), but in 75 cm (30 in.) rows yields were highest with 6.0 plants m^{-2} (24,500/A). With short-season corn, 6.0 plants m^{-2} produced the highest yields in 100 cm rows, but in 75 cm rows, yields were highest with 6.9 plants m^{-2} (28,000/A).

These data fit well with the concept of optimal ear size [1]. In theory, plant population is optimum if the average ear weight at a moisture content of 155 g kg^{-1} (15.5%) is 227 g (0.5 lb). If the ear weight is greater than 227 g, the population is too thin, but if it is less, the population is too thick. Assuming that a population of 4.9 plants m^{-2} (20,000/A) in 96-cm (38 in.) rows achieves the 227 g average ear, plants would be spaced 20 cm (8 in.) apart. If row spacings were reduced to 75 cm (30 in.), the average distance between plants would increase to 25 cm (10 in.), and the average ear weight should be greater than 227 g. The additive increase in ear weights is then the increase in total yield because of narrower rows. To increase yield even further, however, it is necessary to seek the optimum ear size by decreasing intrarow spacing. This might occur in this example at a spacing of 22.5 cm (9 in.) or a population of 5.7 plants m^{-2} (23,000/A). The additional, optimum 227 g ears could theoretically increase the total grain yield by approximately 1.2 Mg ha^{-1} (20 bu/A).

Hybrid, row spacing, and plant population interactions were also reported in Virginia [15]. They found in a 3-year study that corn yields were usually higher when late-maturing hybrids were planted at medium or high populations and that yields increased as the row width decreased. Their supportive data (Table 1), which summarized 9 site years of research, showed an overall mean yield increase of 5% for 78 cm (31 in.) rows compared to 99 cm (39 in.) rows. There was an additional 3% increase when row spacing was decreased from 78 to 41 cm (31 to 16 in.).

Data from Tennessee (Table 2) show an approximate 5% increase in yields when row widths were decreased from 107 to 91 cm (42 to 36 in.). Other row-spacing treatments did not affect yields except for 46 cm (18 in.) rows at a population of 2.2–4.4 plants m^{-2} (9,000–18,000/A), which gave an 8% yield increase over the mean of other treatments.

In North Carolina, Nunez and Kamprath [17] reported no significant differences between two row spacings except at Clayton in 1966, where yields in 53 cm (21 in.) rows were significantly greater than with 106 cm (42 in.) row spacing (Table 3). They concluded that the higher yield with narrower rows was probably due to a more efficient utilization of soil moisture during a particularly dry growing season. The overall mean yield difference due to row spacing in their study was 3.5%.

Data from Mississippi [6] did not show a row spacing by population interaction. However, narrow row spacings produced 6.5% higher yields when compared to conventional 100 cm (40 in.) rows (Table 4).

Survey responses also included results from row-spacing evaluations in some recent "high-yield" irrigated studies conducted in Virginia and Alabama. Virginia data (Preston Reid, personal communication) showed a significant yield increase (13.43 vs. 12.1 Mg ha^{-1} or 214 vs. 193 bu/A) when row spacing was decreased from 76 to 38 cm (30 to 15 in.) in 1982, but no significant difference (13.5 vs. 13.8 Mg ha^{-1}, or 215 vs. 219 vs. 219 bu/A) in 1983. In Alabama (Table 5), Funks RA 1502 yielded 8.8% more in 1982 and 5.7% more in 1983 in narrow (46 cm, or 18 in.) rows than in wide (68 cm, or 27 in.) rows. Alabama data for Funks RA 1604, a mid-season hybrid, showed a 13.2% yield increase for narrow rows in 1982 but no difference in 1983. Both hybrids yielded more in 1984 when planted in wide (68-cm) rows, but this was probably the result of poor plant distribution in the narrow (46-cm) rows. Also, narrow rows in this study were not subsoiled. This probably contributed to decreased yields, because even with irrigation, Camp et al. [2] have shown a yield advantage to subsoiling in the Coastal Plains.

Data from a high-yield study in South Carolina [10], in which spacings of 75 or 96 cm (30 or 38 in.) in single rows were compared with a twin-row system under center pivot irrigation, were also included in the survey response. The twin rows were planted with John Deere Flex-71 units which were spaced 30–35 cm apart and centered on both sides of in-row subsoil shanks that were spaced 96 cm apart. The 2-year average yields (12.0, 11.5, and 12.3, Mg ha^{-1}, or 194, 188, and 196 bu/A) were significantly different (10% level) for the 75 cm, 96 cm, and twin-row configurations. In another intensive management study [9], single rows spaced 96 cm apart were compared with a similar twin-row configuration, but water treatments were applied using a trickle irrigation tubing and the site was subsoiled prior to planting. Those results showed that with irrigation, twin rows yielded 12%, 8%, and 10% more than single rows in 1980, 1981, and 1982, respectively.

Survey responses are summarized in Table 6 as a percentage increase in yield attributed to "narrow" rows. Variation is quite large, and drawing conclusions from survey responses can be biased by the limited scope of the information received. However, reducing row width can generally increase corn production in the Southeast. The average yield increase appears to be approximately 5–10%. The primary question is whether that is sufficient to warrant the equipment changes necessary for the switch. Although that question can only be answered by individual producers or researchers, implementing a twin-row system may be a feasible alternative, since only the planter system would have to be changed. The center pivot twin-row experiments in South Carolina [10] showed that this system could be cultivated and side-dressed without changing tractor wheel-spacing and harvested without changing combine headers.

Twin-Row Research Results

Twin-row research was expanded in 1984 to evaluate more hybrids than in the initial studies [9, 10] and also to compare light interception and spectral quality within the canopy as influenced by row configuration. The nine hybrids selected for this study (Table 7) were chosen to provide a broad range in maturity (1,110–1,530 GDU) and to provide various leaf angles. Variation in hybrid maturity caused significant differences in growth, development, yield, and yield components, as expected, but for comparative purposes, those data are presented in Tables 8 and 9.

Table 7. Characteristics of selected corn hybrids used for light interception and row configuration evaluations

Hybrid	No.	Leaf angle	GDU[a] requirement
DeKalb-Pfizer XL8		Normal	1,110
Pioneer 3950	2	Normal	1,350
DeKalb-Pfizer XL25A	3	Normal	1,306
Pioneer 3707	4	Normal	1,389
Agra Tech GK615	5	Semi-upright	1,361
Asgrow RX511	6	Semi-upright	1,322
DeKalb-Pfizer T1100	7	Normal	1,444
Pioneer 3382	8	Upright	1,522
Coker 21	9	Normal	1,530

[a] GDU = growing degree units = $\Sigma\{[T'_{min} + T'_{max})/2] - 10C\}$ where T'_{min} is the minimum daily temperature or 10°C, whichever is larger, and T'_{max} is the maximum daily temperature or 30°C, whichever is smaller.

Spectral measurements were made within canopies of four hybrids considered to be representative of the early-, middle-, and late-maturing hybrids being evaluated. The Coker 21 and Pioneer 3382 hybrids were chosen to represent normal and upright leaf angles in plants of similar maturity. Each hybrid had approximately 15 leaves when measurements were made, but because of maturity differences, plants were in growth stages R1 (silking), VT (~2 days presilk), V15 (~12 days presilk), and V15 [19] for XL-8, T1100, P3382, and C21, respectively. Data in Table 10 show that 94% or more of the photosynthetically active radiation (PAR) was intercepted above the primary ear (1.5 m, or 5 ft, measurement) and that more than 98% of PAR was intercepted before reaching the soil surface. Those observations were consistent for both row configurations, for all sampling positions, for both sampling times, and for hybrids in late-vegetative or early-reproductive growth stages.

The far-red:red light ratios confirm that a high percentage of PAR was intercepted by the canopies, because those values are 5–20 times higher than the 0.81 ratio measured above the canopy (Table 10). They also support other research [5] stating that increasing LAI beyond 4.0 does very little for improving light interception by a corn canopy.

High far-red:red light ratios measured in this ex-

Table 8. Hybrid growth and development characteristics at growth stage R4 (dough)

Hybrid no.	Days to midsilk	Plant height (m)	Stem		Ear shoot dry weight (g)	Leaf		LAI
			Diameter (mm)	Dry weight (g)		Area (cm^2)	Dry weight (g)	
1	62.1	2.6	22.3[a]	430	228	4,938	173	4.2
2	60.8	2.4	21.6	400	253	4,100	143	3.6
3	65.4	2.8	23.8	460	188	5,328	184	4.9
4	65.0	3.0	22.6	700	548	5,378	186	4.8
5	64.9	2.8	23.8	465	486	6,167	226	5.0
6	67.0	2.8	22.8	540	502	5,883	210	5.1
7	67.8	3.0	24.6	785	680	6,700	245	5.7
8	68.6	3.1	25.5	880	656	5,929	216	5.2
9	71.1	3.4	26.2	1,245	857	7,074	274	6.2
LSD (0.05)	1.1	0.1	1.6	150	86	266	31	0.4
CV (%)	1.7	3.6	6.7	23	17	4.5	14	7.4

[a] Diameter measured just above node 1.

Table 9. Yield and yield components for corn hybrids averaged across single- and twin-row planting configurations

Hybrid no.	Harvest population (ears m^{-2})	Grain yield (Mg ha^{-1})	Rows per ear	Kernels per row	Kernel weight (g 100^{-1})
1	8.4	10.0[a]	15.4	34	25.3
2	8.8	10.0	16.0	34	23.9
3	9.1	11.1	13.7	38	26.9
4	8.8	11.1	13.2	38	26.9
5	8.1	12.0	14.2	35	31.0
6	8.5	9.8	14.6	42	22.6
7	8.2	12.8	16.7	37	27.3
8	8.6	12.8	14.8	40	25.5
9	8.2	10.6	17.6	40	26.1
LSD (0.05)	0.4	0.7	0.5	3	1.7
CV (%)	4.6	6.4	3.5	7	6.3

[a] Adjusted to a water content of 155 g kg^{-1} (15.5%).

periment also offer a possible explanation for the excessive plant height observed in previous experiments [9, 10] when P3382 populations were greater than 7.1 plants m^{-2} (28,750 plants/A). High far-red:red light ratios apparently signal to the plant through its phytochrome system that competition is high and therefore photosynthate is partitioned for stem elongation. On soils with low water-holding capacities, this could be extremely important, because in soybean [13] this increased stem growth occurred at the expense of root development. Similar response to crowding has also been observed for wheat [14] and tobacco (*Nicotiana tabacum* L.) [11].

Effects of precision twin-row and single-row planting configurations on selected growth and development parameters were averaged for the nine hybrids and are presented in Table 11. Stem diameter and weight, and leaf area and weight were significantly greater for twin-row plants than for those planted in single rows. Those vegetative growth advantages resulted in significantly greater grain yields for the twin-row configuration when averaged for the nine hybrids (Table 12).

The hybrid by row configuration interaction (Table 13) was significant (5% level) for grain yield but not for any of the yield components. The early-maturing hybrids (GDU requirement <1,400) showed the largest yield increase when planted in twin rows. This response was similar to that reported in the survey for narrow-row corn in Arkansas and presumably reflects differences in germ plasm. Among the more southern hybrids (Nos. 7–9), Pioneer brand 3382, which has an erect leaf

Table 10. Row configuration and corn hybrid effect on the interception of incident photosynthetically active radiation and the far-red:red ratio of light at and 1.5 m above the soil surface

Corn hybrid	Growth stage	Row config.	LAI[a]	% Interception[b] Surface	% Interception[b] 1.5 m	Far-red:red ratio[c] Surface	Far-red:red ratio[c] 1.5 m
XL-8	R1	Single	4.2	99.0	95.5	10.5	7.3
XL-8	R1	Twin	4.2	99.0	93.9	10.6	4.8
T1100	VT	Single	5.6	98.8	94.2	9.1	4.5
T1100	VT	Twin	5.6	99.2	95.2	12.8	5.0
P3382	V15	Single	5.4	98.4	93.8	8.5	4.4
P3382	V15	Twin	5.0	99.0	95.3	10.8	6.9
C21	V15	Single	6.0	99.5	98.4	18.0	11.9
C21	V15	Twin	6.4	99.3	97.2	13.3	6.4

[a] Leaf area index (LAI) measured at growth stage R4 (dough).
[b] Surface = soil surface; 1.5 m = 1.5 m above soil surface, which was approximately the height of the primary ear.
[c] These ratios can be compared to a value of 0.81 measured in direct sunlight above the canopy.

Table 11. Row configuration effect on selected growth and development parameters measured at growth stage R4 (dough) and averaged across nine commercial hybrids

Row config.	Days to midsilk	Plant height (m)	Stem Diam. (mm)	Stem Dry wt. (g)	Ear shoot dry wt. (g)	Leaf Area (cm^2)	Leaf Dry wt. (g)	LAI
Single	66.2	2.9	23.4	620	478	5,640	201	4.9
Twin	65.6	2.9	24.0	695	500	5,800	212	5.0
LSD (0.10)	0.3	NS	0.6	44	NS	110	7	NS
CV (%)	1.1	3.4	6.9	16.6	15.4	4.8	8.6	7.2

Table 12. Row configuration effect on yield and yield components averaged across nine commercial hybrids

Row config.	Harvest pop. (ears m^{-2})	Grain yield (Mg ha^{-1})	Rows per ear	Kernels per row	Kernel weight (g 100^{-1})
Single	8.6	11.0[a]	15.0	37	26.1
Twin	8.5	11.3	15.2	38	26.2
LSD (0.10)	NS	0.2	0.1	NS	NS
CV (%)	5.5	4.8	2.4	4.8	5.6

[a] Adjusted to a water content of 155 g kg^{-1} (15.5%).

angle and was used in our initial studies (9, 10), once again yielded more in twin rows than in single rows. Physiological reasons for this interaction are not known, but potential leaf number and thus total plant height are presumably involved.

Rhoads and Stanley [18] found that both tasseling and silking occurred earlier in nonstressed plants. When averaged for nine hybrids in this study, the average number of days from emergence to midsilk (Table 11) was less for twin rows than for single rows, even though the 50% seedling emergence date was April 26 for both row configurations. The average number of rows per ear (Table 12) was greater for twin-row plants than for single-row plants, indicating a more favorable early-season growth environment. These results suggest that precision twin-row planting improved plant distribution, decreased intrarow plant competition, and thus improved growth, development, and yield. These data support our previous research [9, 10] which concluded that twin-row planting can increase corn yields.

Table 13. Interaction effects of corn hybrid and row configuration on grain yield (Mg ha^{-1})

Hybrid no.	Single-row		Twin-row
	9.86		10.18
	9.88		10.10
	10.70		11.56
4	10.50		11.74
5	11.49		12.43
6	10.07		9.55
7	13.02		12.49
8	12.64		12.94
9	10.64		10.54
LSD (0.05)		0.77	
CV (%)		4.80	

Summary and Conclusions

The first objective of this review was to survey commodity specialists in the Southeastern U.S. to determine the general yield response by corn to changes in row spacing. The second objective was to expand on previous twin-row research by examining in situ light interception and applicability of the system for corn hybrids with varying maturity and morphological characteristics. The survey showed a general increase in yield of 5–10% when row spacing was decreased from the traditional wide row spacings. The amount of increase varied with hybrid, plant population, and growing season. The primary question appears to be whether that level of yield increase warrants the necessary equipment changes for reducing corn row width.

Twin-row research showed that with irrigation and a population density of 8.6 plants m^{-2}, more than 98% of incident, photosynthetically active radiation was intercepted regardless of row configuration. Far-red:red light ratios within the corn canopies were 5–20 times greater than above the canopy, offering a possible explanation for the increased plant height associated with high-density corn production.

Precision twin-row planting can increase grain yield, especially for early-maturing and erect leaf hybrids, presumably by improving plant distribution and decreasing intrarow plant competition during seedling growth, prior to canopy closure. The system accommodates subsoiling between the twin rows to alleviate root-restrictive layers caused by tillage, traffic, or soil morphology. Precision twin-row planting may be most beneficial on soils that characteristically have limited plant root development and low water retention, because it distributes plants more uniformly than traditional single-row configurations.

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