Effect of Planter Ground Speed and Seed Spacing on Sugarbeet Production.[†]

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ABSTRACT

Sugarbeet plant populations often are determined by placement of seed during planting. This study was conducted to find the effect increasing ground speed has on performance of various commercial sugarbeet planters, and on subsequent production of recoverable sugar. Data was collected from planters mounted on a planter test stand and from field studies at five locations over a two year period. Ground speeds ranged from 1.34 to 2.24 m s^{-1} with seed spacing at 63.5 and 127 mm. For all planter types evaluated, significant decreases in seeding percentage occurred as ground speed increased. A slower ground speed resulted in a significant increase in root yield, recoverable sugar and sugar percentage. Seed emergence was increased by slower ground speed. Sugar production was reduced by increased seed spacing.

Additional Key Words: *Beta vulgaris* L., planter, planting speed, seed spacing, recoverable sugar

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A major problem in sugarbeet (*Beta vulgaris* L.) production is stand establishment or an adequate number of evenly spaced plants per hectare. Plant spacing and plant establishment is determined by sugarbeet planter performance, quality of sugarbeet seed and the environment.

Planter performance has been studied for many years (Bainer, 1947; Barmington, 1962; Bush, 1963) and many new planters have been developed. Researchers (Bainer, 1947; Barmington, 1968; Fornstrom and Miller, 1989) have stated seed spacing precision of sugarbeet planters is related to planter ground speed but limited data is found in the literature. Data collected from a planter test stand demonstrated planter performance is affected by the physical characteristics of the sugarbeet seed and ground speed (Giles et al., 1985). Seed roughness and non-uniformity of seed size among varieties resulted in differences in seeding percentages with the same planter type. The objectives of this study were to determine (1) seeding performance of different types of sugarbeet planters operated at various ground speeds, (2) final stand establishment percentage and (3) yield of sugarbeet planted into different seedbeds with various planter parameters.

MATERIALS AND METHODS

A planter stand unit was constructed with a capacity of attaching different commercial planter units. Sugarbeet seed (Maribo 'Ultramono') of the same seed size and lot number was collected from John Deere 71 Flex and Milton seed metering units mounted on the planter test stand in 1986 and 1987; similar data was obtained from Heath and Nodet Gougis seeding units in 1987. In 1986, the units were set to drop a seed at 76.2 mm intervals and operated at 1.34, 1.78 or 2.24 m s^{-1}. A second set of data was collected with the John Deere metering unit operating at 1.34 or 2.24 m s^{-1} with a seed drop interval of 63.5 or 127.0 mm. In 1987, the metering units were operated at 1.34, 1.78 or 2.24 m s^{-1} and set according to the user's manual to drop seed at 63.5 or 127.0 mm. Material passing through the planters during operation was collected for the time required to travel 30.5 m at the respective ground speed. Visually undamaged seeds were separated from the remaining material and counted. A seeding percentage was calculated for each sample based upon the theoretical number of seeds for the given row length. Three replicate samples were collected for each test.

A continuous revolving belt, with 3.66 meters of level surface, was placed under each test stand planter unit. The grease belt used to trap seed was set to travel at the same ground speed as the seed metering unit. An STP oil treatment was spread on the belt to trap seed as metered by the planter unit. The number of positions at which two or more seeds were placed within 50 mm (double) or no seed within 200 mm (skips) were counted for the 63.5 and 127.0 mm spacing, respectively. Skip and double values were calculated as a percent of the expected number of seeds per 3.05 m of row at the respective seed spacing. Ten replicate runs were made for each planter and speed combination.

Field studies were established during 1986 at the Johanson Farm south of Moorhead, Minnesota on Hegne silty clay (fine, frigid, Typic Calciaquoll); the University of Minnesota Northwest Experiment Station, Crookston, Minnesota on Wheatville loam (coarse-silty over clayey, frigid, Aeric Calciaquoll); and the North Dakota State University Main Experiment Station at Fargo, North Dakota on Fargo silty clay (fine, montmorillonitic, frigid, Vertic Haplaquoll). In 1987, field studies were established on a Glyndon silt loam (coarse-silty, frigid, Aeric Calciaquoll) near Amenia, North Dakota and repeated at Crookston, Minnesota. At each location, sugarbeet seed was planted with a John Deere 71 Flex planter at ground speeds of 1.34 or 2.44 meters per second with seed spacing of 63.5 or 127.0 mm. The experimental design was a randomized complete block with either four or six replicates depending upon location. Two planting dates were established at each location in an attempt to plant into seasonally optimal and late season dry soil moisture conditions. Seeding depth was at approximately 32 mm.

Plant emergence counts began when seedlings first emerged and continued until seedling emergence ceased. Stand counts were made from 6.1 m of row in the four middle rows of each 12.2 m plot. The number of plants not previously emerged was determined on each counting date. Percent emergence was calculated for each treatment by dividing total number of seedlings by actual number of seeds dropped by the metering unit at the respective speed and spacing. Only total final emergence was determined at the Crookston site.

Insecticides were applied at recommended rates at planting time at sites where sugarbeet root maggot was expected. The 63.5 mm seed spacing treatments were handthinned to a 203mm spacing at the six to eight leaf stage to establish an optimum plant population of 5 plants m^{-1}. Weed control was maintained throughout the growing season with herbicide applications, hand labor and mechanical cultivation.

Sugarbeets were harvested mechanically with a one row harvester in late September and early October each year. Four rows, each 12.2 m in length, were harvested in two row combinations from each plot. Total root weight was recorded and a subsample of beets randomly taken from each plot. Tare and quality parameters were determined at the American Crystal Sugar Company's Quality Laboratory in East Grand

Forks, Minnesota. Clean root weight, sucrose percentage, and recoverable sugar by a procedure based on the Impurity Index approach of Carruthers and Oldfield (1961) were determined.

Experimental data were subjected to analysis of variance followed by Duncan's multiple range test at $P < 0.05$ and 0.01 (Steele and Torrie, 1960).

Table 1. Effect of increasing ground speed on seeding percentage, skip percentage and double seeding percentage of raw sugarbeet seed. John Deere 71 Flex, Milton cell wheel and Heath vacuum planter were set for 76.2 mm spacing on the planter test stand, 1986.

Planter		Seeding	Skip	Double
Type	Speed			
	$m\ s^{-1}$	Percent		
John Deere	1.34	94.3a†	10.0b	3.8b
(71 Flex)	1.79	92.3ab	11.0b	2.0b
	2.24	89.0 b	16.0a	8.0a
Milton	1.34	80.3a	14.3c	0.3
(90 cell)	1.79	73.3a	8.0b	0.0
	2.24	56.0b	44.0a	0.0
Heath	1.34	95.3a	8.3c	6.8
(48 hole)	1.79	97.5a	3.8b	9.0
	2.24	90.8b	21.5a	10.3

†Values within columns within each planter type not followed by the same letter are significantly different at the 5% level of probability by Duncan's New Multiple Range Test.

RESULTS AND DISCUSSION

The effect of increasing ground speed on seeding percentage, and percent skips and doubles of sugarbeet seed planted with the John Deere 71 Flex, Milton cell wheel, or Heath vacuum planter units is reported in Table 1. Comparision of planter types was not an objective of this study, so means across planter units are not reported. Significant decreases in seeding percentage occurred with increasing ground speed from 1.34 to 2.24 $m\ s^{-1}$ with all planter units. The decrease was greater with those plante types that enclose the seed in a seed cell. A significant increase in percent skips resulted from increased ground speed with all planter units. The increased double percentage with the John Deere planter is probably caused by a longer seed drop distance compared to other planter types.

Table 2. Effect of increasing ground speed and seed spacing on seeding percentage of raw sugarbeet seed with a John Deere 71 Flex planter on the planter test stand, 1986.

Planter		Seed Spacing	
Type	Speed	63.5 mm	127.0 mm
	m s^{-1}	Percent	
John Deere	1.34	82.0a†	99.2a
(71 Flex)	2.24	70.9b	92.5b

†Values within columns not followed by the same letter are significantly different at the 5% level of probability by Duncan's New Multiple Range Test.

Table 3. Effect of increasing ground speed on seeding percentage of raw sugarbeet seed with a John Deere 71 Flex, Milton cell wheel, or Heath and Nodet Gougis vacuum planters set for 63.5 or 127.0 mm spacing on the planter test stand, 1987.

Planter		Seed Spacing (mm) 63.5			127.0		
Type	Speed	Seeding	Skip	Double	Seeding	Skip	Double
	m s^{-1}	Percent					
John Deere	1.34	104.5a†	12.3b	5.4b	116.8a	5.0a	0.8
(71 Flex)	1.79	92.6b	14.6b	11.7a	101.8b	0.4b	0.8
	2.24	91.0b	9.0a	13.5a	97.6c	6.7a	1.3
Milton	1.34	82.6a	4.6c	5.0a	95.0a	4.2b	4.6a
(90 cell)	1.79	66.4b	9.8b	0.2b	94.6a	3.8b	0.0 b
	2.24	39.0c	26.3a	6.9a	79.4b	10.8a	2.9ab
Heath	1.34	102.2a	4.6c	3.3b	112.5a	4.2a	2.1
(48 hole)	1.79	95.6b	18.5a	7.9a	104.0b	0.4b	2.1
	2.24	85.8c	13.1b	10.4a	96.4c	0.8b	4.2
Nodet Gougis	1.34	104.2a	5.2c	1.7b	96.5ab	0.4c	0.4b
(33 hole)	1.79	83.9b	8.8b	5.4a	98.6a	6.3b	0.4b
	2.24	74.7c	14.8a	5.0a	93.9 b	11.3a	2.5a
Nodet Gougis	1.34	104.0a	4.0b	4.6b	109.3a	5.8a	2.9
(48 hole)	1.79	106.3a	3.3b	1.9b	111.9a	0.8b	2.1
	2.24	93.5b	9.0a	8.3a	100.4b	2.9ab	1.7

†Values within columns within each planter type not followed by the same letter are significantly different at the 5% level of probability by Duncan's New Multiple Range Test.

The effect of increased ground speed on the John Deere planter unit was less when the seed spacing was increased from 63.5 mm to 127.0 mm (Table 2). This would be expected, since rotation of the seed plate is only half as fast.

Results obtained on the test stand in 1987 were similar to those of 1986 (Table 3). Increasing ground speed with each planter type caused a significant decrease in seeding percentage. Performance with the Nodet Gougis 48 hole unit was superior to that of the 33 hole plate because with more holes in the seed plate, plate rotation is slower for any given seed spacing. With greater rotation speed there is less opportunity for a seed plate hole to fill. Skip percentage increased with increasing ground speed for all planter types, particularly with the high density seed spacing. Increases in ground speed resulted in significant increases in percent doubles with the John Deere metering unit at the high density seed spacing. This effect could be even greater with a longer seed tube length, such as on the John Deere Maxi-merge unit.

Seedbeds were dry at all field locations during seeding in 1986, but sufficient precipitation occurred during the week following planting to initiate germination. Seedling emergence at the Johanson and Fargo locations began 10 days after planting. The amount of soil moisture needed for germination was greater at the Fargo location. An increased rate of emergence occurred following additional precipitation on June 6, at the Fargo location. Emergence of the second planting began 11 days after seeding.

Very dry soil conditions were present for the first planting at Amenia in 1987. Seedling emergence was sparse until precipitation occurred in late June. Soil moisture conditions were ideal for seed germination at the second planting date. These seedbed conditions reverse what is normally expected in Red River Valley sugarbeet production.

Increased planting ground speed affected seedling emergence, root yield and recoverable sugar (kg ha^{-1}) when averaged across all locations both years (Tables 4 & 5). A slow ground speed resulted in a significant increase in root yield, and recoverable sugar (kg ha^{-1}) each year.

Plant emergence was increased by slower planting speed except in the first planting at Crookston in 1986 and Amenia in 1987. The slower ground speed resulted in a significantly ($p<0.01$) higher stand count at harvest, from 2.62 to 2.34 roots m^{-1} and 3.11 to 2.64 roots m^{-1} in 1986 and 1987, respectively.

Given these differences in recoverable sugar production, the purchase of additional equipment to complete seeding in the amount of time required for seeding at the faster planting speed would return enough income to pay for equipment purchase, based upon 1985-1987 sugar prices. These data suggest this is of greater importance with early planting.

Table 4. Influence of sugarbeet planter ground speed on seed emergence, yield, recoverable sugar and sugar percentage for two planting dates at Moorhead, MN, Fargo, ND and Crookston, MN during 1986.

Planter	Location						
	Johanson		Fargo		Crookston		
Speed	**Planting Date**						
$m\ s^{-1}$	First	Second	First	Second	First	Second	Mean
	Seed emergence, %						
1.34	70.1	56.8	43.9	65.2	51.7	60.4	59.3
2.24	64.7	56.9	40.4	64.9	59.9	51.8	55.5
	ns	ns	ns	ns	**	**	**
	Root Yield, $Mg\ ha^{-1}$						
1.34	36.0	31.4	42.6	39.4	47.6	42.8	39.3
2.24	29.7	31.6	35.1	39.7	45.5	40.2	36.2
	**	ns	**	ns	**	**	**
	Recoverable sugar, $kg\ ha^{-1}$						
1.34	3670	3444	4962	4440	6685	5406	4608
2.24	2897	3444	3848	4397	6346	4914	4142
	**	ns	*	ns	**	**	**
	Sugar, %						
1.34	14.5	15.2	15.8	15.4	18.8	17.1	15.9
2.24	14.0	15.0	15.3	15.2	18.5	16.7	15.6
	ns	ns	*	ns	ns	*	ns
	Recoverable sugar, $kg\ Mg^{-1}$						
1.34	102	111	116	112	140	126	116
2.24	98	109	110	111	139	122	112
	ns	ns	*	ns	ns	*	ns

*, ** Significance at the 0.05 and 0.01 probability levels, respectively. ns = not significant.

Sugar production was reduced significantly by increasing the seed spacing from 63.5 mm to 127.0 mm in the later plantings in 1986 and 1987 (Tables 6 & 7). This effect was most evident on the light textured soil at Crookston. Final harvest stand counts were not made at the Crookston location; thus final plant population effects could not be determined. Harvest stand counts averaged across the other locations in 1986 were not significantly different, with 2.52 and 2.44 plants m^{-1} of row for the 63.5 and 127.0 mm spacing respectively. A significant decrease in harvest stand counts, from 3.03 to 2.72 plants m^{-1}, occurred with the wider seed spacing in 1987 at the Amenia location.

Table 5. Influence of sugarbeet planter ground speed on seed emergence, yield, recoverable sugar and sugar percentage for two planting dates at Crookston, MN and Amenia, ND during 1987.

Planter	Location				
	Crookston		Amenia		
Speed $m\ s^{-1}$	**Planting Date** First	Second	First	Second	Mean
	Seed emergence, %				
1.34	58.0	26.4	54.1	39.2	44.4
2.24	52.8	24.4	65.9	35.2	44.6
	*	ns	**	ns	**
	Roots, $Mg\ ha^{-1}$				
1.34	46.6	35.8	29.8	29.0	35.3
2.24	43.2	33.4	27.5	22.6	31.7
	ns	ns	ns	**	**
	Recoverable sugar, $kg\ ha^{-1}$				
1.34	6067	4211	3662	3515	4364
2.24	5495	4019	3324	2721	3890
	*	ns	*	**	**
	Sugar, %				
1.34	17.5	16.1	16.8	16.5	16.7
2.24	17.1	16.5	16.6	16.5	16.7
	ns	ns	ns	ns	ns
	Recoverable sugar, $kg\ Mg^{-1}$				
1.34	130	118	123	121	123
2.24	127	121	121	120	122
	ns	ns	ns	ns	ns

*, ** Significance at the 0.05 and 0.01 probability levels,respectively. ns = not significant.

Sucrose content was not significantly affected by planter ground speed or seed spacing in either of the two years.

On the basis of these results, we conclude that excessive ground speed during the seeding of sugarbeets is undesirable. An increase in sugar production also occurs with narrow seed spacing that results in greater plant populations.

Table 6. Influence of sugarbeet seed spacing on seed emergence, yield, recoverable sugar and sugar percentage for two planting dates at Moorhead, MN, Fargo, ND and Crookston, MN during 1986.

	Location						
	Johanson		Fargo		Crookston		
Spacing	**Planting Date**						
mm	First	Second	First	Second	First	Second	Mean
			Seed emergence, %				
63.5	66.8	55.9	43.1	65.8	51.7	52.2	56.4
127.0	68.0	57.8	41.2	64.3	59.9	60.0	58.4
	ns	ns	ns	ns	**	**	ns
			Roots, Mg ha^{-1}				
63.5	32.1	31.3	38.3	40.0	46.3	43.1	37.7
127.0	33.7	31.7	39.4	39.2	46.9	40.0	37.9
	ns	ns	ns	ns	ns	**	ns
			Recoverable sugar, kg ha^{-1}				
63.5	3211	3447	4352	4485	6544	5368	4394
127.0	3356	3441	4457	4352	6487	4952	4356
	ns	ns	ns	ns	ns	**	ns
			Sugar, %				
63.5	14.2	15.2	15.5	15.3	18.8	17.0	15.8
127.0	14.3	15.1	15.5	15.3	18.5	16.9	15.7
	ns	ns	ns	ns	ns	ns	ns
			Recoverable sugar, kg Mg^{-1}				
63.5	100	111	114	112	141	125	115
127.0	100	110	113	111	138	124	114
	ns	ns	ns	ns	ns	ns	ns

*, ** Significance at the 0.05 and 0.01 probability levels, respectively. ns = not significant.

Table 7. Influence of sugarbeet seed spacing on seed emergence, yield, recoverable sugar and sugar percentage for two planting dates at Crookston, MN and Amenia, ND during 1987.

Spacing mm	Crookston First	Crookston Second	Amenia First	Amenia Second	Mean
			Seed emergence, %		
63.5	55.7	28.1	59.8	39.3	45.7
127.0	55.1	22.7	60.2	35.1	43.3
	ns	*	ns	ns	ns
			Roots, Mg ha^{-1}		
63.5	45.4	36.8	29.1	27.5	34.7
127.0	44.4	32.4	28.3	24.1	32.3
	ns	ns	ns	**	*
			Recoverable sugar, kg ha^{-1}		
63.5	5915	4411	3550	3342	4305
127.0	5646	3819	3436	2894	3949
	ns	*	ns	**	**
			Sugar, %		
63.5	17.5	16.5	16.7	16.6	16.8
127.0	17.1	16.2	16.6	16.4	16.6
	ns	ns	ns	ns	ns
			Recoverable sugar, kg Mg^{-1}		
63.5	130	120	122	122	124
127.0	127	118	122	120	122
	ns	ns	ns	ns	ns

*, ** Significance at the 0.05 and 0.01 probability levels, respectively.
ns = not significant.

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