Soybean production in the 1960s and 1970s was conducted using row spacings of about 30 inches. Since 1990, the trend has been toward production in rows planted at spacings less than this. Research conducted in the upper Midwest and southern Canada documents a consistent yield advantage for soybean planted in narrow (approximately 15 inch) vs. wide (approximately 30 inch) rows, although instances occur when there is no yield response to narrow row spacing. The magnitude of the response depends on many variables such as location, year, cultivar, planting date, and tillage system. Average row spacing for soybean production in Iowa is slightly less than the “wide” designation for rows. Despite positive yield reports in soybean, lack of yield responses to narrow rows in corn and the potential for greater incidence and severity of Sclerotinia stem rot in narrow rows has limited widespread adoption.

An advantage of narrow row spacing is more equidistant plant spacing, which leads to increased canopy leaf area development and greater light interception earlier in the season. These changes in canopy formation increase crop growth rate, dry matter accumulation, and seed yield.

Abiotic and biotic stresses can mitigate the yield response of soybean to narrow row spacing. Moisture stress has been documented to reduce the yield benefit from narrow row spacing in some states. Nitrogen stress and increased seeding rates in dry, low-yield potential environments reduced yield in narrow rows. The presence of brown stem rot reduced the yield benefit from narrow row spacing and early planting for a susceptible cultivar in a study in Wisconsin. Some researchers speculated that the presence of soybean cyst nematode removed any benefit from planting soybean in narrow row spacings.

Increased seeding rates potentially could be used in a narrow row system to maximize space utilization. Prior research indicates that optimal seeding rates increase in a narrow row spacing system. A concern is that as seeding rate increases, plant competition increases, generating stress on the canopy and minimizing the benefit to narrow row spacing, especially when environmental conditions limit plant growth.

In a recent study published in Agronomy Journal, researchers hypothesized that narrow row spacing would produce greater yields than wide row spacing and that economic advantages exist for narrow row soybean production. The objectives of the research were (i) to determine seed yield response to changes in row spacing and seeding rates and (ii) to measure changes in costs and revenues associated with a change in row spacing using a split-row planter compared with a traditional planter.

Materials and methods

Studies were conducted at three locations during 2004 to 2006. Locations were in eastern Iowa near De Witt.
(Klinger silt loam, fine-silty, mixed mesic, Typic Hapludolls), central Iowa near Nevada (Canisteo clay loam, fine-loamy, mixed mesic, Typic Hapludolls), and western Iowa near Whiting (fine-silty, mixed mesic, Typic Hapludolls). The experiment was a randomized complete block in a split-plot arrangement with four replications. The main plot was 15- and 30-inch spacing, and the subplot was four seeding rates of soybean seed. Seed was inoculated with *Bradyrhizobium japonicum* (EMD Crop BioScience), and the plots were treated with glyphosate for weed control. Other pests, including soybean aphids, spider mites, and bean leaf beetles were controlled with Lorsban 4E (Dow AgroScience) and Baythroid (Bayer CropScience).

Yield was determined by harvesting the center four narrow rows and two wide rows with an Almaco plot combine, and harvested seed was adjusted to a stable moisture content. Other measurements taken at harvest were final plant population, plant height, and seed mass based on a sample of 300 seeds.

Partial-budget analysis compared three farm sizes and three corn and soybean rotations. Farm size ranged from the state average of 356 to 3,196 acres. Corn–soybean rotations were 50/50, 60/40, or 70/30. The standard practice of both corn and soybean planted in wide row spacing was compared with corn planted in wide row spacing and soybean planted in narrow row row spacing using a split-row planter. Corn was not considered in this analysis because expenses and revenues associated with corn production would not change. Soybean price was determined by harvesting the center four narrow rows and two wide rows with an Almaco plot combine, and harvested seed was adjusted to a stable moisture content. Other measurements taken at harvest were final plant population, plant height, and seed mass based on a sample of 300 seeds.

Results and discussion

Growing conditions, especially rainfall patterns, were variable among locations and years. Heavy single rainfall events in May at Nevada (2005), De Witt (2006), and Whiting (2006) caused soil erosion and crusting and contributed to lower-than-expected emergence. In 2004, rainfall at all locations except De Witt was above average in May, below average in June, and average in July. Rainfall at all locations was below average in August. In 2005, rainfall was below average all season long but was above average during June through August at other locations. In 2006, rainfall during May and June was 4.7 and 5.1 cm below normal at Nevada and Whiting, respectively. Plots were irrigated at Whiting each year.

Harvest plant population

Implementing harvest plant population as a covariate, a continuous variable rather than a discrete variable, allowed for comparisons among locations and row spacing to be made on an equal harvest plant population. Plant establishment rates for narrow and wide row spacing indicated that establishment was greater in narrow compared with wide rows. On average, 67 plants survived until harvest for every 100 seeds planted in narrow row spacing compared with a rate of 49 plants in wide row spacing. Increased intra-row competition in wide row spacing as seeding rates increase potentially explains that greater establishment rate in narrow row spacing. Improved plant establishment using narrow row spacing presents an opportunity for producers to minimize the risk of a poor stand at lower seeding rates. Differences in plant establishment between wide and narrow rows could potentially confound yield responses attributed to row spacing.

Seed yield

Locations varied in yield potential, and yields were significantly greater at both Whiting and De Witt com-
pared with Nevada. Whiting and De Witt were high-yield locations that produced yields considerably greater than the lower-yielding location of Nevada, mainly due to soil characteristics and high pathogen pressure from soybean cyst nematode, sudden death syndrome caused by *Fusarium virguliforme*, and seedling diseases. This range in environmental yield potential presented the opportunity to investigate the theory that high-yielding environments do not benefit as much from reduced row spacing.

There were no interactions between the main effects of location, row spacing, and the covariate variable, indicating that a similar response existed between yield and harvest plant population for both narrow and wide row spacing. Yields remained very stable even with large declines in harvest plant population. For all locations and row spacing combinations, more than 95% of the maximum yield was attained at harvest populations between 48,097 and 86,558 plants/ac depending on location and row spacing (Table 1). Seeding rates of 74,899 and 12,510 seeds/ac were sufficient to achieve this final population for either row spacing (Table 1). Seeding rates at 30 and 17% less than current seeding were used by producers in Iowa in narrow and wide row spacing, respectively.

**Seed mass**

An interaction was identified between location and row spacing. Increased seed mass without a concurrent increase in yield, as documented in this study, indicates the seed mass increase was compensated for by fewer seeds at higher seeding rates and would be consistent with the yield response to harvest plant population reported in this study.

**Plant height**

Plant height was approximately 6.8 and 3.6 inches greater at both Whiting and De Witt, respectively, compared with Nevada. Row spacing had no influence on plant height, but denser final populations increased plant height by a little less than an inch to about 2.5 inches compared with the less dense final populations. Lodging was not a significant problem with greater seeding rates and was not influenced by changes in row spacing.

**Grower return**

Locations differed in the gross profit that remained to pay land rent, chemicals, depreciation on equipment other than the planter, and labor (Table 2, next page). As expected, grower return followed closely with yield, and both De Witt and Whiting had greater economic returns compared with Nevada. Production in narrow row spacing did not produce greater return for 356-acre farms that had less than 50% of the land dedicated to soybean production (Table 2, next page). For larger farms, the conversion to narrow row spacing was always cost effective for all three corn–soybean rotations (Table 2). The covariate harvest plant population was not significant, and number of plants at harvest, or seeding rate, did not influence grower return.

Farms that are more than 700 acres and have 30% of the land dedicated to soybean production would benefit fi-
nancially by changing to a narrow row system as long as a yield increase of a little less than 2 bu/ac can be attained. Yield increases of 0.25 to 3.7 bu/ac yield were necessary, depending on farm size and percentage of land in soybean production, to achieve an economic benefit for the conversion to reduced row spacing (Table 3). The risk associated with purchasing a narrow row planter decreases dramatically as farm size increases, although small farms could expect a return on this investment because the overall yield benefit from this study and other reports support that narrow row spacing will increase yield by an amount greater than 3.7 bu/ac (Table 3). Only the costs of new equipment were determined, and the purchase of used equipment would reduce one or more of the following requirements: farm size, soybean production acres, and yield gain necessary to achieve an economic benefit from narrow row soybean production.

## Conclusion

The majority of farmers in large soybean-producing states such as Illinois and Indiana use narrow row spacing while Iowa still predominately uses wide row spacing. Both yield and economic benefits were documented in this extensive study for narrow-row soybean production in Iowa. The additional cost of a split-row planter was less than the economic gain for most farm sizes and rotation sequences. Smaller farms may not benefit as much from converting to narrow rows given the large fixed costs associated with the planter, but farms greater than 356 acres with levels of soybean production greater than 30% of the land base would benefit economically from narrow row soybean production. Changes in seeding rates contributed to significant yield changes but not to changes in profitability. Adoption of narrow row spacing and seeding rates less than current production recommendations could be used to reduce production costs and increase yield and profitability. &