PLANTER DEVELOPMENT FOR SEGMENTED SUGAR-BEET SEED

Roy Bainer 1/

Recent investigations at the California Agricultural Experiment Station have been directed toward the development of precision planting equipment for segmented sugar-beet seed. Previously conversion units were developed and submitted to manufacturers of drills employing internal run and fluted feed principles. (1) One manufacturer of fluted feed drills adopted the modified unit and made it available commercially. Although the modified internal run feed unit was never made commercially available, one sugar company had patterns made and cast a sufficient number of these units to meet their own needs. The conversion units do fair work for seeding rates as low as 5 pounds per acre. They leave unplanted skips when lower rates are used. On the other hand, for higher seeding rates they tend to bunch the seed. Attempts to modify the Planet Jr. planter failed to improve its performance. Nothing has been done to improve the performance of the plate planters.

Before starting the planter work, apparatus was set up in the laboratory for mounting planter units and driving them at any desired speed. An endless conveyor was provided for carrying grease coated boards (96 inches long) under the planting unit, being tested, to receive and hold the seeds for distribution studies. The speed of the conveyor may also be varied to give any desired rate. A method for making statistical analyses of the data covering the seed arrangement on the greased boards was developed by Dr. F. A. Brooks. (2). The dispersion coefficients obtained from an analysis of the data provides a mathematical comparison of the performance of different planters for similar seeding rates. As the value of the dispersion coefficient approaches the zero the planter performance approaches perfection.

Several principles of metering seed were investigated early in the development program. These included a cup pickup type, horizontal plates and vertical plates. The latter type has several desirable characteristics worthy of consideration. Therefore, much time has been spent in the study and development of this type of planter.

A Rassmann vertical plate planter was obtained for trial. After modifying the cut-off, eliminating the agitator,

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(1) Bainer, Roy. New developments in Sugar Beet Production. Agricultural Engineering. Vol. 24, No. 8, pp. 255-58. August 1944.

(2) Brooks, F. A. Agricultural Engineer, California Agricultural Experiment Station. Statistical Method of Rating and Interpreting Single-Seed Planter Performance. Unpublished.

1/ Agricultural Engineer, University of California.

and relieving the housing at the discharge, this unit began to show promise. The Rassmann unit consists of a cast iron housing enclosing a wheel or plate 14 inches in diameter with a 1 inch offset rim. One hundred eighty-five equally spaced 0.180 inch cells, slightly countersunk, extend through the offset rim. The underside of the rim is backed by a cast iron ring. As the rim passes through the hopper, which is located on top of the housing, the cells fill with seeds. Upon leaving the hopper the rim passes under a cutoff, into a confined area of the housing until near the lowest point of travel. Here the housing is relieved so that the seeds can fall out, or be pushed out, by a positive star wheel knock-out. The construction at this point accounts for some of the irregularity with which it drops seeds. The time differential between a seed falling out of a cell due to gravity and another remaining in a cell until forced out is great enough to influence regularity of spacing. The trajectories taken by different seeds as they leave the wheel also have some effect upon placement. A planter, when traveling at 2 m.p.h., cover 36 inches of row every second. A fraction of a second delay in the time required for a seed to fall from the planter to the furrow has a definite influence upon the spaces between seeds.

The Rassmann unit is quite consistent in metering the same number of seeds per revolution of the wheel.

The number of seeds dropped in an 8 board run varies only two or three seeds per board for a given seeding rate. This unit gives good results with seed graded through a 10/64 inch and over an 8/64 inch screen, table 1, which follows:

Table 1.- Greased board tests with the Rassmann vertical plate planter.

Graded U. S. 33 seed used
185 - 0.180-inch holes slightly countersunk
Theoretical Spacing, 2.38 inches
Length of run 64 feet
Speed 2 m.p.h.

Seed size	Rate Lb./Acre	Seeds per inch			Inch spaces without seeds					Dispersion coefficient
		3	2	1	0	1	2	3	4	
Thru 10 Over 9	3.20		5	317	36	157	108	20	3	0.14
Thru 9 Over 8	3.36	1	33	295	29	182	100	14	4	0.22
Thru 10 Over 8	3.32		16	320	34	185	101	14	1	0.19
Thru 10 Over 7	3.43	8	100	248	79	154	103	15	1	0.57

The results were as good or better when the unit was used with seed varying 1/32 inch in size than with seed varying only 1/64 inch in size. When 10/64 inch to 7/64 inch was used there were over 6 times as many doubles than when 10/64 inch to 8/64 inch was used. In addition there were 8 groups of 3 seeds per inch.

A new unit, patterned after the Rassmann planter was built for mounting between the disks of a redesigned furrow opener. This unit was made with 128 cells and the width of the wheel rim was cut to 1/2 inch. The leading edges of the cells were relieved to facilitate feeding. No changes were made in the knock-out arrangement. A 1-inch length of 1/2-inch tubing was attached to the discharge side of the planter to conduct the seeds away from the wheel, and reduce the angle of the trajectories followed by different seeds as they fell. Grease board tests indicated improvement in seed spacing from the addition of the tube. The unit is mounted with discharge end of the tube only 1 inch from the bottom of the furrow. Field plantings have not yet been made with this unit.

The Cobbley vertical plate planter recently redesigned by Rowland Cannon, Agricultural Engineer for the Utah-Idaho Sugar Company, is under test at Davis. The unit shows much promise for seeding rates from 2.5 to 4 pounds per acre, when handling seed graded between 9/64 inch and 7/64-inch screens---the size for which it was designed. The unit consists of a rotor 6 inches in diameter and 3/4 inch thick with fifty, 5/32 inch equally spaced cells extending 1/8 inch radially into the rim. The leading edges are relieved to facilitate filling. A machined groove extends around the rim passing through the center of the cells. This permits the use of a thin tapered metal ejector for crowding the seeds out of the cells at the point of discharge. The rotor is operated with its axis horizontal. It is enclosed in a metal case with a seed hopper on top. As the rotor revolves through the hopper, seeds fall into the cells. A stationary cut-off removes surplus seeds as the filled section of the rotor leaves the hopper. The outer case fits close enough to the rotor to hold the seeds in the cells until the point of discharge, which is near the bottom. The metal ejector is attached so that it starts to crowd the seeds out of the cells as soon as the cells leave the case, resulting in a uniformly timed discharge of seeds. In other words, there is no opportunity for the seeds to fall out of the cells before being ejected as is possible with the Rassmann unit.

A preliminary run with the Cobbley unit, in which 9 to 7 seed furnished by the Utah-Idaho Company was used in a 384-inch run, showed 20 inches with doubles out of 158 inches containing seeds. When another lot of seed (US 33) graded between the same limits was used, only 2 inches out of 150 inches contained 2 seeds. A screen analysis, table 2, showed that the sample of US 33 was made up of a higher percentage of larger seed. The screen analysis shows the wide variation that may be expected in seed size range even though originally graded between the same limits. This variation in size distribution has a marked influence upon planter performance.

Table 2.- A screen analysis of two lots of 9 to 7 seed.

Seed size	Percentage Retained	
	Utah-Idaho Seed	U.S. 33 Seed
Through 10 over 9	0.0	0.26
Through 9 over 8	31.0	57.5
Through 8 over 7	57.0	38.0
Through 7 over 6	11.5	3.8
Through 6 over 5	0.2	0.36
Through 5 on pan	0.3	0.08

A series of tests were run with the Cobbley unit to determine how seeding rates and plate fill varied with rotor speed. The runs were made with the planter discharge 1 inch above grease boards traveling at 2 m.p.h. The data taken, runs 1 to 5, table 3, were used for calculating a dispersion coefficient for each rotor speed. The plate fill was calculated by dividing the actual number of seeds caught on the boards for a given length of time by the number of cells exposed to the seed hopper during the same time interval. On this basis a rotor speed of 16.65 r.p.m. gave a seeding rate of 2.4 pounds per acre and a plate fill of 106.2 percent as compared to a seeding rate of 4.33 pounds per acre and a plate fill of 76 percent at a rotor speed of 42 r.p.m. A comparison of the above data shows that a speed increase of 250 percent resulted in only a 180 percent increase in seeding rate, which may be accounted for by the difference in plate fill.

The construction of the Cobbley unit makes it possible to more easily adapt it to the shoe opener than to the disk opener, and keep the discharge point close to the furrow base. It was quite evident that if the metering unit could be mounted with the rotor discharge 15 inches above the ground level enough space could be made available for locating a disk opener below it. This type of mounting requires the use of a 15-inch tube for conducting the seeds from the unit to a point 1 inch above the furrow base midway between the disks. When a 15-inch length of iron pipe 15/32 inch in diameter was used in conjunction with the unit a dispersion coefficient of 0.48 was obtained as compared to 0.24 when the seeds were dropped only 1 inch, indicating a marked change in performance. When a glass tube of the same dimensions was used a coefficient of 0.12 was obtained which indicated considerable improvement in performance. Likewise, a chrome-moly tube gave similar results. (Runs 7 and 8, table 3). Apparently the roughness of the iron pipe had an effect upon the course the seeds followed in passing through it. The fact that the performance was improved with use of smooth tubes instead of a short free fall was probably due to narrowing the trajectory taken by the seeds upon leaving the metering device. The unit has been mounted above the disks of a regular beet planter in order to test the unit in the field.

Table 3.- Greased board tests with Cobbley vertical plate planter.

Note: Seed used in all trials was U.S. 33 graded through 9/64-inch and over 7/64-inch round-hole screens. Speed of greased boards was 2 m.p.h. Length of run, 32 feet.

	Seeds per Inch			Inch Spaces without Seeds						Dispersion Coefficient
	3	2	1	0	1	2	3	4	5	
Run No. 1 Rotor speed 16.65 rpm. 1-inch free fall Seeding rate 2.4 lb./A 106.2 % plate fill										
		5	147	16	59	58	13	3	1	0.24
Run No. 2 Rotor speed 22.2 rpm. 1-inch free fall Seeding rate 3.07 lb./A 101.5 % plate fill										
	1	5	188	51	109	31	5	1		0.24
Run No. 3 Rotor speed 30 rpm. 1-inch free fall Seeding rate 3.84 lb./A 96 % plate fill										
		17	214	115	83	24	3	3		0.30
Run No. 4 Rotor speed 37.5 rpm. 1-inch free fall Seeding rate 4.1 lb./A 81.0 % plate fill										
		10	249	166	68	13	9	1		0.22
Run No. 5 Rotor speed 42.0 rpm. 1-inch free fall Seeding rate 4.33 lb./A 76.0 % plate fill										
	2	32	215	155	62	19	10	1		0.43
Run No. 6 Rotor speed 22.6 rpm. Through 15-inch length of 15/32-inch iron pipe										
		37	148	56	81	33	12	4		0.48
Run No. 7 Rotor speed 22.6 rpm. Through 15-inch length of 15/32-inch glass tube										
		8	203	60	134	15	3			0.12
Run No. 8 Rotor speed 22.6 rpm. Through 15-inch length 35/62-inch Chrome-Moly tube										
		9	205	58	140	12	2			0.11

While the vertical plates give uniform distribution throughout a limited range of seeding rates, they are not able to handle the wide range possible with the horizontal plate. This characteristic is more pronounced for the Cobbley unit than for the Rassmann planter because the distance between cells on the Cobbley rotor is 60 percent greater than on the Rassmann wheel. The cell walls are vertical only in one position during their circular path through the seed hopper thus affording a less favorable position for filling as compared to the cells in a horizontal plate. In addition, the length of contact between a cell and the seed is greater for the horizontal plate, which gives greater opportunity for filling the cell.

Another precision planting unit, now under construction, consists of a carefully machined and fitted horizontal plate for metering seed into cups uniformly spaced on a vertical chain and synchronized with the plate cells. The purpose of the latter is to carry the seeds from the plate to a position between the opener just above the bottom of the furrow, thus maintaining the uniform distance between seeds received from the plate until discharged into the ground. Since finding that small tubes can be used for conveying seeds through short distances without disrupting their relative arrangement, further work is contemplated with horizontal plates and tubes for discharging the seed close to the ground.

* During the spring of 1943, an experimental distributed hill plate was developed for use on a low-drop planter. The distance from the plate to the ground level was 7 inches. The plate was constructed to plant four seeds 1.1 inches apart in hills, with a center to center distance for each grouping of 9.9 inches. Other spacings may be obtained by changing the speed of the plate. A distinct distributed hill was obtained in the grease board tests and in the field. When a similar plate was tried on a planter with a 34-inch drop, the hill effect was lost, indicating crossed trajectories resulting from different paths followed by seed in dropping through the longer seed tube. The tube used was of the regular spiral construction.

The objective in developing distributed hill planting was to entirely eliminate thinning. In general, field germination under average conditions amounts to less than 50 percent. By planting four seeds per hill, the likelihood of obtaining one or two plants in each hill appeared to be favorable. If extra plants are produced in a hill, they may be treated as weeds during the normal hoeing operation, thereby eliminating a separate thinning operation.

A half-acre plot was planted with such a planter in 1943 and the crop carried through to harvest. A seeding rate of 2 pounds per acre was used which gave an average of 4.5 planted seeds per hill, the center to center distance of which was approximately 10 inches. The planting was made quite late under unfavorable field and weather conditions. The segmented seed

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* See insert, page 59-b.

used, had been scalped off from the heavy side of a gravity separator and re-graded between 9/64-inch and 7/64-inch round-hole screens. This treatment brought the laboratory germination test of this sample up to 91.5 percent. The seed was untreated which resulted in one-third of the germination stand being lost, from damping off. This planting was not thinned other than to cut out an occasional beet when hoed for weed control. The final stand in this plot was 87 poorly spaced beets per 100 feet. The factor of safety of planting four seeds in a hill when only one plant was wanted came close to providing a satisfactory stand under the adverse field and weather conditions.

When harvest data were taken on all of the plots the stand in the distributed hill planting was 90.6 beets per 100 feet and the yield was 31.98 tons per acre as compared to a stand of 113.7 beets and a yield of 33.45 tons per acre in the plot where 6.5 pounds of seed were planted per acre and handled in the usual manner. A statistical analysis of the yield data indicated that the difference was not great enough to be significant. Another field planting has recently been made with this planter.

A 4-row planter, incorporating a standard plate unit used with a regular spiral tube, a Cobbley unit with a 15-inch tube for dropping seeds between disk openers, a rebuilt Rassmann unit mounted close to the ground between the disks of a redesigned opener, and the expxrimental precision unit with a cupped chain conveyor for lowering the seeds to the ground level, is under construction and will be used for field trials. Field experience is now necessary before the laboratory work can be fully evaluated.

* Insert for page 58.

Following the presentation of the above material at the Denver meeting, tests were run on a John Deere horizontal plate planter equipped with different types of tubes. Because of the importance of the findings, it was deemed desirable to incorporate this material in the paper even though it was not ready for presentation at the time the paper was given.

Tests were run with the planter equipped with the standard spiral tube and furrow opener, a 15-inch length of 35/64-inch chrome-moly tube, and a 32-inch length of telescoped tube which incorporated a 15-inch 35/64-inch chrome-moly tube and a 19-inch length of 45/64-inch brass tube. The latter combination permits the use of the plate in its regular position. The only change necessary is to lengthen the draw bar of the furrow opener $3\frac{1}{2}$ inches in order to permit the use of a straight tube from the plate to the furrow opener. By attaching the lower half of the telescoped tube to the casting of the furrow opener in a universal mount, the opener can be raised and lowered in the usual manner. The cut-off operating against the top of the plate was built up with bronze and fitted to conform to the shape of the plate, thereby decreasing any tendency for seed to leak past it.

The results, table 4,, show that the performance of the horizontal plate is comparable with the Cobbley and Rassmann when the 15-inch length of 35/64-inch chrome-moly tube was used. While the result obtained with the 32-inch telescoping tube were not quite as good as obtained with the 15-inch tube, they were good enough to justify field trials with this type of set up. The regular spiral tube gave an irregular pattern of seed distribution, table 4, run No. 3, which eliminates it for precision work. Field plantings now under way will make an evaluation of the grease boards tests possible.

Table 4.- Greased board tests with John Deere Plate Planter showing effect of type of seed tube upon the distribution of seed.

Note: Plate speed 15 r.p.m. 72 cells per plate
Grease board speed 2 m.p.h.

Seeds per Inch				Inch Spaces without Seeds									Dispersion Coefficient
4	3	2	1	0	1	2	3	4	5	6	7	8	
Run No. 1	Cell diameter 9/64" Plate thickness 7/64" Seed graded thru 9/64 over 7/64 - thru 15" length of 35/64" chrome-moly tube.												
		19	190	54	143	11	1						0.12
Run No. 2	Same as run No. 1 except that 15" chrome-moly tube was used with a 45/64" brass tube to give a telescoped section 32" long.												
		14	179	52	104	34	6						0.25
Run No. 3	Same as run No. 2 except that seed was discharged thru regular 1-3/4" John Deere Spiral Tube and double disk furrow opener. Total drop 32".												
2	7	40	118	62	43	31	15	8	3	2	0	1	1.19
Run No. 4	Cell diameter 10/64" Plate thickness 8/64" - Through 15" length of 35/64" chrome-moly tube. Seed graded through 10/64" over 8/64" screens.												
		16	182	34	139	19	3						0.18
Run No. 5	Same as run No. 4 except seed used was graded through 10/64" over 7/64".												
	6	73	174	133	115	5	1						0.34