# SEEDBED PREPARATION SYSTEMS FOR IMPROVED EMERGENCE AND YIELD OF SUGARBEETS

John A. Smith, Robert G. Wilson, and Gregory D. Binford
Machinery Systems Engineer and Weed Specialist, University of Nebraska, 4502 Ave. I, Scottsbluff, NE, and Agronomist, Pioneer Hi-bred International, Inc., 64 Denny Circle, Newark, DE

## Background

In the early 1980's, the sugarbeet industry in western Europe developed programs to improve sugarbeet stand establishment. To maintain profitability they needed to reduce production costs and increase yields. Labor was no longer available or affordable for thinning and weed control. Early stands with correct populations of accurately spaced plants were necessary to improve yields. One of the major outcomes of these industry efforts to improve stand establishment was a dramatic change in seedbed preparation prior to planting. This effort focused on reducing cost, improving seed-soil contact, and retaining soil moisture. The primary system that evolved for growers, following extensive research and demonstration, includes two tillage operations prior to planting: late fall plowing with a trailing packer, and one secondary tillage in the spring using a "precision" tillage implement immediately ahead of planting. The precision tillage implement that was developed operates very shallow, does not invert the soil, and leaves the soil surface firm without compacting the soil below. These systems have delivered lower production costs, improved emergence, and higher yield for growers.

Sugarbeet emergence for Nebraska producers is generally lower than desired, and is inconsistent from field to field, grower to grower, and year to year. Emergence tends to be lower and more inconsistent for growers who do not irrigate-up than for those who use irrigation to manage emergence. High and consistent emergence is necessary with plant-to-stand systems to achieve the target plant population with minimal plant skips, which in turn support maximum yield, good weed control, and low harvest loss. The purpose of this study was to examine sugarbeet emergence obtained with current Nebraska tillage systems and tillage systems used in western Europe.

## Objective

Compare sugarbeet emergence using traditional Nebraska seedbed preparation systems with those systems currently used in Western Europe.

## Procedure

This three-year study was conducted at the Panhandle Research and Extension Center during the years 1994, 1995, and 1996. The soil type in the plot area was a very fine sandy loam with a pH of 8.0 and O.M. of 0.9 %.

***Tillage Systems*** - Eight tillage systems (treatments) were included in the study in 1995 and 1996 and are listed in Table 1. Six of these treatments were used in 1994. Treatment 3, the modified ridge system, and Treatment 8, fall plow with one spring tillage, required fall operations and were initiated in the fall of 1994 for inclusion in 1995 and 1996. Treatment 1 represents the typical tillage system used in Nebraska. The plow-plant system, Treatment 7, is also used in Nebraska. The double disk system, Treatment 6, is used by a number of growers under pivot sprinklers. Treatments 4 and 5 reduce or eliminate spring tillage. Treatments 2 and 8 represent systems used in Europe which include the moldboard plow for primary tillage plus one "precision" secondary tillage immediately prior to planting. Treatment 3 is a ridge tillage system patterned after systems currently used in several U.S. growing areas. It should be noted for Treatment 3 that the field was not plowed prior to ridging, nor was there a ripping shank used within the row ahead of ridging. These ridges or 'beds' were firmed during formation in the fall with a rolling cultivator gang to reduce moisture loss, to make a firmer bed for planting, and to create some cloddiness to the top surface.

**Table 1. Description of the seedbed preparation systems.**

| Treat-ment Number | System Name | System Description | No. of Tillage Operations |
|---|---|---|---|
| 1 | Spring plow, roller harrow twice | Disk, moldboard plow with trailing packer in early spring, roller harrow twice between plowing and planting | 4 |
| 2 | Spring plow, one BBG at planting | Moldboard plow with trailing packer in early spring, use BBG tillage implement once, immediately prior to planting | 2 |
| 3 | Modified Ridge | Form firm ridges in fall, remove top of ridge with planter and plant directly into ridge | 1 |
| 4 | No plow, no spring tillage | With last operation in previous crop in previous fall, leave soil relatively level, plant directly into this without any tillage | 0 |
| 5 | No plow, one BBG at planting | Leave soil surface relatively level the previous fall, use BBG tillage implement once, immediately prior to planting | 1 |
| 6 | No plow, double disk | Disk twice in spring | 2 |
| 7 | Plow-plant | Disk early in spring, plow with trailing packer one to two days before planting | 2 |
| 8 | Fall plow, one BBG at planting | Moldboard plow with trailing packer in fall, use BBG tillage implement once, immediately prior to planting | 2 |

Field scale implements, matched to an 80 hp tractor, were used in these plots. Common models of rollover style moldboard plow with trailing packer, roller harrow, and tandem disk were used in respective tillage systems. The "precision" tillage

implement used in Treatments 2, 5, and 8 was manufactured by the German company Bodenbearbeitungsgerate (BBG) and was the model "Europak". This implement was comprised of, from front to rear, a leveling bar; a rolling basket; four rows of narrow, closely spaced, vertical tines; a leveling bar; a light crumbler roller; a rolling basket; and finger tines. This implement was designed to operate very shallow, preferably 2 in. deep. The tractor was equipped with dual rear radial tires with 7 psi inflation pressure for maximum floatation to avoid deep tire tracks which would require deeper tillage. Tillage depth was set at four inches for the roller harrow, two inches for the BBG, five inches for the disk, and eleven inches for the moldboard plow.

***Plot Design*** - Two completely separate sets of plots with different dates of tillage and planting were included each year to experience different soil and weather situations, critical to comparison of tillage systems. The first planting date was scheduled during a period considered the normal planting date range in Nebraska while the late planting date was scheduled approximately one month later. The late planting date was intended to expose the seedbeds to a drier environment and perhaps separate tillage treatments on the basis of moisture conservation. A randomized complete block statistical design with six replications of tillage treatments was used within each date. Tillage plots were 55 ft long by 20 ft wide and contained eight rows of sugarbeets on 22 in. row spacing. Four of the eight rows within each plot were randomly assigned to be planted with a Kleine UniCorn 3 planter and the other four rows with a Deere MaxEmerge 2 planter. The Deere planter was equipped with the newest sugarbeet seed tube and associated runner.

***Cultural Practices*** - Prior crops in the plot area were dry edible beans in 1993, malt barley in 1994, and a radish trap crop following malt barley in 1995. The bean straw was disked lightly after harvest in 1993. After barley harvest in 1994, the straw was removed and soil was disked and irrigated several times in late summer to minimize any volunteer barley the following year. The straw was removed following barley harvest in 1995 and a radish trap crop for nematode control was established in early August. The radish tops were disked into the soil in October of 1995 following a killing freeze. No further field operations were performed in the plot area prior to the tillage operations described in Table 1.

Seedex variety Monohikari pelleted seed, regular pellet size, was planted each year at a target spacing of 6.0 in. between seeds. Actual seed spacing for calculation of percent emergence was determined by collecting seeds dropped from each planter within a specific number of turns of the drive wheels. The distance traveled for a specific number of turns of each drive wheel was measured for each planter. Target seed depth was 1 in. Planting dates were chosen when precipitation was not anticipated for at least five days after planting to encourage any potential differences in soil moisture at planting. 'Normal' planting dates were May 4, May 16, and May 13 for 1994, 1995, and 1996 respectively. 'Late' planting dates were May 17, June 15, and June 14 for 1994, 1995, and 1996, respectively. No irrigation was applied until mid-July to allow any differences to materialize in soil moisture due to tillage. After this time, the plots were sprinkler irrigated according to crop water use requirements. The

plot area was soil sampled in the spring of each year and recommended rates of fertilizer were applied by the first week in July to minimize any fertility differences among tillage treatments. The plots were cultivated, post-emerge herbicides were applied, and hand weeding was used to control weeds.

***Measurements*** - One, 2 in. depth, soil sub-sample was taken from within each planted sugarbeet row in each plot to measure soil moisture in the seed zone immediately after planting in 1995 and 1996. The soil samples were weighed, oven dried, and reweighed to determine soil moisture. Emerged sugarbeet plants were counted in the center 40 ft length of all eight rows of each plot to monitor rate of emergence and final emergence. The inside two rows of each four row sub-plot for the full plot length were machine harvested. Harvest dates were September 30, October 9, and October 14 in 1994, 1995, and 1996, respectively. Root samples from each subplot were taken to the Western Sugar Co. Tare Lab for analysis.

## Results

Amount and timing of any precipitation relative to the date of planting had a large influence on final emergence, the rate of emergence, and relative performance of the tillage treatments. Significant precipitation did not occur between planting and initial emergence for the normal planting date in 1994 and the late planting dates in 1994 and 1995. Precipitation in excess of ½ in. fell between planting and initial emergence for the normal planting dates of 1995 and 1996 and for the late planting date of 1996.

Final emergence for the plots planted with the Kleine planter was statistically higher than the final emergence of the plots planted with the MaxEmerge 2 planter when combined over all tillage treatments during both the 94-96 period and the 95-96 period. Average final emergence combined over the six tillage treatments used for the entire 94-96 period was 60.2% for the MaxEmerge 2 planter and 64.3% for the Kleine planter. Average final emergence combined over all eight tillage treatments for the period 95-96 was 69.2% for the MaxEmerge 2 planter and 73.1% for the Kleine planter. Sugarbeet yield was not statistically different between the two planters when combined over tillage treatments for either the 94-96 period or 95-96 period. All results discussed in the following sections are combined over both planters.

***Soil Moisture at Planting Time*** - Soil moisture (Table 2) measured in the top 2 in. of soil in the row immediately after planting was highest in the modified ridge system (Treatment 3) and the plow plant system (Treatment 7). This would be expected since fresh, moist soil was exposed or brought to the surface prior to planting. Although it was not measured, in those plantings where rain did not occur within a week after planting, it was observed that Treatments 2, 3, 4, 5, and 8 had the highest soil moisture at seed depth approximately five days after planting. The soil tended to be cloddy and loose and did not retain as much moisture in Treatments 1, 6, and 7 as in the other treatments.

**Table 2. Soil Moisture in the top two inches of soil, in the crop row, immediately after planting.**

| System | Soil Moisture (%) at Planting | | |
|---|---|---|---|
| | Normal Planting Date | Late Planting Date | Both Planting Dates |
| | 95-96 Average | 95-96 Average | 95-96 Average |
| 1 - Spring plow, roller harrow twice | 9.1 | 6.3 | 7.7 |
| 2 - Spring plow, one BBG at planting | 10.0 | 7.4 | 8.7 |
| 3 - Modified Ridge System | 11.5 | 9.7 | 10.6 |
| 4 - No plow, no spring tillage | 9.4 | 6.3 | 7.8 |
| 5 - No plow, one BBG at planting | 8.7 | 6.3 | 7.5 |
| 6 - No plow, double disking | 8.2 | 7.6 | 7.9 |
| 7 - Plow-Plant System | 11.0 | 10.8 | 10.9 |
| 8 - Fall plow, one BBG at planting | 8.3 | 6.9 | 7.6 |
| LSD (p=0.05) | 1.6 | 1.6 | 1.1 |
| Average | 9.5 | 7.7 | 8.6 |

***Rate of Emergence*** - Rate of emergence was highly dependent on tillage treatment, normal or late planting date, soil moisture at time of planting, and timing of precipitation following planting. When favorable rainfall occurred within a few days after planting, emergence was relatively rapid, high, and there were no differences in rate of emergence among tillage treatments. However, when rain did not fall between planting time and initial emergence, there were large differences in rate of emergence among tillage treatments. Typical results when rain did not occur soon after planting time are shown in Figure 1. Treatments 3 and 5 achieved the most rapid early emergence in this planting. Surface soil in Treatments 1 and 6 was loose, cloddy, and lost moisture during several prior tillage operations.

***Final Emergence*** - Final emergence averaged over both planting dates for all eight treatments for the years 1995-96 was highest for Treatments 2, 5, and 8 (Table 3). All three of these treatments included the BBG tillage implement, conserved soil moisture prior to planting, and had a firm seedbed without large clods at seed depth. Treatment 5 provided nine percent higher final emergence than any other treatment when averaged over the three years and six planting dates.

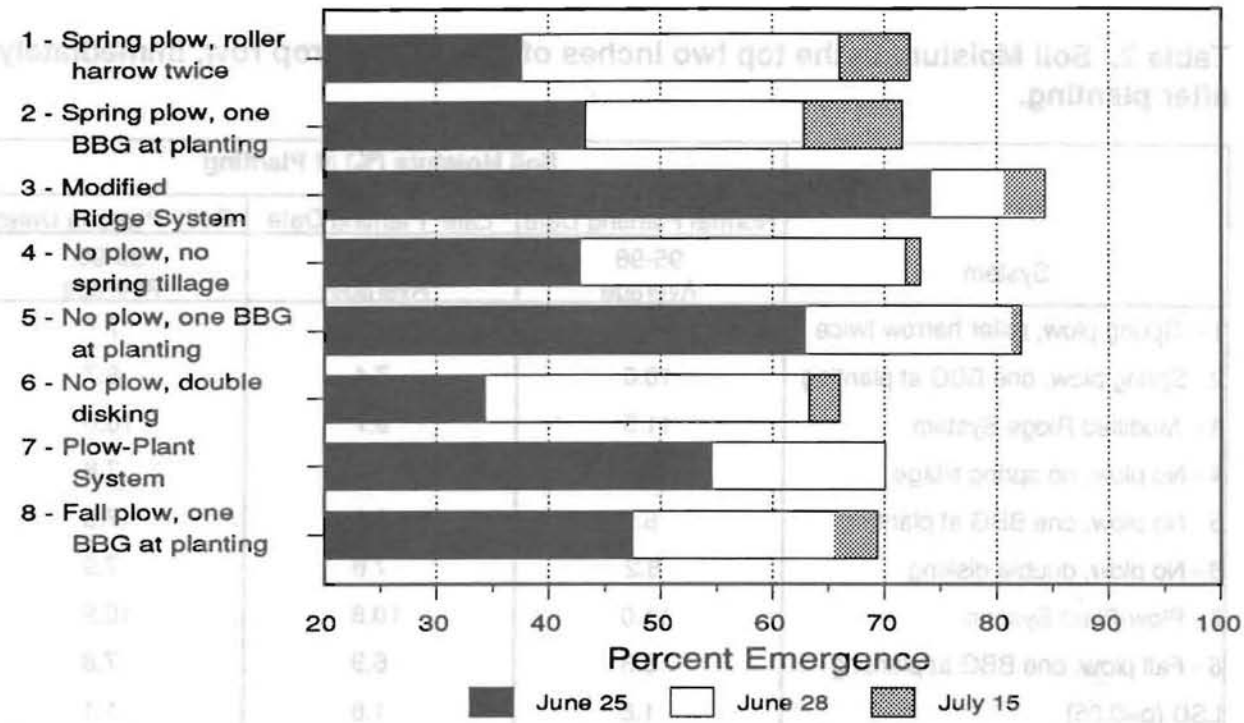


**Figure 1. Sugarbeet emergence measured at three dates during the emergence period for the late planting date (planted 6/14/96) in 1996.**

## Table 3. Final sugarbeet emergence.

| System | Percent Final Emergence | | | | | |
|---|---|---|---|---|---|---|
| | Normal Planting Date | | Late Planting Date | | Both Planting Dates | |
| | 95-96 Average | 94-96 Average | 95-96 Average | 94-96 Average | 95-96 Average | 94-96 Average |
| 1 - Spring plow, roller harrow twice | 83.7 | 78.4 | 50.7 | 47.4 | 67.2 | 62.9 |
| 2 - Spring plow, one BBG at planting | 85.7 | 77.5 | 65.6 | 47.6 | 75.6 | 62.6 |
| 3 - Modified Ridge System | 78.2 | -- | 66.5 | -- | 72.3 | -- |
| 4 - No plow, no spring tillage | 81.6 | 72.8 | 56.3 | 51.2 | 68.9 | 62.0 |
| 5 - No plow, one BBG at planting | 85.6 | 78.8 | 69.9 | 64.7 | 77.7 | 71.7 |
| 6 - No plow, double disking | 80.6 | 69.1 | 52.1 | 43.2 | 66.3 | 56.1 |
| 7 - Plow-Plant System | 81.9 | 72.8 | 47.8 | 43.9 | 64.8 | 58.3 |
| 8 - Fall plow, one BBG at planting | 88.3 | -- | 64.6 | -- | 76.5 | -- |
| LSD (p=0.05) | 5.5 | 6.4 | 5.5 | 6.4 | 3.9 | 4.6 |
| Average | 83.2 | 74.9 | 59.2 | 49.6 | 71.2 | 62.3 |

***Sugarbeet Yield*** - Root yield averaged 22.4 and 23.4 ton/A for the two year and three year periods, respectively (Table 4). However, normal planting dates averaged 27.4 ton/A and late planting dates averaged 17.2 ton/A for the two year period. There were statistically significant differences in root yield among treatments when averaged over both the two year and three year periods. For the two year period, Treatments 2 and 8 were among the highest yielders, while Treatments 7 and 4 were among the lowest. Averaged over the three year period, Treatments 6 and 7 were among the lowest yielders, and Treatment 5 was among the highest.

**Table 4. Root yield with tare removed.**

| System | Root Yield (tons/acre) | | | | | |
|---|---|---|---|---|---|---|
| | Normal Planting Date | | Late Planting Date | | Both Planting Dates | |
| | 95-96 Average | 94-96 Average | 95-96 Average | 94-96 Average | 95-96 Average | 94-96 Average |
| 1 - Spring plow, roller harrow twice | 28.3 | 28.4 | 15.8 | 19.1 | 22.1 | 23.7 |
| 2 - Spring plow, one BBG at planting | 27.5 | 27.0 | 18.9 | 19.3 | 23.2 | 23.2 |
| 3 - Modified Ridge System | 27.4 | -- | 18.2 | -- | 22.8 | -- |
| 4 - No plow, no spring tillage | 26.3 | 27.2 | 16.4 | 19.4 | 21.3 | 23.3 |
| 5 - No plow, one BBG at planting | 27.2 | 27.7 | 17.6 | 21.3 | 22.4 | 24.5 |
| 6 - No plow, double disking | 27.2 | 26.7 | 16.8 | 19.2 | 22.0 | 22.9 |
| 7 - Plow-Plant System | 27.2 | 26.4 | 15.7 | 19.1 | 21.5 | 22.7 |
| 8 - Fall plow, one BBG at planting | 28.4 | -- | 18.0 | -- | 23.2 | -- |
| LSD (p=0.05) | 1.8 | N.S. | 1.8 | N.S. | 1.3 | 1.7 |
| Average | 27.4 | 27.2 | 17.2 | 19.6 | 22.3 | 23.4 |

There were no statistically significant differences in percent sugar among the treatments when averaged over the two or three year periods (Table 5). The normal planting date generally averaged one percent sugar higher than the late planting date.

There were statistically significant differences in sugar yield among treatments when averaged over both the two and three year periods (Table 6). The normal planting dates averaged nearly 3500 lb/A more sugar than the late planting dates. Treatments 2, 5, and 8 where among the highest yielding treatments while Treatments 4 and 7 were among the lowest yielding.

## Table 5. Percent sugar.

| System | Percent Sugar | | | | | |
|---|---|---|---|---|---|---|
| | Normal Planting Date | | Late Planting Date | | Both Planting Dates | |
| | 95-96 Average | 94-96 Average | 95-96 Average | 94-96 Average | 95-96 Average | 94-96 Average |
| 1 - Spring plow, roller harrow twice | 15.7 | 15.7 | 14.6 | 14.8 | 15.1 | 15.2 |
| 2 - Spring plow, one BBG at planting | 15.8 | 15.7 | 15.0 | 14.8 | 15.4 | 15.3 |
| 3 - Modified Ridge System | 15.9 | -- | 15.2 | -- | 15.5 | -- |
| 4 - No plow, no spring tillage | 15.7 | 15.8 | 14.7 | 15.1 | 15.2 | 15.4 |
| 5 - No plow, one BBG at planting | 15.8 | 15.8 | 15.0 | 15.4 | 15.4 | 15.6 |
| 6 - No plow, double disking | 16.0 | 15.8 | 15.0 | 14.8 | 15.5 | 15.3 |
| 7 - Plow-Plant System | 15.5 | 15.6 | 14.7 | 14.9 | 15.1 | 15.3 |
| 8 - Fall plow, one BBG at planting | 16.0 | -- | 14.8 | -- | 15.4 | -- |
| LSD (p=0.05) | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |
| Average | 15.8 | 15.7 | 14.9 | 14.9 | 15.3 | 15.3 |

## Table 6. Sugar yield (percent sugar multiplied times clean root yield).

| System | Sugar Yield (pounds/acre) | | | | | |
|---|---|---|---|---|---|---|
| | Normal Planting Date | | Late Planting Date | | Both Planting Dates | |
| | 95-96 Average | 94-96 Average | 95-96 Average | 94-96 Average | 95-96 Average | 94-96 Average |
| 1 - Spring plow, roller harrow twice | 8890 | 8875 | 4688 | 5714 | 6789 | 7294 |
| 2 - Spring plow, one BBG at planting | 8674 | 8505 | 5656 | 5713 | 7165 | 7109 |
| 3 - Modified Ridge System | 8731 | -- | 5529 | -- | 7130 | -- |
| 4 - No plow, no spring tillage | 8245 | 8582 | 4873 | 5925 | 6559 | 7254 |
| 5 - No plow, one BBG at planting | 8584 | 8777 | 5297 | 6598 | 6940 | 7688 |
| 6 - No plow, double disking | 8698 | 8425 | 5066 | 5691 | 6882 | 7058 |
| 7 - Plow-Plant System | 8470 | 8239 | 4686 | 5729 | 6578 | 6984 |
| 8 - Fall plow, one BBG at planting | 9057 | -- | 5335 | -- | 7196 | -- |
| LSD (p=0.05) | 662 | 783 | 662 | 783 | 468 | 554 |
| Average | 8669 | 8567 | 5141 | 5895 | 6905 | 7231 |

## Summary and Conclusions

In general, tillage systems that used minimal operations in the spring and that left a firm seedbed with minimal soil clods at seed depth, provided most rapid emergence, highest final emergence, and highest yield. When favorable rainfall occurred within approximately one week of planting, there were few differences in sugarbeet emergence and resulting yield. When rainfall did not occur soon after planting, differences in rate of emergence, final emergence, and yield were more pronounced.

Tillage systems that tended to have the most favorable performance and be the most consistent included:

- Fall moldboard plow with one pass of the European-style tillage implement immediately prior to planting (Treatment 8)
- No moldboard plowing, with one pass of the European-style tillage implement immediately prior to planting (Treatment 5)

An appealing system that performed very well in specific planting dates and years but that was inconsistent at other times was the modified ridge system (Treatment 3). This system almost always had the most rapid emergence but usually did not have the highest final emergence. Observations suggest two changes to this system would likely overcome the inconsistency of performance while maintaining the benefits. First, the soil should be ripped in the row area during the ridge forming operation to alleviate any compaction that might exist under the planted row. This ripped area and the resulting soil ridge should be firmed to help reduce large clods, voids in the soil, and reduce moisture loss. Second, in this study the top of the ridge was removed with double disk row cleaners attached to the planter, exposing moist soil in the path of the planter gage wheels, furrow opener, and press wheels. This tended to create a "hard" soil and probably reduced final emergence. An improvement would be to make some minimal tillage on the ridge top by stirring, leveling, and firming but without exposing a completely fresh, moist surface.

Treatments that tended to be low performers or inconsistent, particularly when precipitation was limited after planting, included the no-plow double disk system (Treatment 6), the plow-plant system (Treatment 7), and the spring plow roller harrow twice system (Treatment 1). These systems left the soil cloddy and loose at seed depth which likely caused poor seed-soil contact and excessive soil moisture loss during tillage and after planting.

Based on these results, when moisture is limited prior to sugarbeet emergence, choice of tillage system can make an important difference in final emergence and yield of sugarbeets.