Effects of Plant Population and Row Width on Yield of Sugarbeet[1]

C. Dean Yonts and John A. Smith

University of Nebraska,
Panhandle Research and Extension Center,
4502 Avenue I, Scottsbluff, NE 69361

ABSTRACT

Yields of sugarbeet grown in 35, 56, 76, and 97 cm row widths were compared in field trials in the Nebraska Panhandle. Five target plant populations of 25,000, 40,000, 65,000, 100,000 and 150,000 plants/ha were established for each row spacing tested. Sugarbeet grown in 56 cm row width or less responded with a higher sugar yield than sugarbeet grown in the wider row widths tested. Target plant populations of 100,000 and 150,000 plants/ha produced the highest percent sucrose. More small roots, those that would be lost during harvest, were produced as row spacing increased and as plant population increased.

Additional Key Words: Row width, plant population, plant spacing

[1] Published as a Journal Series No. 11433, Nebraska Agriculture Research Division. the research was partly funded by the Western Sugar Grower Joint Research Committee Inc.

The question of wide vs. narrow row width for sugarbeet has long been debated by farmers and studied by researchers. Tolmon, et al. (1948) indicated that moving to wider rows was necessary to accommodate the use of mechanical equipment. Herron et al. (1964) stated that while some studies showed narrow rows i.e. 41 to 51 cm, to be more desirable, current practices of planting in 56 to 61 cm row width was more popular because of the convenience in using farm machinery. Fornstrom and Jackson (1983), compared row widths of 56 and 76 cm. The desire of the farmer to use bigger equipment was again pointed out in their research as the basis of using wider row widths. In each case, the research indicated that narrow rows provided better yields. In a review of the literature by Cattanach and Schroeder (1980), the results of 31 different research trials were examined. The data indicated that narrow rows (46 to 56 cm) produced greater average sugar yields compared to wide rows (58 to 76 cm) by 0.66 Mg/ha.

In the Central High Plains of Colorado, Nebraska, and Wyoming, sugarbeet was traditionally planted in rows spaced 56 cm apart. Corn and dry edible bean, two of the primary crops grown in rotation with the sugarbeet, gradually moved to a 76 cm row spacing for both crops. As this transition occurred, equipment and tire size increased along with the desire to maintain a standard row width for all crops grown by a single producer. The result has been a gradual move to 76 cm row width for sugarbeet production. Aldrich et al. (1975) indicated in a study on row spacing that corn producers may well need to adopt narrower rows, 51 to 76 cm, in areas producing field bean and sugarbeet where narrow rows have a clear-cut advantage.

Even though consistent results of the previous research studies indicate narrow rows produce higher yields, producers in the Central High Plains continue to convert to a 76 cm row width. As pointed out by Cattanach and Schroeder (1980) new growers in the Red River Valley started with wide rows but quickly switched to narrow rows. This too occurred in Nebraska as sugarbeet production was expanded outside of the North Platte Valley to areas where equipment was traditionally larger. However, the switch to narrow rows has not occurred in the Central High Plains and the trend to switch to wider row spacing continues.

Plant population plays an important role in quality sugarbeet production. Burcky and Winner (1986) found that increasing plant population resulted in higher root yield and/or higher sucrose content. Robinson and Worker (1969) concluded that the population influence on yield is the same over a wide range of climates. Maintaining high plant population through harvest is often considered difficult to achieve in wider row spacings.

A majority of the research studies described above have concentrated on row spacings near 56 and 76 cm. In addition, there has been limited work on the combination of row width and plant population for sugarbeet production in the Central High Plains. Evaluation of a range of row widths and plant populations is needed for one of the newer sugarbeet varieties grown in this region. Studying a range of row widths with different plant populations in the Central High Plains will assist in determining the best combination of row spacing and plant population.

The primary objective of this research trial was to compare four row widths in combination with five plant populations in the Central High Plains sugarbeet production area and to determine optimum row width and plant population based on the total sugar produced. Based on observation during harvest, a secondary objective of the research was to evaluate the amount of sugarbeet produced in a given population and row width that would be lost in the harvesting process due to small root size.

MATERIALS AND METHODS

The study was conducted at the University of Nebraska, Panhandle Research and Extension Center near Scottsbluff, NE over a four-year period, starting in 1986. Plots were lost in 1987 due to hail. In addition to the Scottsbluff site, a second site was included in 1989 near Mitchell, NE to compare a total of four site-years. At all sites the soil was a Tripp very fine sandy loam.

Each field was plowed and roller harrowed prior to planting. Cycloate was applied pre-plant at 1.6 kg/ha. Mechanical cultivation was not used during the season. Split applications of desmedipham plus phenmedipham at 0.33 kg/ha and hand weeding were used for post-emergence weed control. Plots were sprinkler irrigated and water was applied based on water use by the sugarbeet crop.

A 4X5 factorial experiment involving four row spacings and five plant populations were compared in a randomized complete block design with four replicates. Target plant populations of 25,000, 40,000, 65,000 100,000 and 150,000 plants/ha were included in row spacings of 35, 56, 76 and 97 cm. The variety Monohikari was seeded at a 2.5 cm depth and at approximately a 2.0 cm within row spacing using a John Deere 71 Flexi-Planter. Plots were 9.1 m long and 6 rows wide for the 35, 56, and 76 cm row width treatments. Plots were 4 rows wide for the 97 cm row width treatment.

After final emergence, when the plants were in the 2 to 4 true leaf stage, the sugarbeet plants were hand thinned. Wooden sticks, 5X5 cm and 4 to 5 m long, were marked corresponding to the desired in-row plant spacing for each combination of plant population and row width. The sticks were placed beside each planted row and used as a guide to select the plants to keep and the plants to be removed. A random in-row spacing was not compared in this study for two reasons. First, it was felt that using a more precise in-row spacing would best meet the objectives of this study. Second, the ability of the industry to precision plant could be better simulated using an established in-row spacing.

Roots were hand harvested from 6.1 m of the center two rows of each plot. All sugarbeet roots, regardless of size, were counted to determine harvest plant population. Approximately 11 kg samples were collected from each plot to determine tare. The samples were then analyzed for percent sucrose by the method outlined by the Association of Official Chemists (1955).

The sugarbeet plants were hand dug, topped and weighed. During the first year of study, a significant number of small sugarbeet roots were observed during harvest. The quantity of small roots appeared to be more abundant in the wide row spacing and high population treatments. Although the small sugarbeet plants would add to the total harvest weight in the research plots, these same sugarbeet plants would likely be lost during field harvest operations. It was decided to measure the amount of small sugarbeet roots during site-years two through four.

Knott et al. (1976) indicated small roots would likely fall through 5.7 cm spaced chain links on a harvester. Fornstrom (1980), Hills (1973) and Nelson (1974) used a 5.1 cm crown diameter as the criteria to separate harvestable and non-harvestable sugarbeet roots. The spacings between sugarbeet harvester chains used in Nebraska were measured and also the size of sugarbeet roots that were being returned in the tailings from the factory. Based on this information, sugarbeet roots less than 6.3 cm in diameter at the largest portion of the crown were counted as part of plant population but were weighed separately. These sugarbeet roots then represented the quantity of roots that would likely be lost during harvest or removed as tare.

RESULTS

The data were analyzed using a two factor ANOVA combined over site years. No statistically significant interactions were found among the combinations of year, population and row width for root yield, sucrose or sugar yield. Plant populations, determined at harvest, for the different row widths and target plant populations are presented in Table 1 and are combined over all site-years. Harvest population, on the average, was higher by 7% at 25,000 and 40,000 plants/ha than the target plant populations. An increase in the target plant population could be attributed to incomplete removal of the seedlings during thinning. At target populations of 65,000 to 150,000 plants/ha, harvest population was less than target population and decreased more as target population increased. It is thought that the higher plant populations were difficult to maintain because in-row spacing was small during the thinning process and plants could have been damaged when unwanted plants were removed.

Table 2 gives the weight of sugarbeet roots(Mg/ha) that were less than 6.3 cm in diameter for all row width and plant populations tested. Significant interactions were found among the population and row width within years and across years.

Treatments with target populations of 150,000 plants/ha averaged 119,000 roots/ha at harvest (Table 1). The weight of small sugarbeet roots, averaged over all treatments, was determined to be 0.12 kg/root. Therefore, an estimated additional 26,000 roots/ha would be lost during harvest of the 150,000 plants/ha treatment due to small root size. Combining these two factors, harvestable sugarbeet roots would be reduced from 150,000 plants/ha at thinning to 93,000 roots/ha at harvest when small roots were removed. Fornstrom (1980), in a plant to stand study used regression to develop an equation to predict sugarbeet stand at harvest as a function of initial stand. Using his criteria, 150,000 plants/ha would equate to a harvest population of 103,000 plants/ha. The difference in the predicted roots/ha would partially be attributed to the criteria used to eliminate small roots. Fornstrom (1980) used a crown diameter of 5.1 cm compared to 6.3 cm crown diameter used in this study.

Table 1. Plant populations (plants/ha) at harvest for row width and target plant population treatments. These plant populations include all roots and are the means of all four site-years.

	Target Plant Population, plants/ha				
Row Width	25,000	40,000	65,000	100,000	150,000
cm	Harvest Population, plants/ha				
35	29,200	49,200	62,800	99,100	112,700
56	25,700	38,800	61,000	91,900	132,200
76	26,900	44,200	59,600	82,800	114,400
97	25,000	39,000	59,100	86,500	117,600
Average	26,700	42,700	60,500	89,900	119,100

Even with care in sugarbeet plant spacing, the competition between plants appeared to cause reduced development of some sugarbeet roots. To realize the yield advantage associated with high in-row plant spacing in wide rows, more attention will need to be focused on accurate plant spacing and on the harvesting and cleaning process in order to recover small sugarbeet roots.

Row Width

Sugarbeet root yield, sucrose and sugar yield for the row widths and target plant populations tested are given in Tables 3, 4, and 5

Table 2. Quantity of small sugarbeet roots (Mg/ha) (roots less than 6.3 cm diameter at the crown) harvested from row width and target plant population treatments.

		Small Sugarbeet Roots				
Row Width	Target Plant Population	Site-Year 1	Site-Year 2	Site-Year 3	Site-Year 4	All Site-Years
cm	plants/ha	Mg/ha				
35		n/a	0.4	1.0	0.9	0.8
56		n/a	0.8	0.9	0.8	0.9
76		n/a	0.6	1.3	1.2	1.0
97		n/a	1.3	1.8	1.0	1.4
	25,000	n/a	0.1	0.2	0.0	0.1
	40,000	n/a	0.2	0.1	0.1	0.1
	65,000	n/a	0.2	0.6	0.3	0.4
	100,000	n/a	0.9	1.6	1.4	1.3
	150,000	n/a	2.5	3.8	3.0	3.1
Interactions:	Site-Year*Row Width		N.S.	N.S.	N.S.	**
	Site-Year*Population		N.S.	N.S.	N.S.	**
	Row Width*Population		**	**	**	**
	Site-Year*Row Width*Population		N.S.	N.S.	N.S.	**

** and N.S. represents significance at the 0.01 probability level and not significant

Table 3. Response of sugarbeet root yield (Mg/ha) to row width and target plant population treatments.

		Root Yield				
Row Width	Target Plant Population	Site-Year 1	Site-Year 2	Site-Year 3	Site-Year 4	All Site-Years
cm	plants/ha			Mg/ha		
35		62.1	80.9	63.2	52.5	64.8
56		62.8	78.7	68.6	56.7	66.6
76		62.8	79.1	63.4	52.9	64.6
97		58.1	75.1	57.8	49.8	60.1
LSD @ 5%		N.S.	2.9	4.3	3.6	2.0
	25,000	63.9	79.8	62.3	52.5	64.6
	40,000	61.6	82.9	65.9	55.8	66.6
	65,000	62.1	80.5	64.8	53.4	65.0
	100,000	59.4	76.2	63.4	54.0	63.2
	150,000	60.1	72.9	60.1	49.1	60.5
	LSD @ 5%	N.S.	3.4	4.9	4.0	2.2

Table 4. Response of sugarbeet sucrose (% to row width and target plant population treatments.

		Sucrose				
Row Width	Target Plant Population	Site-Year 1	Site-Year 2	Site-Year 3	Site-Year 4	All Site-Years
cm	plants/ha			%		
35		15.9	16.4	17.1	18.7	17.1
56		15.6	16.8	17.5	19.0	17.2
76		15.7	16.7	17.2	18.8	17.1
97		15.3	16.4	17.1	18.4	16.8
LSD @ 5%		0.4	N.S.	N.S.	N.S.	0.2
	25,000	14.9	16.2	16.4	18.0	16.4
	40,000	15.4	16.5	17.2	18.6	16.9
	65,000	15.7	16.3	17.4	18.8	17.1
	100,000	16.1	17.1	17.7	19.0	17.5
	150,000	16.1	17.0	17.5	19.2	17.4
	LSD @ 5%	0.5	0.7	0.5	0.5	0.3

respectively. Sugarbeet root weight in these analyses does not include the weight of sugarbeet roots smaller than 6.3 cm in site-years two through four. Total root weight is only included in site-year one. Sugarbeet root yield from the 56 cm row width was greater than from 76 cm rows and yield from 76 cm rows was greater than from 97 cm rows, combined over site-years (Table 3). Root yield tended to peak at the 56 cm row width. Percent sucrose was similar with row widths of 35, 56, and 76 cm for all site-years combined and percent sucrose was less with 97 cm row width (Table 4). The production of sugar was at least 0.4 Mg/ha greater at the 56 cm row width, combined over site-years, than at the other row widths(Table 5).

Plant Population

Sugarbeet root yield was greatest when target plant population was below 150,000 plants/ha(Table 3). The trend was for root yield to peak at 40,000 plants/ha and decrease with higher and lower plant population. Sucrose content tended to increase with higher plant populations up to 100,000 plants/ha(Table 4). Sucrose content at 100,000 plants/ha was similar to sucrose content at 150,000 plants/ha but was greater than at 65,000 plants/ha. Plant populations of 40,000, 65,000 and 100,000 plants/ha produced the highest sugar yields(Table 5). Sugar yield was reduced by 0.7 and 0.5 Mg/ha if population was decreased to 25,000 plants/ha or increased to 150,000 plants/ha, respectively.

Table 5. Response of sugar yield (Mg/ha) to row width and target plant population treatments.

		Sugar Yield				
Row Width	Target Plant Population	Site-Year 1	Site-Year 2	Site-Year 3	Site-Year 4	All Site-Years
cm	plants/ha	Mg/ha				
35		9.9	13.4	10.9	9.8	11.0
56		9.7	13.2	12.0	10.8	11.4
76		9.8	13.2	10.9	9.9	10.9
97		8.8	12.3	9.9	9.1	10.0
LSD @ 5%		0.7	0.7	0.8	0.7	0.4
	25,000	9.5	12.9	10.2	9.4	10.5
	40,000	9.4	13.6	11.3	10.4	11.2
	65,000	9.8	13.1	11.2	10.0	11.0
	100,000	9.6	13.0	11.2	10.3	11.0
	150,000	9.7	12.4	10.6	9.4	10.5
	LSD @ 5%	N.S.	0.7	0.9	0.8	0.4

SUMMARY

The results of this study indicate that maximum production of sugar (Mg/ha) was attained when using a 56 cm row width. Sugar yield in 56 cm row width was increased by 0.5 Mg/ha compared to 76 cm row width. Sugar yield (Mg/ha) was highest when the target plant population was between 40,000 and 100,000 plants/ha. As plant population and row width increased, the number of sugarbeet roots less than 6.3 cm in diameter tended to increase which reduced the number of harvestable sugarbeet roots.

In the 31 studies reviewed by Cattanach and Schroeder(1980) sugar yield of narrow rows averaged 0.66 Mg/ha greater than wide rows. Results of this study indicate a 0.5 Mg/ha sugar yield advantage when using narrow, 56 cm row width compared to wide, 76 cm row width. An optimum plant population was not as clearly defined in this study. Similar results in sugar yield were found for target plant populations ranging from 40,000 to 100,000 plants/ha. For all site-years combined, there was a trend for higher sugar yield at the 40,000 plants/ha population. These results may not reflect the optimum economic production level as a result of other factors such as equipment and labor which can influence production costs and the final net profit.

LITERATURE CITED

Aldrich, S. R., W. O. Scott, and E. R. Leng. 1975. Modern Corn Production. A & L. Publications. pp. 84-85.

Association of Official Agriculture Chemists. 1955. Official methods of analysis. 8th ed. Washington. D. C. pp. 564-568.

Burcky, K. and C. Winner. 1986. The effect of plant population on yield and quality of sugar beet at different harvesting date. J. Agron. and Crop Sci. 157:264-272.

Cattanach, A. and G. Schroeder. 1980. A comparison of 22 versus 30-inch row spacing at equal plant population in 1976-77. 1979 Sugarbeet Res. and Extension Rep. 11:198-203.

Fornstrom, K.J. 1980. Planting sugarbeets to stand in Wyoming. J. Am. Soc. Sugar Beet Technol. 20(6):535-543.

Fornstrom, K.J. and G. Jackson. 1983. Sugarbeets planted to stand in 56 and 76-centimeter rows. J. Am. Soc. Sugar Beet Technol. 22(2):108-118.

Herron, G.M., D.W. Grimes, and R.E. Finker. 1964. Effect of plant spacing and fertilizer on yield, purity, chemical constituents and evapotranspiration of sugar beets in Kansas I. Yield of roots, purity, percent sucrose and evapotranspiration. J. Am. Soc. Sugar Beet Technol. 12(8):686-698.

Hills, F.J. 1973. Effects of spacing on sugar beets in 30 inch and 14-26 inch rows. J. Am. Soc. Sugar Beet Technol. 17(4):300-308.

Robinson, F.E. and G.F. Worker, Jr. 1969. Plant density and yield of sugar beets in an arid environment. Agron. J. 61:441-443.

Knott, C., G.M. Palmer and E.J. Mundy. 1976. The effect of row width and plant population on the yield of sugar beet grown on silt and black fen soils. Expl. Husb. 31: 91-99.

Nelson, J.M. 1974. Effect of spacing in 14-26 inch rows on production of fall planted sugarbeets. J. Am. Soc. Sugar Beet Technol. 18(1):76-80.

Tolman, B.R. Johnson, and A.J. Bigler. 1948. Row widths and sugarbeet production. Proc. Am. Soc. Sugar Beet Technol. 5:282-286.