Production of Snap Beans as Affected by Soil Tillage Method and Row Spacing

Charles A. Mullins and R. Allen Straw
Department of Plant and Soil Science, University of Tennessee, Plateau Experiment Station, Rt. 9, Box 363, Crossville, TN 38555

David L. Coffey
Department of Plant and Soil Science, University of Tennessee, P.O. Box 1071, Knoxville, TN 37901

Additional index words. Phaseolus vulgaris, tillage methods, no-till, ro-till, plant density, plant population, weed control

Abstract. Conventional tillage (CT), no-tillage (NT), and rotary strip-tillage (RT) methods were combined with row spacings of 0.46 m (28 plants/m²) and 0.92 m (56 plants/m²) in 1985 and 1986 snap bean (Phaseolus vulgaris L.) tests with a split-plot factorial arrangement of treatments. Yields were lowest with NT and 0.92-m row spacings both years, while plant stands were lowest with NT and RT. Plant lodging was lowest with NT and highest with CT each year. Pod clustering and broken pods following machine harvest were lowest with NT both years, while rotten pods and percentage no. 2 to 4 sieve-size pods were lowest with NT in 1986. Incidence of broken pods was higher with the 0.46-m row spacing than with the 0.92-m row spacing in 1985 and the incidence of rotten pods was greatest with the 0.46-m row spacing in 1986. The 0.46-m row spacing improved yields over the 0.92-m spacing, with minimal difference in pod quality. Weed control was less effective with NT than with CT and RT methods.

No-tillage (NT) culture has become a widely accepted cultural method for field corn and soybeans (6). Various NT and reduced tillage methods have been evaluated with several vegetable crops (4–7, 10, 12, 13). NT culture of squash, cabbage, lima beans, and other vegetable crops has not been highly successful (4–6, 12). However, NT culture has been fairly successful with sweet corn and popcorn (4, 7), especially when soil moisture was adequate (13).

In most trials, NT and rotary strip tilling (RT) of snap beans have generally been less successful than conventional tilling (CT) of snap beans (5, 10, 12). Adequate stand and weed control have been major problems in NT snap beans (12).

Planting snap beans at high densities generally has produced higher yields than standard 0.91- to 0.92-m row widths (3, 8, 9, 12, 14–16). The yield increase in high-density plantings has varied with factors such as soil moisture, mineral nutrition, weed control, in-row spacing, and cultivar. Higher-density plantings have decreased plant root and shoot weights, but have not affected lodging (4). Seed yields of dry beans were not improved, although green weights were higher (3) at the higher densities. Pod sieve size was slightly reduced at higher densities (15), and crops such as cabbage produced much smaller heads as plant density increased (2, 6).

This study was conducted to compare the effects of CT, NT, and RT methods at row spacings of 0.46 and 0.92 m on snap bean yield and pod quality.

Materials and Methods

The study was conducted in 1985 and 1986 at the Plateau Experiment Station near Crossville, Tenn. on a Lily (mesic Typic Hapludult) sandy loam soil. A soil test indicated the presence of 45 kg P/ha, 270 kg K/ha, and pH 5.9 at the start of the study. The plot area produced winter wheat cover crops that were cut and removed as hay =3 weeks before each crop, thus leaving a stubble residue 0.05 to 0.08 m high. Commercial tillage, planting, and harvesting equipment was used for all production stages.

Tillage method plots (main) were 6.1 m long by 6.2 m wide. Sub-plots were 6.1 m long and 3.1 m wide and contained either seven rows at a 0.46-m spacing, or four rows at a 0.92-m spacing. A 6.1-m alley between replications was left to permit equipment manipulation around the plots. The CT plots were plowed and fertilizer was broadcast as 67N–67P–67K (kg·ha⁻¹) in 1985 and 56N–56P–56K (kg·ha⁻¹) in 1986 on all plots. The CT plots were then disked. The RT plots were tilled with a ro-till (Bush Hog, Selma, Ala.) unit equipped with a subsoil shank, two fluted coulters, and a paddle wheel that prepared a 0.30-m wide seedbed. A seven-row Kinze planter (Kinze Manufacturing, Williamsburg, Iowa) equipped with NT furrow openers was used to plant all plots with 'Eagle' snap beans. The fluted coulter furrow openers at planting provided the only tillage with NT culture. The same plots were used both years of the study.

1-1'-dimethyl-4-4'-bipyridinium salts (paraquat) was applied to the NT and RT plots at 0.28 kg·ha⁻¹ just before planting on 9 July 1985 and 8 July 1986. Preplant herbicides consisted of 2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)acetamide (metolachlor) at 2.25 kg·ha⁻¹ each year and 2-(1-methylpropyl)-4,6-dinitrophenol (dinoseb) at 3.4 kg·ha⁻¹ in 1985. A postemergence application of 3-(1-methylethyl)-1H-2,1,3-benzothiadiazin-4(3H)-one-2,2-dioxide (bentazon) at 0.85 kg·ha⁻¹ was applied on 29 July 1986 for control of broadleaf weeds.

Precipitation in 1985 was 215 mm; no irrigation water was supplied. Precipitation in 1986 was 197 mm; supplemental irrigation of 40 and 38 mm of additional water was applied on 23 July and 6 Aug., respectively.

Plant stand counts were taken on a 1-m section of the two middle rows of each plot =2.5 weeks after planting each year. Leaf blade tissue samples of the youngest mature trifoliate leaves were collected from these same rows at early bloom each year and washed, dried, ground, and digested according to Ashburn (1). A Technicon Auto Analyzer (Technicon Corp., Ardsley, N.Y.) was used to determine N and P concentrations, while a Perkin–Elmer Model 5000 Atomic Absorption Spectropho-
were similar each year, but supplemental irrigation was applied to vine growth and is often associated with high yield potential.

Analysis included a factorial of tillage, spacing, and year for all factors. Data were analyzed by analysis of variance and means were separated by Duncan’s multiple range tests at the 5% level. Analysis included a factorial of tillage, spacing, and year for all factors.

Results and Discussion

Yields were higher with CT and RT than NT culture (Table 1). Plant growth, as observed in other trials (3, 4), appeared less vigorous with NT culture, which likely was due to restricted root growth in a compact soil that inhibited plant growth. Yields were similar each year, but supplemental irrigation was applied to all plots in 1986.

Plant stands were not affected by tillage treatment in 1985, but stands were higher with CT than NT or RT in 1986 (Table 1). The fine, smooth, level seedbed provided by CT seems optimum for consistently high plant stands (5, 11). The average stand of 24 plants/m of row during both years is near optimum for snap beans in 0.92-m rows in Tennessee. Plant lodging was more severe with CT than with NT or RT in both years (Table 1). Plant lodging is increased by excessive vine growth and is often associated with high yield potential and excessive N fertilization (11). These results support other studies (4, 11) that showed plant growth reduction with NT culture.

Grass control was excellent each year regardless of tillage or spacing treatment. However, percentages were slightly lower with NT than with CT or RT culture (Table 1). Broadleaf weed control ratings were lower with NT than CT and RT both years (Table 1). Although broadleaf weed control was acceptable with all tillage methods in this study, others have reported less favorable results with NT culture (12, 16). Lack of adequate weed control has been a disadvantage to NT culture of most crops. Weed control also can be a problem in close spacing when herbicides fail to perform properly.

Pod clustering and the percentages of broken pods and No. 2 to 4 sieve-size pods were lowest with NT (Table 1). Shorter plants always are more efficient than tall plants to machine-harvest if the pods are set sufficiently high in the plant. Straw residue on the soil surface reduced the amount of pod tip rot (Rhizoctonia) in 1986, when rainfall levels during the last week were high. Wet soil conditions, with 85 mm of rainfall the week before harvest, persisted during harvest. The wet soil likely led to higher percentage of trash in harvested pods in 1986 than in 1985 (14.5% vs. 2.6%). The trash in harvested pods did not vary among tillage methods and plant populations in either year (data not presented).

Yields were higher with 0.46-m than with 0.92-m row spacings (Table 2). Higher plant density improved yields as in most previous trials (3, 8, 9, 12, 14-16), probably due to more efficient use of available light, water, and nutrients.

Grass control was excellent at both spacings, but was better at the closer spacing (Table 2).

Plant stands, lodging, broadleaf weed control, and pod characteristics of clustering, broken pods, rotten pods, and sieve size distribution were not affected by row spacing. Most previous trials have shown similar responses, but pod sieve sizes were smaller in one study (15).

Interaction effects between year, tillage method, and row spacing were not significant for plant stand, plant lodging, broadleaf weed control, pod clustering, broken pods, rotten pods, and sieve-size distribution (data not presented). Yields were slightly, but significantly, higher in 1985 than in 1986 due to a slightly more favorable growing season (Table 3). Spacing × tillage affected grass control and spacing × year affected yield (Table 3). Actual differences were only slight, and trends were similar each year for these two factors.

Reduced tillage seems to offer a method for soil conservation, but generally without increased yields. In many studies, as in this trial, NT production resulted in lower yields than CT production. RT production appeared highly favorable, although more studies are needed with the system. Width of the tillage strip needs to be evaluated along with energy requirements. Based on our tractor use, an estimated 26,100 to 37,300 W (35 to 50 HP) per row was necessary to pull the RT unit through the soil, which seemed very high.

Higher plant densities increased yields in this and other studies (9, 14); also, the use of multi-row harvesters makes closer densities a viable production method for snap beans.

Neither tillage nor spacing affected pod length, which is more

| Table 1. Effect of soil tillage method on growth and yield of mechanically harvested snap beans (1985 and 1986 seasons).a |
|---|---|---|---|---|---|---|
| Tillage method | Total yield (t·ha⁻¹) | Plant stand (plants/m) | Plant lodging (%) | Grass control (%) | Pod clustering (clusters/kg) | Broken pods (%) |
| Conventional (CT) | 10.6 a | 28 a | 36 a | 99 a | 98 a | 8.1 a |
| None (NT) | 6.8 b | 23 a | 14 b | 96 b | 86 b | 5.4 b |
| Rotary strip (RT) | 9.8 a | 25 a | 23 a | 99 a | 94 a | 8.8 a |

*Mean separation within treatment method within column by Duncan’s multiple range test, 5% level.
Control was achieved in this trial, but the use of dinoseb was grass control than the 0.92-m row spacing. Pod quality characterization evaluated varied little with row spacing. The 0.46-m spacing gave higher yields and better lodging control than the 0.92-m row spacing. Pod clustering, broken pods, and rotten pods. NT culture of snap beans is not recommended as a production practice for snap beans in Tennessee and similar environments, primarily due to inadequate chemical weed control methods. RT results were highly favorable in this initial trial, but more studies are needed before RT can be recommended fully as a commercial production method.

Table 2. Effect of row spacing on growth and yield of mechanically harvested snap beans (1985 and 1986 seasons).^1

<table>
<thead>
<tr>
<th>Row spacing (m)</th>
<th>Total yield (t-ha^-1)</th>
<th>Plant stand (plants/m)</th>
<th>Plant lodging (%)</th>
<th>Grass control (%)</th>
<th>Broadleaf weed control (clusters/kg)</th>
<th>Pod clustering (clusters/kg)</th>
<th>Broken pods (%)</th>
<th>Rotten pods (%)</th>
<th>Sieve size 2 to 4</th>
<th>2 to 4</th>
<th>2 to 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.46</td>
<td>11.3 a</td>
<td>24 a</td>
<td>24 a</td>
<td>97 b</td>
<td>94 a</td>
<td>7.8 a</td>
<td>17.0 a</td>
<td>2.9 a</td>
<td>93 a</td>
<td>93 a</td>
<td>93 a</td>
</tr>
<tr>
<td>0.92</td>
<td>7.0 b</td>
<td>24 a</td>
<td>25 a</td>
<td>99 a</td>
<td>91 a</td>
<td>7.0 a</td>
<td>18.4 a</td>
<td>1.8 a</td>
<td>93 a</td>
<td>93 a</td>
<td>93 a</td>
</tr>
</tbody>
</table>

^1Mean separation within treatment method within column by Duncan's multiple range test, 5% level.

Table 3. Interactions among year, soil tillage method, and row spacing on yield and grass control of mechanically harvested snap beans (1985 and 1986 seasons).

<table>
<thead>
<tr>
<th>Effect</th>
<th>Total yield (%)</th>
<th>Grass control (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>**</td>
<td>NS</td>
</tr>
<tr>
<td>Tillage × year</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Spacing × tillage</td>
<td>NS</td>
<td>**</td>
</tr>
<tr>
<td>Spacing × year</td>
<td>**</td>
<td>NS</td>
</tr>
<tr>
<td>Spacing × tillage × year</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

^1Not significant or significant at 0.05 level or 0.01 levels, respectively.

of a cultivar trait than a response to cultural conditions (data not presented).

Leaf nutrient content (data not presented) varied slightly in a given year, but no trends developed and no nutritional deficiencies seemed to limit plant growth. Nutrition levels varied little in a previous trial at this location (12).

The RT and CT production methods yielded similar results, but NT was less successful in snap bean yield, plant stand, and weed control. NT was more favorable than CT or RT for pod clustering, broken pods, and rotten pods. NT culture of snap beans is not recommended as a production practice for snap beans in Tennessee and similar environments, primarily due to inadequate chemical weed control methods. RT results were highly favorable in this initial trial, but more studies are needed before RT can be recommended fully as a commercial production practice. The 0.46-m spacing gave higher yields and better grass control than the 0.92-m row spacing. Pod quality characteristics evaluated varied little with row spacing. The 0.46-m row spacing was highly successful and is recommended for producers who harvest with multi-row harvesters. Adequate weed control was achieved in this trial, but the use of dinoseb was officially suspended at the conclusion of the 1986 growing season and effective chemical weed control is now a potential problem both for reduced tillage methods and higher-density plantings. High-density plantings now may require a cultivation to ensure adequate weed control.

Literature Cited

1. Ashburn, E.L. 1970. The yield and uptake of nutrients by selected corn genotypes as influenced by nitrogen fertilization. PhD Diss., Univ. of Tennessee, Knoxville.


