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A STUDY OF PRINCIPLES
AFFECTING THE PERFORMANCE
OF MECHANICAL SUGAR BEET
SEED PLANTERS

Thesis for the Degree of M. S.
MICHIGAN STATE COLLEGE
Herbert Ernest Hentschel
1946

THESIS

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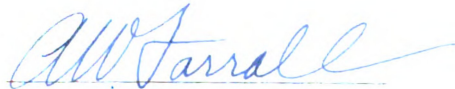
"A STUDY OF PRINCIPLES AFFECTING THE PERFORMANCE
OF MECHANICAL SUGAR BEET SEED PLANTERS."

presented by

HERBERT ERNEST HENTSCHEL

has been accepted towards fulfillment
of the requirements for

M. S. degree in Agriculture

A handwritten signature in blue ink, appearing to read "A. W. Farrell", is written over a horizontal line.

Major professor

Date December 3, 1946

A STUDY OF PRINCIPLES AFFECTING
THE PERFORMANCE OF MECHANICAL
SUGAR BEET SEED PLANTERS

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SUGAR BEET SEED PLANTERS

By

Herbert Ernest Hentschel

A THESIS

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INTRODUCTION:

The combined work of industry, experiment stations, and private research organizations have produced an amazing amount of modern equipment and machines to help the farmer perform his duties better and easier. Machines eliminate a large amount of hand labor that has always been a part of agricultural production. Many crops have already been completely mechanized, while others are only in the beginning phase of mechanization.

Up to about 10 years ago mechanization had had very little effect upon the sugar beet crop. It has always required a great amount of hand labor in planting, blocking, thinning, weeding, and harvesting.

Actual mechanization of the raising of sugar beets has been in effect since before 1879 when mechanical planters were used in the best fields of Europe (10). The planters were inefficient, but did serve to place enough whole seed, containing three to five germs per seedball, in the ground to produce a solid row of plants that could be blocked and thinned to the desired stand. Labor was plentiful up to 1940 and could be obtained to do the extra work of blocking and thinning at a very low wage.

In the present day, with labor a critical factor, it is imperative that mechanical equipment be developed that will all but eliminate the necessity of much hand labor in blocking and thinning. To accomplish this end it is necessary to attempt to develop planters and planting techniques that will produce a seedling for every germ placed in the seed bed.

Buschlen (2) reports, from preliminary greenhouse and small plot tests, that the emergence of uncoated segmented seed is, on the average, only 39% of the potential plants; while Bainer (1) reports that in general, under average conditions, field germination is less than 50%.

One of the main problems in the mechanization of sugar beets, therefore, is to develop equipment to determine the effects of various methods of mechanical seed bed preparation with reference to tillage, placing of seed, seed coverage, and soil compactness over the seed, in an effort to increase the emergence rate.

HISTORY OF SUGAR BEET PLANTING, EQUIPMENT AND TECHNIQUES:

The placing of the sugar beet seed in the ground by mechanical means was given very little attention until the early 1930s. Up to then, and to some extent even now, the seed was planted with a grain drill by closing off several of the seed chutes to produce the desired row widths. While seed was sown at the rate of 20 to 30 lbs. per acre. During World War I a four row beet drill, with a common seed box, was in use in the beet field. It varied very little from the grain drill in principle (4).

About 15 years ago a beet and bean drill was developed as a four row planter with individual seed and fertilizer hoppers for each row. The seed was still metered to the ground by a fluted or double run feed as was commonly used in the grain drill.

In 1933 an interrupted-feed drill was developed and tested the next four years with excellent results reported in 1938 (6). The machine was designed to drop seed for 3 inches in the row and then skip 6 inches, planting at the rate of four pounds of seed per acre. It reduced hand thinning considerably and caused the remaining plants to be disturbed less in thinning and weeding.

In 1938, Garner and Sanders (3) concluded four years of experiments at the School of Agriculture at Cambridge, on the optimum spacing of sugar

beets with the idea of reducing hand-labor and increasing horse-hoeing.

In 1939 Mervine and McBirney (7) reported on the amount of research work being carried on to develop single seed type planters so that uniformly spaced planting could be obtained. The results, however, were not very encouraging.

All these developments in sugar beet planters did tend to eliminate considerable of the hand or "stoop labor." "The sugar beet seedball, however, contains on the average, more than one germ each. Regardless of method of planting, each seedball may produce from none to several seedlings, making finger thinning imperative if a uniform distribution of single seedlings is to be obtained. A reduction in the number of germs per seedball will materially reduce the hand labor of thinning. Moreover, if the beets are to be thinned mechanically, or with a long handled hoe, the percentage of potential singles are greatly increased"(1).

Attempts have been made to produce a single germ seedball through plant breeding. The results have not been satisfactory. "Dr. W. Knolle of the Institute of Land Machines at Holle, Germany, developed a process prior to 1940 for cracking sugar beet seed in an endeavor to reduce the number of germs per seedball. This process was at once commercialized and a limited amount of seed was made available that year. Correspondence with the director of the experiment station at Holle yielded no technical information about the process"(1).

The University of California started an investigation in 1940 in an effort to produce a single germ unit by mechanical means. In 1941 a laboratory machine was built for breaking the seedball into segments of approximately one germ. The shearing process proved a great success in 1942.

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Bainer (3) reports that experience resulting from the use of sheared seed on several thousand acres in 1942 indicates that seeding rates of four to seven pounds per acre produce sufficient seedlings to give satisfactory final stands.

The use of segmented or sheared seed increased rapidly since 1942. The Sugar Beet Journal (8) reports that 70% of all the beets planted in the Eastern area in 1946 were planted with segmented seed.

In 1945 Buschlen (2) reported that the effect of the introduction of segmented seed may be the turning point in the history of the sugar beet industry.

The rapid expansion of the use of segmented seed necessitated the development of seed metering units to handle the smaller single germ cells. A number of metering units were developed and modified since 1943. A satisfactory modified seed metering unit was developed for the internal-run type of feed mechanism. The external fluted-feed mechanism was also modified satisfactorily for the smaller seeds.

An experimental distributed hill plate was developed for use on the low drop or low can planter in 1943. "A seeding rate of two pounds per acre was used with an average of 4.5 seeds per hill. The center distance of the hills was approximately 10 inches. Since the field germination amounts to less than 50%, it was anticipated that the likelihood of obtaining one or two plants per hill was possible. This condition would eliminate hand thinning entirely. Extra plants in the hill could be treated as weeds during the normal hoeing operation" (1). Data on further tests of this planter are not now available.

Some planters have been modified in the last year to reduce the seeding rate to one and a half to two pounds per acre. One company at present is testing a very low drop planter. The purpose of this type of planter is to give gravity less time to work on the single germ cells to cause bunching or bouncing of the seeds in the furrow.

In the spring of 1945, Higgins, McKinley, Witherspoon, and Weckel (5) started experimental work on a vacuum planter, using a new principle of vacuum selection of seed. Some encouraging results in grease-board trials and actual field plantings were obtained.

In 1945 the Dow Chemical Company (2) started research and experimental work on pelleting the segmented seed to produce a seed that is uniformly round and of a size that is easier to work with in designing planters. Good results were reported in the development of the coating process, but a uniform stand, as was anticipated, was not obtained the first year. Further tests are being made on seed pelleting and increasing emergence by adding plant nutrients, insecticides and fungicides to the coating material.

THE EXPERIMENTAL PLANTER:

Development of the Experimental Planter

The construction of a planting machine incorporating a number of variable units to test various planting methods, techniques, and equipment was the first problem. In order to determine the various components of the machine, the points to be investigated were outlined as follows:

1. To study the effects of varying degrees of soil fineness.
2. To study the effects of soil compactness prior to planting.

3. To study the effects of various degrees of soil-seed contact.
4. To study the effects of soil compactness over the seed.
5. To study the effects of various types of furrow openers.
6. To study the effects of various methods of seed covering.

The drawing, Fig. 1, was considered as containing the essential units to aid in carrying out the above studies. It was made as the preliminary work was accomplished in establishing the need for the studies. A means of checking the experimental trials with that of present planters was also determined as essential. A standard planting unit was added to the machine for this purpose. This necessitated changing the preliminary design to include the standard planting unit. The completed planter is shown in Figure 2.

Description of the Planter in General:

The planter was constructed in the research laboratories of the Agricultural Engineering Department at Michigan State College. It incorporated the use of a rotary-tillage unit for better fitting of the seed bed; two interchangeable compacting units in the form of a section of a multipacker and a heavy flat roller, to test the effects of soil compactness prior to planting; two interchangeable furrow openers; and a furrow closing unit and press wheel to test the various degrees of soil-seed contact, soil compactness over seed, and seed covering.

The planter was designed to plant two rows at a time; an experimental row, and a check row or standard row. The standard planter was attached to the machine so that it would operate in much the same manner as the

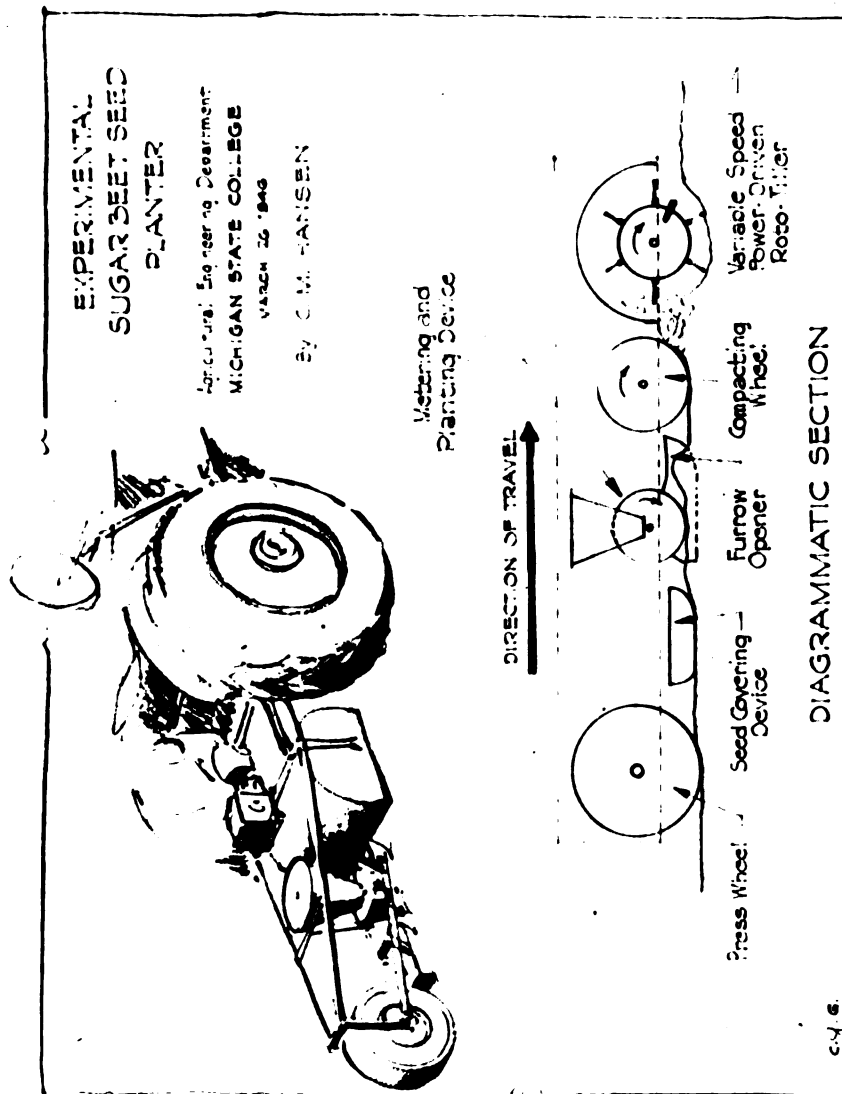


Fig. 1. Preliminary Drawing Experimental Sugar Beet Planter

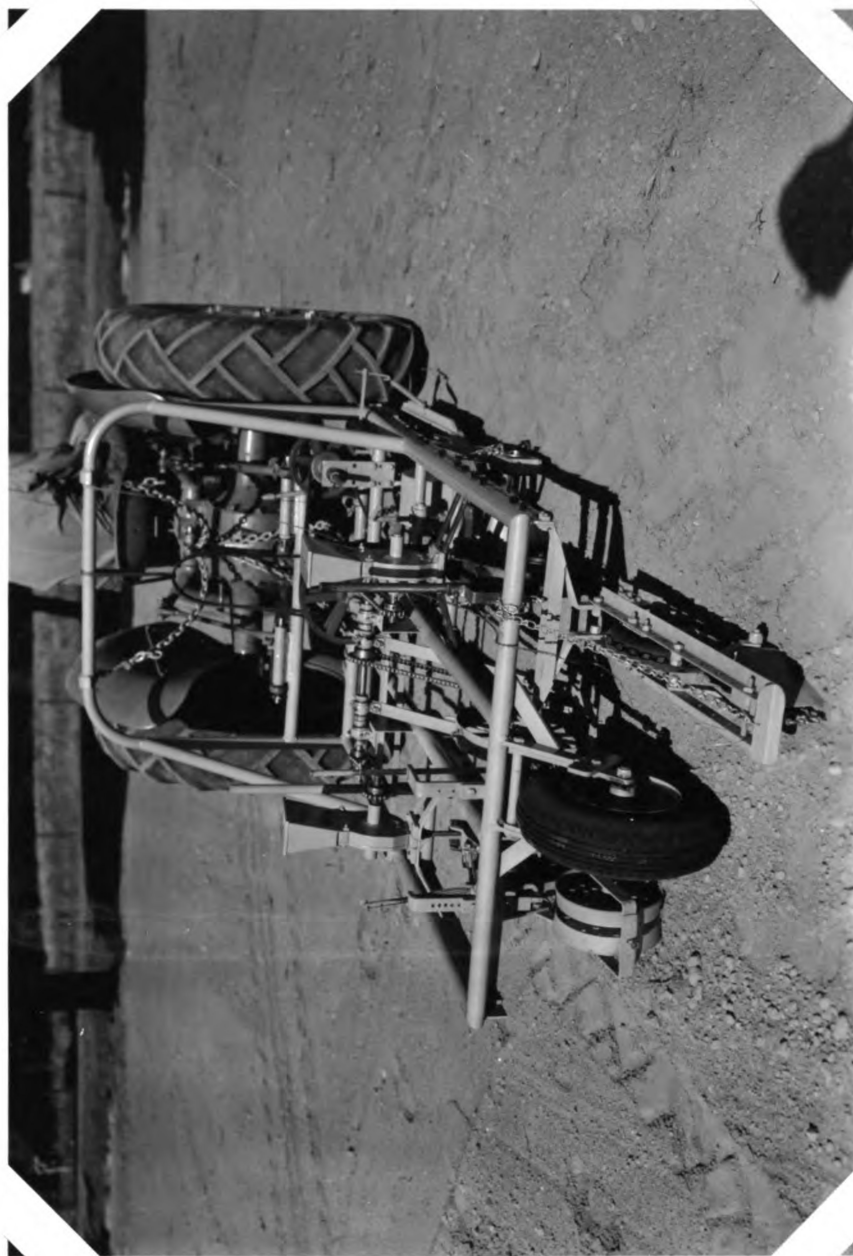


Fig. 2. Experimental Sugar Beet Planter

present machines in the field. The two rows of the planter were fed seed from two separate Copley metering units. Both units were driven at the same speed by a common shaft that was driven by a spiked wheel rolling on the ground. Seed was metered to each row at the same rate.

The entire planting mechanism was designed to attach to the hydraulic lifts of the Ford Ferguson tractor to facilitate moving around in a small field.

Description of Individual Units:

Rotary Tillage Unit:

The rotary-tiller (Fig. 3 and 4) was of the rigid type having two four-inch square plates welded two inches apart on a three-quarter inch shaft. Eight L-shaped teeth, with the foot of the L three quarters of an inch long, were bolted to each square plate in a staggered manner. The cut of the rotor was four and one-half inches and the maximum depth four and a half inches. Power to drive the rotor was supplied by the power take off of the tractor through a drive shaft, V-belts, and a roller chain.

Compacting Unit:

A three wheel section of a cultipacker (Fig. 5 and 6) was assembled in much the same manner as the commercial cultipacker, to supply approximately the same pressure as each section of the commercial machine.

The compacting unit was attached to the planter to follow the rotary tiller. It was suspended in a manner that would permit varying of the pressure from nothing to as much as desired. It can also be easily removed from the machine so that other types of compacting units can be tested.



Fig. 3. Rotary Tillage Unit - Side View

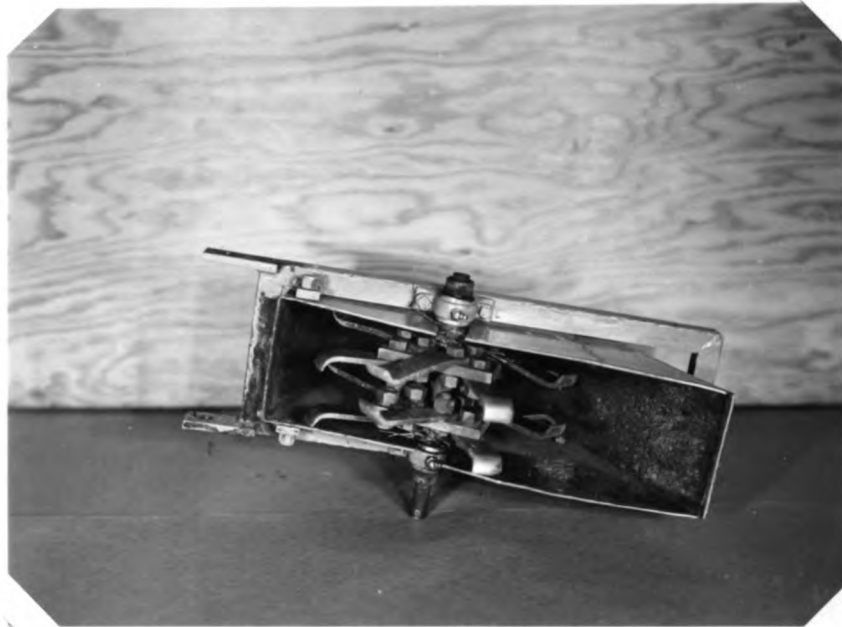


Fig. 4. Rotary Tillage Unit - Bottom View



Fig. 5. Cultipacker Compacting Unit - Side View



Fig. 6. Cultipacker Compacting Unit - Bottom View

A flat roller-type compacting unit (Fig. 7) was also assembled for various tests. This unit was eight inches in diameter, four inches wide, and weighed forty-seven pounds. It was used in place of the cultipacker.

The Furrow Openers and Metering Units:

The furrow opener and metering unit followed the compacting unit. The metering unit was the commercial Cobley unit as developed by the Utah-Idaho Sugar Company. It was bolted in place 20 inches above the ground level with provisions for the furrow opener to be suspended below it in a manner that would facilitate changing from one type to another. Adjustments for changing the depth of planting were also included.

Two types of furrow openers were used (Fig. 8 and 9): the standard shoe-type, as used in older model beet drills, and a laboratory designed furrow opener known as the boat-type opener. It was made to resemble the prow of a boat that would open a furrow by pushing the soil aside and down, giving a rather firm bottom to the furrow. It was expected that a rather firm compact furrow bottom would provide better soil-to-seed contact and would allow the soil moisture more freedom of movement in the vicinity of the seed to improve germination in dry soil.

The Furrow Closing Units:

The furrow closing equipment (Fig. 10) consisted of two separate units to test the effect of soil-seed contact, soil compactness over the seed, and seed covering methods.

One unit consisted of a narrow rubber tired-wheel, as used on the lawn mowers, to follow in the furrow to press the seed into the firm furrow bottom before the seed was covered with soil and also to follow after a



Fig. 7. Compacting Wheel - 47 pounds



Boat Type

Shoe Type

Fig. 8. Furrow Openers - Side View



Boat Type

Shoe Type

Fig. 9. Furrow Openers - Bottom View

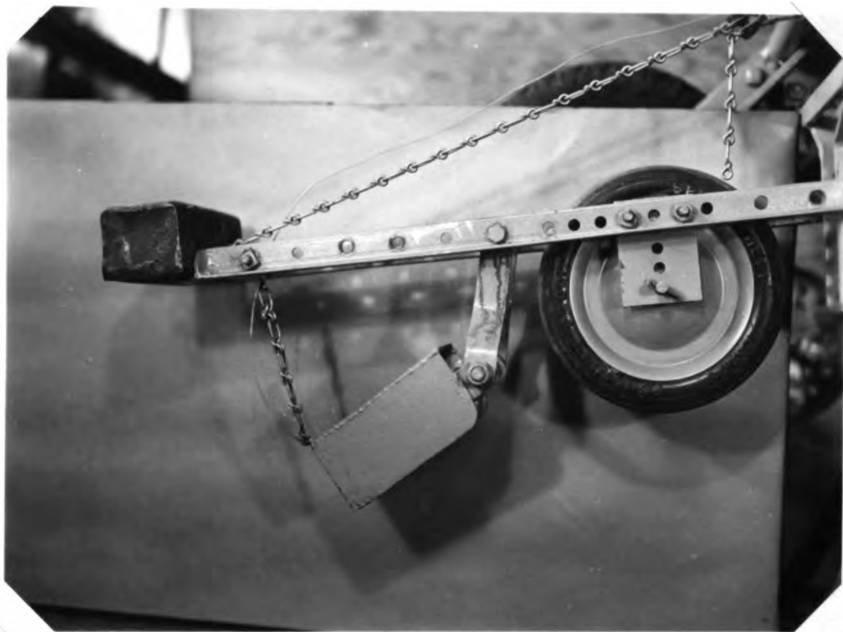


Fig. 10. Furrow Closing Units

closing unit to press the soil on the seed.

The furrow closing unit was a reversed V-type plow, open at both ends, to carry loose soil into the furrow.

The press wheel and the closing unit were made interchangeable so that tests could be planted with the units in either of the two positions.

The Check or Standard Unit:

The standard planter (Fig. 11) was attached to the planter frame 28 inches to the left of the experimental planter. It contained a disc furrow opener with the covering and compacting wheels attached. A Cobley metering unit was used to feed seed to the furrow opener. The check row planter, as used in these trials, was the best of the commercial units now in use.

FIELD PROCEDURE IN PLANTING:

Germinator Test:

At the beginning of the field tests, several samples of seed were obtained from the planter for germinator tests. In order to obtain representative samples, the tractor with the planter was driven down a row one hundred feet long, as in actual planting, with sacks tied over the seed spouts to catch the seed as it was metered to the row. Several runs of this type were made. The seeds thus obtained were taken to the laboratory, accurately sampled with the Boerner Sampler and placed in the moist blotter germinator.

According to the germinator count the seed used in the tests should have produced an average of 475 plants per hundred feet.

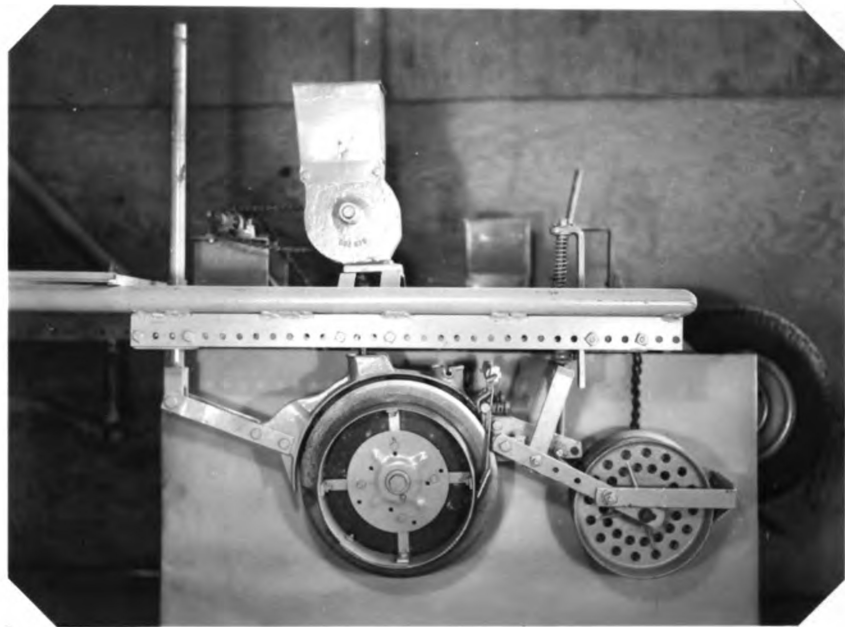


Fig. 11. Standard Planter

Planting Procedure:

Plantings were made in only one direction, so that each experimental row had a standard row, or check row, on each side of it. The various units for the treatment were placed in the proper position with the furrow opener set at one-half inch depth. Then for the next planting the furrow opener was set at one-inch depth, then rows one and one-half inches deep, and two inches deep were planted. In the next treatment the other type furrow-opener was used with the same procedure repeated.

The next treatments were accomplished by interchanging the covering shoe and press wheel. The same planting procedure was followed again for each furrow opener and for each of the four depths.

This procedure was carried through for the entire test. Test plantings were made with the rotary-tiller running at approximately 240 R.P.M. at a depth of three and one half inches, followed by the cultipacker, without a compacting unit, and with a flat 47 pound compacting wheel. Other tests were made with the rotary-tiller running at 240 R.P.M. at a depth of one and one-half inches, with the cultipacker, and without a compacting unit. Tests were also made using the cultipacker without the rotary-tiller and without the rotary-tiller or compacting unit. All tests were made using segmented seed.

WEATHER:

The field testing was carried on from June 24th to August 31, 1946. The period was marked by an extreme drought. The rainfall for July was .05 inches and for August .73 inches. The normal rainfall taken from a 40-year average, 1901 to 1940, is 2.67 inches for July and 2.65 inches

for August.*

The soil moisture content was very low throughout the trials. Moisture determination of an adjacent area indicated 4.63% moisture on July 1, 6.7 % on July 6, 10.1% on July 19, 9.3% on July 27 and 6.46% on August 3. The field moisture capacity of a Hillsdale sandy loam is approximately 15% (9). Rainfall, soil temperature and soil moisture are given on the chart - Figure 12.

THE TEST PLOT:

The emergence test plot was a rectangular field 160 feet wide and 350 feet long. It was located on the experimental farm of the Farm Crops Department of the college. The soil was a Hillsdale medium sandy loam with areas which appeared to be of a heavier soil type, Sugar beet experiments were carried out on the plot the preceding year.

The emergence rate, as a whole, in this test, was somewhat distorted through the presence of black root disease and possible other pre-emergence diseases that were quite predominate in the field.

DETERMINATION OF EMERGENCE RATE:

Due to the unusual dry weather conditions a definite schedule for counting the seedlings could not be followed. Counts were made when it was thought that most of the seeds had produced seedlings. The actual

*Precipitation data by courtesy of R. C. White, Project Supervisor, Michigan Hydrologic Research Project, U. S. D. A., S. C. S., of East Lansing, Michigan.

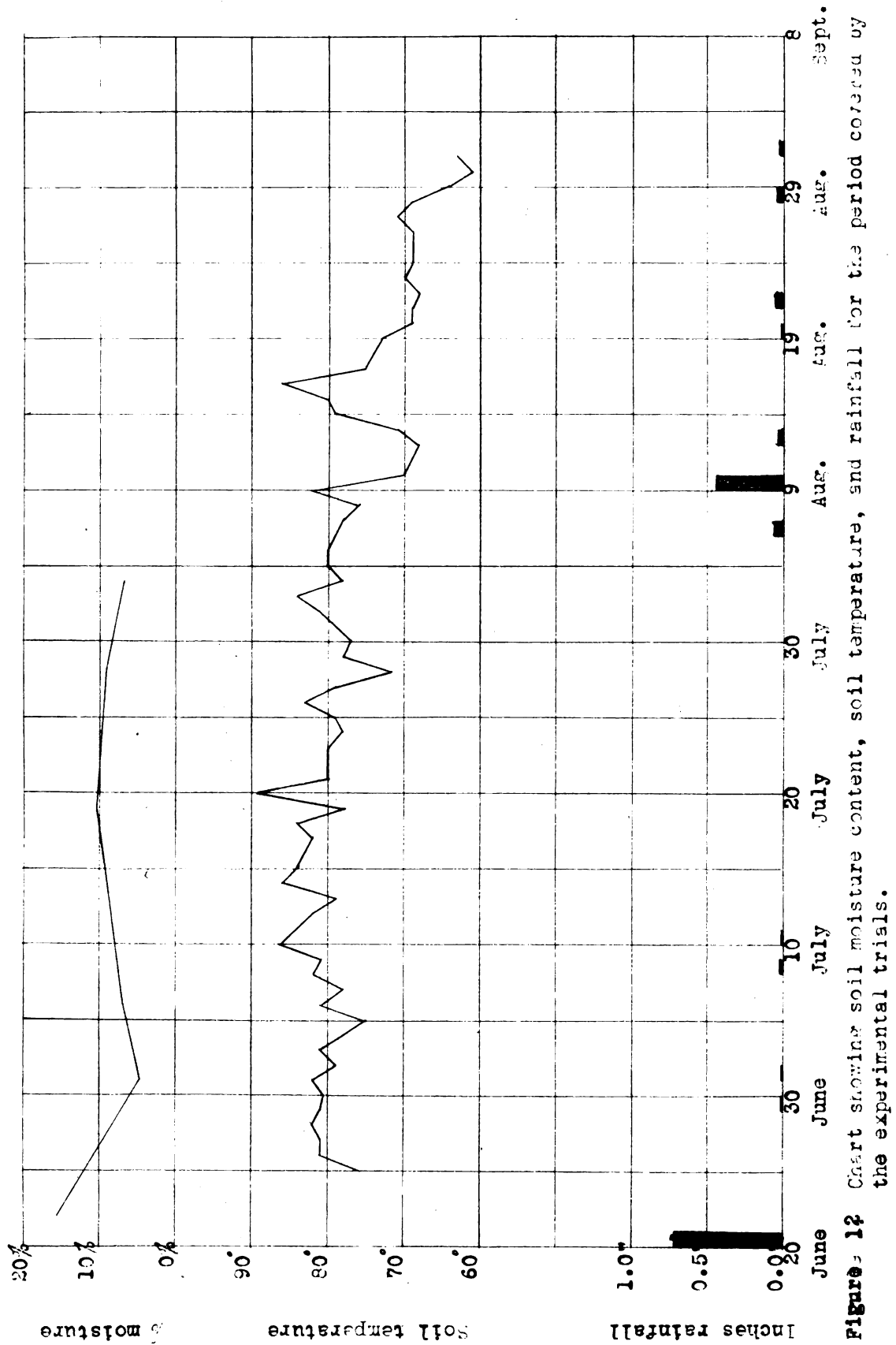


Figure 12 Chart showing soil moisture content, soil temperature, and rainfall for the period covered by the experimental trials.

counting was accomplished by stretching a cord across one end of the field and another one 100 feet down the row. All the seedlings in the measured area were counted and tabulated. Several counts were made of some rows at various lengths of time after planting to determine the emergence rate. In most cases it was found that the count at the later dates was less than the earlier counts, indicating a loss of plants through disease, drouth, or other causes.

PRESENTATION OF THE DATA:

The data obtained in the trials was tabulated and combined into Table I.

The units as listed across the top of the table give the order of operation of the units in the experimental planter. The crosses in the columns headed by the units indicate which of the units were used in each treatment. The figures in the depth of planting columns denote the percent emergence, or the emergence rate of the experimental planter as compared to that of the standard planter.

The emergence rates of the standard rows were grouped by planting dates. The average emergence of the standard rows of each planting date was used to determine the percent emergence of the experimental rows of those planting dates. Exceptions to this method exist in a few treatments where it was determined that a more representative emergence rate could be gotten using the average of the two standard rows on each side of the experimental row.

Table I. Summary Table Showing Results of All Planter Tests

Date planted	Treat- ments	Rotary tiller 3½" deep	Rotary tiller 1½" deep	Cultipacker	Compacting wheel	Furrow openers		Press wheel and covering shoe	Covering shoe and press wheel	Depth of planting			
						Shoe-type	Boat-type			¾"	1"	1½"	2"
June 25	1	X		X			X	X		71	75	57	65
	2	X		X			X		X	99	95	99	65
June 26	3	X		X		X			X	82	80	71	44
	4	X		X		X		X		57	66	68	49
July 1	5		X	X		X		X		38	58	71	55
	6		X	X			X	X		45	82	99	78
July 2	7		X	X			X		X	41	92	87	79
	8		X	X		X			X	34	52	75	52
	9	X				X			X	37	80	72	52
	10	X					X		X	90	125	91	86
	11	X					X	X		34	74	75	50
	12	X				X		X		40	101	75	32
	13		X			X		X		9	51	93	54
	14		X				X	X		56	129	99	106
July 3	15		X				X		X	45	101	111	125
	16		X			X			X	34	61	71	68
	17					X			X	81	94	67	40
	18						X		X	117	98	99	68
July 18	19						X	X		162	159	130	119
	20					X		X		64	119	77	64
	21	X			X	X		X		14	60	75	109
	22	X			X		X	X		13	57	113	125

GROUPING OF TREATMENT RESULTS:

All of the data were tabulated into major groups according to depth of planting. The major groups were then broken into minor groups according to the percentage of emergence. Groupings were made as follows:

Major groups:

Group A - Treatments planted at the half inch depth (Table II.)

Group B - " " " " one inch depth (Table III.)

Group C - " " " " one and one half inch depth

(Table IV.)

Group D - " " " " two inch depth (Table V.)

Minor groups:

Low emergence group - Treatments from which the emergence rate was less than 85% of the standard emergence rate.

Average emergence group - Treatments from which the emergence rate was 85% to 115% of the standard emergence rate.

High emergence group - Treatments from which the emergence rate was more than 115% of the standard emergence rate.

Table II.

RESULTS: GROUP A

90% of tests making use of press wheel followed by covering shoe were in low emergence group

70%	"	"	"	covering shoe followed by press wheel	"	"	"	"
100%	"	"	"	shoe-type furrow opener	"	"	"	"
63%	"	"	"	boat-type furrow opener	"	"	"	"
89%	"	"	"	rotary tillage unit	"	"	"	"
33%	"	"	"	no rotary tillage unit	"	"	"	"
90%	"	"	"	A compacting unit	"	"	"	"
75%	"	"	"	no compacting unit	"	"	"	"

The boat-type furrow opener was used in both treatments that fell in the average emergence group. There were no other substantial differences in the two treatment results.

The two treatments that fell in the high emergence group used the boat-type furrow opener.

Table III.

RESULTS: GROUP B

67% of tests making use of press wheel followed by covering shoe were in low emergence group

40%	"	"	"	covering shoe followed by press wheel	"	"	"	"
73%	"	"	"	shoe-type furrow opener	"	"	"	"
36%	"	"	"	boat-type furrow opener	"	"	"	"
67%	"	"	"	a rotary tillage unit	"	"	"	"
None	"	"	"	no rotary tillage unit	"	"	"	"
80%	"	"	"	a compacting unit	"	"	"	"
33%	"	"	"	no compacting unit	"	"	"	"

Four of the six treatments falling in the average emergence group used the boat-type furrow opener.

There were no other substantial differences in the six treatments.

Of the four treatments falling in the high emergence group, three of them used the boat-type furrow opener and three used the press wheel followed by the covering shoe.

Table IV.

RESULTS: GROUP C									
58% of tests making use of press wheel followed by covering shoe were in low emergence group									
50%	"	"	"	"	"	covering shoe followed by press wheel	"	"	"
91%	"	"	"	"	"	shoe-type furrow opener	"	"	"
18%	"	"	"	"	"	boat-type furrow opener	"	"	"
56%	"	"	"	"	"	rotary tillage unit	"	"	"
50%	"	"	"	"	"	no rotary tillage unit	"	"	"
60%	"	"	"	"	"	a compacting unit	"	"	"
50%	"	"	"	"	"	no compacting unit	"	"	"
89% of tests in average emergence group used boat-type furrow opener									
11%	"	"	"	"	"	shoe type furrow opener			
89%	"	"	"	"	"	a rotary tillage unit			
11%	"	"	"	"	"	no rotary tillage unit			
44%	"	"	"	"	"	a compacting unit			
56%	"	"	"	"	"	no compacting unit			
56%	"	"	"	"	"	press wheel followed by the covering shoe			
44%	"	"	"	"	"	covering shoe followed by the press wheel			

The only test falling in the high emergence group was made using boat-type furrow opener with press wheel followed by covering shoe.

Table V.

RESULTS: GROUP D

67% of tests making use of press wheel followed by covering shoe were in low emergence group

80%	"	"	"	covering shoe followed by press wheel	"	"	"	"
90%	"	"	"	shoe-type furrow opener	"	"	"	"
54%	"	"	"	boat-type furrow opener	"	"	"	"
72%	"	"	"	rotary tillage unit	"	"	"	"
75%	"	"	"	no rotary tillage unit	"	"	"	"
80%	"	"	"	compacting unit	"	"	"	"
67%	"	"	"	no compacting unit	"	"	"	"

The three tests in the average emergence group used the rotary tillage unit, and only one test used the compacting unit, shoe-type furrow opener, and covering shoe followed by the press wheel.

All three tests in the high emergence group used the boat-type furrow opener, only one test used no rotary tillage unit, a compacting unit, and covering shoe followed by the press wheel.

DISCUSSION OF RESULTS;

At all four depths of planting, the use of rotary-tiller, compacting unit and shoe-type furrow opener, did not appreciably effect the rate of emergence as compared with the rate obtained with the standard planter. Interchanging the position of the seed press wheel and covering shoe did not effect the emergence rate appreciably.

At all depths the boat-type furrow opener appeared to have some merit, over the shoe-type, in its use as an integral part of the planter. Twenty-five of the 30 trials falling in the average and high emergence groups used the boat-type furrow opener.

CONCLUSIONS;

1. When the method of metering seed is kept constant in planting sugar beets at the deeper levels, under conditions prevailing during these trials, the depth of planting generally had a greater effect upon emergence than did the method of fitting the seed bed and planting the seed. The trials at the one inch depth gave better results than those at the other depths.

2. Under the conditions prevailing during these trials, the use of the rotary tiller and compacting units in fitting and compacting the seed bed is of no value as a part of the planting procedure. The normal preparation of the seed bed evidently breaks the soil up into particles that are small enough to promote good germination.

The use of the rotary-tillage unit may have some value as a part of the planter under planting conditions when the seed bed has not been

normally prepared, or when the soil has been packed excessively by heavy rains prior to planting. Trials were not made using the rotary-tiller under conditions of that kind.

3. In most of the trials, the use of the boat-type furrow opener proved superior to the conventional shoe-type opener. The opening of a furrow by pushing the soil aside and down, leaving a firm furrow bottom for the seed, is evidently the reason for an emergence rate greater than that obtained with the standard planter.

4. Under conditions prevailing in these tests, the addition of supplemental tillage and furrow closing units to the planter did not improve the rate of emergence over that obtained by the use of present day planters.

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