

THE EFFECT OF CULTURAL PRACTICES ON EMERGENCE
AND UNIFORMITY OF STAND OF SUGAR BEETS

By

Irvin Mirle Wofford

A THESIS

Submitted to the School of Graduate Studies of Michigan
State College of Agriculture and Applied Science
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Farm Crops

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AN ABSTRACT

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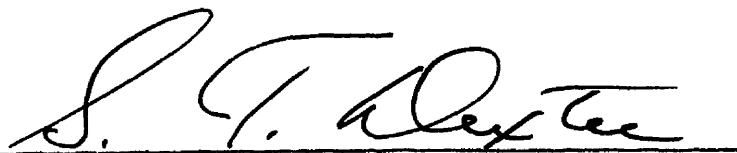
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A handwritten signature in cursive script, reading "S. T. Dexter", is written over a horizontal line.

THESIS ABSTRACT

To determine the effects of various seedbed preparation techniques, soil conditioning materials, green manure crops and seed treatments on the emergence and uniformity of stand of sugar beets, greenhouse and field experiments were conducted in Michigan during the 1951-1953 seasons.

Green manure crops and a wheat straw mulch were turned under with a moldboard plow to give a "plowed" seedbed, disked into the soil to a depth of from three to five inches to give a "medium rough" seedbed, or disked into the surface soil to the extent that part of the material was uncovered and part was just covered with soil, forming a "rough" seedbed. None of these tillage methods gave significantly better stands, vigor or yields of sugar beets. Large amounts of green plant material was supplied by the rye, small amounts by peas, oats, and a mixture of oats and peas and intermediate amounts by barley and ryegrass. An intermediate amount of green plant material added to the soil in the spring resulted in a significant improvement of stand count of sugar beet seedlings and yield of marketable beet roots in comparison with large amounts or small amounts of green plant material. Adding the wheat straw mulch to the soil produced a significantly lower yield of marketable beets than adding an intermediate amount of green plant material.

Various seedbed tillage methods were used on a good alfalfa sod where all, part or none of the hay had been removed the year before growing sugar beets. Emergence of sugar beet seedlings was as high on

plots where all the alfalfa hay was removed as on those where all or part of the hay was left the previous year. Seedbed preparation by plowing or field cultivating in the fall or in the spring gave no statistical stand count differences, the small differences obtained being in favor of spring tillage. In no case did the alfalfa present physical difficulties in the culture of sugar beets that followed. Weeds growing on the field cultivated plots were more vigorous than those growing on the plowed plots. Planting rye in fall field cultivated plots did not affect weed vigor, but resulted in significantly fewer broad-leaved weeds than when no rye was planted.

A series of greenhouse and field experiments were set up to determine the effects of Krilium¹ soil conditioning materials on sugar beets when applied in small amounts (one to 20 pounds per acre) on or in the planted sugar beet row or when applied in large amounts (100 to 1000 pounds per acre) broadcast and disked into the surface soil. No improvement in emergence of seedlings or yield of sugar beet roots was found in these experiments from applications of CRD-186 and CRD-189.

Lots of segmented sugar beet seed were soaked for six hours in running water or partially germinated for periods, ranging from 24 hours to 48 hours, prior to planting. Planting these soaked or partially germinated sugar beet seeds did not increase the rate or earliness of seedling emergence.

¹ Krilium is the collective name given to all soil conditioner materials released by the Monsanto Chemical Company.

A field experiment was set up to study the effects of loose-wet, firm-wet, firm-dry and loose-dry seedbeds on germination and seedling emergence of dry and soaked sugar beet seeds. Data from this experiment show that, (1) sugar beet seedlings emerged earlier from loose-wet and firm-wet seedbeds than from firm-dry and loose-dry seedbeds; (2) rapid emergence of sugar beet seedlings compared with weed seedlings made weed control easiest on the loose-wet seedbed; (3) at all times throughout the growing season the beets appeared most vigorous on the loose-wet plots; (4) a more uniform stand and a higher rate of seedling emergence was obtained when loose-wet and firm-wet seedbeds were used than when the seedbeds were loose-dry or firm-dry; (5) a high rate of sugar beet seedling emergence resulted from compacting the row with tractor wheels in the process of planting on the loose-wet seedbeds.

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INTRODUCTION

Improvement of the percentage and uniformity of sugar beet seedling emergence in the field is at present one of the most important needs in sugar beet production. The unevenness with which sugar beet seeds germinate in the field contributes greatly to the problem. The sugar beet grower is well aware that there is a great deal more variation in rate and percentage emergence of sugar beets than of other seed types such as beans, corn, and small grains. The percentage of emergence frequently varies 200 or 300 percent on different parts of the field or even from count to count down a row.

There are several factors which it is logically believed influence the emergence of sugar beet seedlings. These factors may be conveniently divided into two classes. In one group are the characteristics inherent in the seed germ itself. Why one seed will produce a strong plant and another seed similar in appearance will produce a weak seedling is a problem that has received some attention from different investigators (29,50,51). If there could be found some physical measurements which could be the basis for selection of these seeds inherently capable of producing a strong seedling, undoubtedly this would be a very considerable benefit in obtaining a higher percentage stand and more uniform stands of sugar beet seedlings. In the other group are the external factors which affect emergence rates. Some factors known to affect emergence

are seedbed fitting, planter, planting job, seedbed moisture, disease organisms and insects and soil temperature. In addition to its positive effect on beet yields, the improvement of percentage and uniformity of sugar beet seedling emergence in the field is necessary before complete spring mechanization can be accomplished.

The line of approach herein reported is that of experimentally testing various seedbed preparation techniques, soil conditioning materials, green manure crops, and seed treatments which might have the effect of modifying the environment in which the sugar beet seed is deposited. If some physical measurement could be discovered which, when applied at time of seedbed preparation and planting, could be correlated with emergence, it would be of value, at least as a research tool.

REVIEW OF LITERATURE

Securing satisfactory sugar beet stands from whole or processed seed depends as well on a number of other factors. Along with seed, land preparation, seedbed preparation, seed treatment, environment surrounding the planted seed and growing seedling, and rate and depth of planting have equally important parts in producing desired stands.

Culbertson (22) states that stand is composed of two major factors, first, the original allotment of soil surface determined by the row width and spacing within the row of the individual plants, and second, the number of blank spaces within the row. Dexter (29) states that "large numbers of seed must be planted, and later thinned, in order to get an acceptable stand, because the seeds cannot be planted accurately, nor depended upon to germinate promptly." According to Leach and Bainer (58) field plantings show the same tendency toward increased singleness with lower levels of emergence as is shown by controlled plantings. Evenari (37) reports that the presence of germination-inhibiting substances in plants seems to be a widespread phenomenon. They occur in all parts of plants -- in fruit pulp, fruit coats, endosperm, seed coat, embryo, leaves, bulbs and roots, and are non-specific in their effects. Tolman and Stout (101,102) reported that water-soluble substances contained in the corky pericarp of sugar-beet seedballs were toxic to the germinating seed and reduced both rate and total germination percentage.

Removal of the true seed or soaking in running water eliminated the injurious effects. Further studies by these workers (99) showed that the toxic effect on germinating seed to be largely due to the toxic action of free ammonia released from nitrogenous compounds in the course of seed germination.

Repeated experiments by Barton (8,9) have shown that soaking injury to seeds is enhanced by passing oxygen through the water or salt solution in which the seeds are soaked; passing air or nitrogen in a similar manner reduced the harmful effect but did not permit normal germination.

Hunter (50) in studying various facts concerned with the germination of seeds, particularly in relationship to the behavior of sugar beet seeds in the field and in the laboratory, reports that conditions of proper moisture, temperature, aeration and often light are necessary for germination and to overcome dormancy. Results by Hunter and Erickson (52) indicated that a soil should have a pF of at least 3.7 in order for segmented sugar beet seeds to germinate, whereas corn germinated in considerably drier soil and at conditions slightly drier than this, the seed "dries out" the surrounding soil without germinating. This value is no longer as critical once the seed has germinated. Working with segmented sugar beet seed Hunter and Dexter (51) found, (a) that the seed failed to germinate in air at 100 percent relative humidity and that at this high humidity the seeds obtained a maximum of 29 percent moisture content; (b) in soil, germination did not occur unless the seeds took up somewhat over 30 percent moisture; (c) that germination took up somewhat

over 24 hours, but water absorption was complete in about four hours. On plantings made in soil adjusted to moisture levels ranging from near field capacity to near the permanent wilting percentage, Leach et al. (59) found that decorticated sugar beet seed germinated faster and showed a higher percentage of potential emergence than whole seed at low soil moistures. Only slight differences were noted in rates of emergence between whole, decorticated and segmented beet seed at high soil moistures. Pelleted seed showed a lower emergence and a longer emergence period, the delay being more pronounced in low soil moistures. Doneen (34) reported that the growth of sugar beets is independent of soil moisture so long as readily available water is in the soil.

According to Bayer and Farnsworth (10) long tapering sugar beets, which produce a high tonnage are produced in a friable and well aerated soil. Results of research by Archibald (5) showed that there was a definite relationship between the aeration of the soil and the germination of sugar beets. Wiersma and Mortland (106) found that oxygen can be a limiting factor in growth of sugar beets, and its deficiency may be corrected by use of peroxides. When oxygen diffusion was very low, response to peroxide fertilization was obtained. Data presented by Eyster (38) on the use of concentrations of 0.0015 to 15 percent hydrogen peroxide, show that the rate of water absorption by bean seeds is inversely proportional to the concentration of hydrogen peroxide.

Various seed treatments have been employed in an attempt to stimulate sugar beet seed germination. Tests conducted by Skuderna and Doxtator (93) on presoaking of seed for two hours prior to conducting

germination tests versus dry seed, showed that with beetseed from a fresh crop this treatment is not necessary, unless presence of toxic substances in the seed has been shown. However, on older seed, the presoaking treatment was beneficial. Although sugar beets are regarded as a salt tolerant crop data indicate that they are relatively sensitive to salinity during germination (46,6). Ayers and Hayward (6) found that the percent germination of sugar beet seeds in soil decreased as the amount of sodium chloride added to the soil was increased. Results of experiments by Hunter (50) showed that germination of sugar beet seed treated with magnesium sulphate, sodium chloride, dextrose and sucrose was slightly less than that of the water treatment and these results suggested that the more rapid germination was due to the apparent beneficial action of the water rather than the chemicals in the water in which the seeds were soaked.

Satchell (87) treated sugar beet seed with sodium chloride. Results showed that a more rapid germination was obtained with the sodium chloride treated seed than with the untreated seed, however, the sodium chloride treatments were not superior to treatment with water alone. Greenhouse and field experiments conducted by Garner and Sanders (41) indicated that treatment with strong sulphuric acid is effective in accelerating and increasing germination of sugar beet seed, giving a greater plant population at harvest. Milling of seed, however, was approximately as effective as the sulphuric acid treatment. Lackey (56) gives results of tests by the blotter method which showed that hydrochloric acid and sulphuric acid treatments hastened the rate and

increased the percentage germination of sugar beet seed over checks treated with distilled water. The hydrochloric treatment hastened germination in soil also. Seed treated with magnesium chloride and "drecht" solution showed depressed and abnormal germination in blotter tests and greenhouse conditions, but similar tests with water, phosphoric acid, calcium chloride and sucrose solution treated seeds gave normal germination and, in some cases, an increase in seedling emergence (76).

The literature on the possibility of modifying growth of sugar beet plants through the application of certain synthetic growth-regulating substances to the seed or to the foliage of plants is not in close agreement. Some claims have been made that the yield and quality of plants have been greatly increased by the use of these chemicals and commercial preparations. Other reports have shown that applications of different concentrations have produced no beneficial response to a wide variety of plants. In an attempt to stimulate germination and growth of sugarbeets, using water solutions and dusts and sprays of various hormone preparations, Dexter (31,32) found that growth was not improved nor germination hastened by their use. The differences that were noted among the plots were in favor of those planted with untreated seed. Stout and Tolman (98) found no significant benefits as to seedling emergence, vegetative growth, or yield of beet roots per acre from applications of synthetic growth-regulating substances applied in dusts to the sugar beet seed before planting and in sprays to the foliage of growing sugar beet plants. Data obtained by Mikkelsen et al. (69) indicated that foliar treatments with maleic hydrazide, on sugar beets

grown under conditions conducive to extreme vegetative growth and late maturity, may improve the yield, sucrose content and sucrose yield per acre of the harvested beets.

The results of tests conducted by Skuderna and Dextator (93), using various size seedballs, indicated a positive correlation with seed size and germination. Other workers (30,53,61) have also found that as size of seed increased, germination of sugar beet seed increased. Results of tests conducted by Bush and Brewbaker in 1910 and 1911 (14), showed no significant differences between yields of sugar beets from plantings made with seed graded into different sizes. Bush (13) reports that segmented and whole seed of the same grades (graded with screens) appeared to give about the same results under comparable field conditions. He also found that field germinations produced a higher percentage of singles, for all types of seed, than was obtained in the laboratory.

Results of experiments conducted by Buschlen (15) indicated that germination was most rapid when sugar beet seed was planted in towel tissue containers with loam soil as a germinating medium. He concluded that pre-packaging and space planting of sugar beet seed in small containers appears to be a feasible technique provided efficient machines for packaging and planting are developed. Dionne (33) presented results which indicated that yields can be increased four to five tons per acre by transplanting the sugar beets, but that it is difficult to maintain good shaped roots and mechanical transplanters are not adapted to the beet transplants.

All sugar beets carry some color pigment of either red or yellow color. Nuckols (72) attempted to determine whether color of seedling had any direct correlation upon weight of root or sugar content of beets at harvest time and found that color of plant does not seem to be correlated with either yield or sugar content in the varieties studied.

Considerable agronomic attention has been given to spacing trials in an attempt to determine the optimum stand of plants that will allow the most economical use of the soil resources available. An extensive review of literature regarding space relationships as affecting yield and quality of sugar beets has been compiled by Coons (20). In reporting on work during 1910, 1911 and 1912 Shaw (91) states that the deficiencies of stand, representing a mean of 50 percent, may be divided into three groups: (1) those occurring in the germination stand, averaging 19.32 percent; (2) those due to improper spacing and thinning, averaging 25.53 percent; and (3) those occurring between thinning and harvest, averaging 7.26 percent. In a study on sugar beets Maxson (65) found that, of the mean post-thinning loss of 8.63 percent, diseases accounted for 42.11 percent of the total loss. This worker also found that losses were less when beets were thinned in May than when thinned in June.

Brewbaker and Deming (12) concluded that uniformity of stand, or the elimination of the skips, is more important than actual space allotment in determining yield of sugar beets grown under irrigation. From research conducted over a period of 12 years on plant population experiments with sugar beets Deming (25,26,27,28) concluded, (1) as stands

were reduced yields declined, but the declines were not proportional to the reductions in stand, a 70 percent stand producing about nine-tenths as much as a full stand, a 50 percent stand three-fourths and a 30 to 40 percent stand two-thirds of a normal crop; (2) that it would be more profitable for a grower to save as little as a half stand of timely planted beets than to replant in May; (3) the hill, irrespective of the number of plants it contained, was the unit of stand which determined sugar beet yields; (4) yields declined as row widths increased from 20 inches to 40 inches; (5) additional plants present in multiple plant hills may have some adverse effects on yields under some conditions.

Working with muck soils Davis (23) reports that spacings of 10.7, 12.4 or 14.1 inches between plants in 28-inch rows had no significant effect on yields of sugar beets, and a significant correlation coefficient between stand and yield was not found until the average stand was less than 60 percent. In Ohio, Gray and Volk (42) found that the most productive spacing of sugar beets was 22-inch rows and 12 inches in the row.

The seedbed constitutes the environment of the young sugar beet plant as it advances from germ to the emerged seedling. Much work has been done on the effects of tillage practices as related to seedling emergence and crop yields. Results of these experiments vary as to which method is considered best. This variation is expected because of the differences in the characteristics of the soils used for the studies. An extensive review of literature up to 1919 regarding tillage is presented by Sewell (90). According to Shaw (91) the loss of stand

caused by imperfect germination was due largely to the poor preparation of the seedbed, since fall plowing was seldom practiced and rarely deep enough. Nutt and Peele (74), experimenting with row crops at South Carolina on Cecil sandy loam involving the use of summer crops as sources of mulch, reported that the mulch-disk method afforded a practical way of producing corn and maintaining high yields, while erosion and runoff were reduced to negligible quantities.

Russell and Keene (86), from their comparative studies on different methods of tillage, concluded that plowing is the most satisfactory tillage operation for higher production of crop yields. Results of a study carried out by Dreibelbis and Nair (35) in Ohio on plowed and disked plots, on which there was a 4-year rotation of corn, wheat and two years of meadow, to determine the effects on certain properties, showed that the percentage of soil moisture in the disked plots was consistently higher than in the plowed plots, the air space porosity in the four to seven inch depth was significantly higher in the plowed plots, the percentage of water stable aggregates were greater in the top 4-inch layer on the disked plots but greater in the four to seven inch layer on the plowed plots, and even though corn plants were taller and thinner on disked plots, yields varied from year to year in favor of each treatment. Hill (49) pointed out, as early as 1922, that to secure good yields of sugar beets, deep plowing and subsoiling to a depth of 8 to 10 inches, to make a mellow deep seedbed, is essential to permit the development of a good long root. Farnsworth (39) reported that better sugar beet yields were obtained by farmers who prepared their

seedbed by disking and not by plowing and over-working. According to Gregg (43) and Gregg and Harrison (44) there was an indication that a soil should remain mellow for at least the first half of the growing season for best growth and production of sugar beets.

Smith (95) and Smith and Cook (96) reported that compaction of the soil, following corn and legumes in pot cultures, resulted in a considerable reduction in yield of sugar beets and compaction was found to be more serious than the addition of excess water. On compacted soils where normal moisture levels were maintained additional aeration materially increased yields. Cook (17) reports that sugar beet yields were depressed more than were yields of other crops when grown in the greenhouse in excessively packed clay loam soil. The depth of planting was found by Hentschel (48) to have a greater effect upon emergence than did the method of fitting the seedbed and planting the seed. The average of two plantings made by McBirney (66) showed no significant differences in sugar beet seedling emergence between the harrowed and unharrowed portions of a seedbed which had been fitted for a week or so before planting and which had received 0.4 inch of precipitation. Painter (76) suggested that a heavily worked soil seedbed is not needed to obtain a sufficient stand of sugar beet seedlings under field conditions of excessive moisture, but is needed to obtain a sufficient stand where there is a shortage of moisture. He also found that the packing of soil over seed depressed seedling emergence and soil-seed contact was of greater importance. Correlation studies conducted by Barmington (7) between soil moisture, soil firmness and seedling emergence showed a

striking similarity between the shapes of the curves, indicating the relation between the three factors. Highest emergence of beet seedling was obtained when soil moisture and soil firmness were highest and lowest when these factors were lowest.

Pendleton (78) reports that Chehalis sandy loam, which had been compacted by conventional tillage operations to a point of only about five percent non-capillary porosity in the plow depth could be improved considerably by deep tillage or rotary tillage treatment. Results were characterized by better shaped beet tap roots, faster fall growth and a little improvement in seed yields. It has been reported (67) that if beets are planted on a loose seedbed the top soil is likely to dry out because the subsoil moisture cannot rise through the loose plow layer.

Cook (17,18) reports that experimental results, over a five-year period, from comparisons of seven tillage methods, did not reveal any tillage method that resulted in yields greater than those obtained where the moldboard plow was used, and weed control was more difficult after soil was fitted by those methods which mixed the vegetation with the surface soil. Good yields of sugar beets were obtained from plots where the soil had been plowed and fitted in one operation, and at all times throughout the growing season the crop looked the best on those plots which had received the least pre-planting tillage. Cook and Rood (19) report that records of nine Michigan farmers showed their beet yields increased from below to above the factory averages during seasons in which minimum seedbed preparation was practiced, and all the farmers agreed that weed control was easier after the new method of tillage.

In Sanilac County, Michigan, several sugar beet growers have obtained increased crop yields during the past few years from the use of deep tillage and minimum seedbed preparation (45). Deep tillage refers to the practice of working the soil with various types of field cultivators to a depth of several inches. Johnson (54) reports that farmers in Michigan are trying once-over tillage as a new system of preparing ground to plant corn.

The literature on the subject of fall plowing versus spring plowing is controversial. In the past, the matter of time was one big reason for fall plowing, but this situation has been largely eliminated with the use of the tractor. According to Millar (68) objections to fall plowing include exposure to erosion, use of cover and green-manuring crops is prohibited, and reduction of land on which to spread manure during the winter and early spring. Observations by Schwartz (89) have shown that the soils of Indiana which are fall-plowed are unable to absorb the spring rains, while spring-plowed ground absorbs the moisture and is dry enough to work in two or three days. He further reports that according to soil and crop authorities at Purdue University, whether or not to fall-plow depends a lot on the type of soil and it is most important that a soil which is fall-plowed must contain a lot of humus.

Using a corn-oats rotation experiment, DeBoodt et al. (24) show that yield increases from fall plowing, as compared with spring plowing, were in favor of fall plowing every year. Cox and Hill (21) and Wenner (105) report that fall plowing to a good depth is conceded to be the

best initial preparation for large sugar beet yields; however, when spring plowing is necessary it should be done as early as possible. These workers advocated the use of the cultipacker immediately after seeding and before the beets are up to pack the soil around the seed and to break any crust which develops. Workers at Michigan State College (67) reported that sugar beets should be planted on a firm, granular seedbed which is well supplied with moisture, this condition being most easily obtained on fall-plowed fields. Lill and Rather (60) found that beets yielded best when alfalfa was plowed August 12 and poorest yields resulted from spring (April 15) plowing. In a study made by Johnson and Wright (55), the yield of sugar beets ranged from 10.3 tons per acre for fall plowing, 10.2 tons for a combination of fall and spring plowing, and 9.5 tons for spring plowing. They further reported that spring plowing took about one-third less time and cost about a third less, but there was little difference in cost of fitting the ground after fall or spring plowing.

Extensive research has been conducted on the use of soil building or green manure crops in crop rotations or crop sequences as to their influence upon the crops which follow. A complete discussion of various green manuring principles and practices with a comprehensive bibliography on the subject is presented by Pieters (80). Ripley (83) gives an extensive review of material on crop rotations and influences of crops upon those which follow.

According to Robertson (84) and Robertson et al. (85) highest sugar beet yields were obtained in the rotation where the crop followed

beans which in turn had followed two years of alfalfa-brome hay and lowest yields where there was no legume in the rotation. These workers found that beets did well after alfalfa when moisture and aeration conditions were favorable, but beets did poorly in such a crop sequence during wet seasons when soils became puddled. This suggested to them that possibly a lack of soil air resulted in the accumulation of certain toxic decomposition products where fresh alfalfa had recently been turned under. In a report on new soil physics studies with sugar beets, Farnsworth (39) stated that beets following alfalfa or clover gave larger yields, but some farmers claimed that beets following alfalfa were usually injured by root rot. Morris and Afanasiev (70) concluded, (1) that if sugar beets follow alfalfa the soil should be plowed after the second crop of alfalfa, which should preferably be plowed under and some additional nitrogen (manure) and phosphorus should be added, and (2) the planting of sugar beets on late-fall-plowed alfalfa land, unless manure, nitrogen and phosphorus are added to the soil, is not recommended because the prevalence of root rots makes it difficult to obtain a satisfactory stand and yield. Nuckols and Harris (73) found that legumes, such as alfalfa and sweet clover, in the rotation almost doubled acre yields of sugar beet roots and gross sugar in comparison with results from non-legume rotations. Reeve (82) reports that land may be improved so as to double yields of sugar beets by the use of alfalfa and sweet clover together with heavy applications of commercial fertilizers if the first green manure crop of the season is cut and allowed to remain on the land, the second crop grows through, and the

entire mat plowed under before August 15. According to Garner and Robertson (40), on land which is not well-fertilized with nitrogen carrying materials, alfalfa will contribute materially to crops which follow it in rotation, but where large quantities of nitrogen fertilizers are used the contribution of alfalfa is less important.

Skuderna and Johnson (94) report that beets can follow many crops in rotation but do best after sweet clover left to lie fallow, potatoes, onions, beans and other vegetable crops. Crops with heavy residues like grain stubble and late-plowed or uncrowned alfalfa should be avoided, unless these residues have rotted well. They also report that, where alfalfa is used in the rotation, the practice varies as to whether the first, second, or third cutting is plowed under; the important thing is to turn down some top growth.

In recent years a number of synthetic chemicals have been tested for aggregating soils. Some early investigations (36,57,103) showed that silicates and volatile silicones were effective in aggregating soils, but have such drawbacks as high alkalinity, waterproofing effects or difficulty in application.

The recent release to the public of synthetic polyelectrolyte soil conditioners has stimulated considerable interest in the possibility of soil improvement from their use.

The two synthetic conditioners most widely available are a hydrolyzed polyacrylonitrile (yellow in powder form) and a modified vinyl acetate maleic acid compound (white in powder form). These materials, which were used in the experiments reported here, have been designated

Krilium CRD-189 and Krilium CRD-186 by the Monsanto Chemical Company.

Swanson (100), in an account of what the experiment station tests on soil conditioners have indicated, describes these materials as being long-chain polymers with extremely high molecular weights. Preliminary work by Hedrick and Mowry (47) suggests that at least some of the conditioners have no apparent toxic effects on plant and animal life in the soil and no interference with the absorption of nutrients and trace elements has been detected. It is reported by Schulenberg (88) and Zorch (107) that Krilium does not provide additional crop or plant nutrients, but permits those nutrients already in the soil to become more effective.

Soil structure has a predominant influence on seedling emergence and plant growth. Even though a desirable soil structure can be prepared prior to seeding, it may break down unless there is some stability of the structural units or aggregates. Nason (71) and Zorch (107) state that the primary or direct effect of Krilium is to stabilize the natural soil aggregates against the dispersing or slaking action of water. Many workers (47,62,63,64,71,81,92) report that the addition of synthetic polyelectrolyte conditioners, especially to structurally-poor or "problem" soils, has increased the percentage of water-stable aggregates, and this, in turn, improves soil aeration, soil moisture relationships and soil workability and tilth.

In a recent paper, Hedrick and Mowry (47) reported that additions of CRD-186 and CRD-189 increased the moisture equivalent of soils while leaving the wilting point unchanged, concluding that the use of such

conditioners will cause the soil to hold greater amounts of water available for plant growth. To the contrary, Bodman and Hagan (11) and Peters et al. (79) found that applications of polyelectrolyte soil conditioners do not appear to offer a means of increasing the quantity of available moisture stored in soils.

The changes in soil physical properties are not always reflected in better plant growth. Some plants, however, respond to treatments of soil conditioner materials. In some preliminary experiments, Allison (4) obtained full stands of corn on all CRD-186-treated alkali soils, but because of heavy crust formation, the stands on the untreated soils varied from 0 to 40 percent with little or no yield. Additions of the polymer did not significantly increase corn yields on normal soil. It is reported by Martin et al. (63) and Swanson (100) that the Ohio Experiment Station obtained no statistically significant yield increases of potatoes and sugar beets as a result of applying 0.08 percent CRD-186 or CRD-189 to Brookston and Miami soils in the field. The beets, however, were more easily dug and came out of the ground clean. These workers reported that corn, oats, tomatoes and carrots were most responsive to conditioner treatments and significant yield increases were obtained. In some cases, these yield increases appeared to be closely related to better seed germination and to increased root penetration in the treated soil.

Generally the powder forms were used in the research work reviewed here. However, liquid conditioners may have a place in surface treating of seed rows. Peck and Vittum (77) have developed a machine for accurate

placement of bands of soil conditioner solutions directly over the planted row. Germination and emergence improvement were obtained with several crops including sugar beets from the use of "Kriliun Soil Conditioner Liquid" (3,100). In some experiments treatment resulted in a 40 percent yield increase in oats, and no yield increase in sugar beets on an adjoining plot.

Soil conditioners may prove useful in combating erosion. Swanson (100), Weeks and Colter (104) and Zorch (107) report on their use in stabilizing surface soil against erosive action of rainfall, and, reducing water runoff.

Plant breeders are also attacking the problem of emergence and uniformity of stand of sugar beets. Programs on breeding for single and double germed seed balls have been going on for some time (75). It has even been suggested that single germ seed will be the next significant development in sugar beet production (16).

EXPERIMENTATION

A series of greenhouse and field experiments was set up to determine the response of sugar beets to various seedbed preparation techniques, soil conditioning materials, green manure crops, and seed treatments. All field experiments were conducted on the Michigan State College Farm.

Unless otherwise specified, segmented sugar beet seeds of commercial variety 215x216 were used in all experiments during 1951 and 1952, and commercial variety 216x226, treated with Ortho Seed Guard Liquid, in 1953. The field planting rates, using a commercial four-row beet drill, were eight pounds per acre for dry seeds and six pounds per acre for soaked seeds.

Results were analyzed statistically by standard methods (97).

Experiment I

On June 26, 1951 a planting of sugar beet seed was made using two types of seedbed preparation and including the application of a small amount of water with the seed at the time of planting. Stand counts were used as the means of evaluating the results.

The objective with these different seedbed treatments was to study the effect of seedbed refinement upon plant emergence. The entire area

on which this series of plots was planted was plowed, tandem disked, and dragged with the spring-tooth harrow. This was the degree of working that the plots with the minimum of seedbed preparation received. The next operation consisted of rolling strips 20 feet wide with a cultipacker. These cultipacked strips alternated with strips not cultipacked of the same width. The strips were at right angles to the direction of the rows that were subsequently planted.

Equipment was built on the planter to apply water in the seed furrow immediately after the seed was dropped and before it was covered by the press wheels. It was thought that a small amount of water applied in this manner might give the seed enough stimulus to markedly affect germination rates. Water was applied, at the rate of 22 gallons per acre, to one row only of the four drill rows. Four rounds were made with the drill, making a total of four rows per replication which were treated. The water was turned on and off alternately on each 80-foot section of row so that comparisons with and without water could be made. The planter equipment for applying water is shown in Figure 1.

Data for these experiments are shown in Table I.

Discussion

If seedbed compaction and refinement were desirable under the field conditions that prevailed at the time this planting was made, it would seem logical to expect seedbed B, which was conventional preparation plus cultipacking, to show some improvement over seedbed A, which is termed as conventional.

Figure 1. Equipment used for applying water with sugar beet seed.

Top: Water tank mounted on drill for application of water with the seed in the extreme right hand row.

Bottom: Water tank and shut-off valve for applying water with the seed.



TABLE I

EMERGENCE RATES WITH SUGAR BEET PLANTING MADE ON TWO DEGREES OF SEEDBED PREPARATION WITH AND WITHOUT THE APPLICATION OF WATER

Seedbed Preparation	Water Applied*	No Water Applied*	Average**
A - Conventional	1612	1624	404.50
B - Cultipacked	1633	1728	420.12
Average	405.62	419.00	

* Total stand count for 400 inches of row per treatment per four replications.

** Average for four replications.

Treatment differences were not statistically significant.

Results of this experiment show that total emergence rates were highest on the cultipacked seedbed, regardless of water treatment.

Even though there were no consistent nor significant responses to the application of water, total emergence rates were higher on plots receiving no water.

There was considerable difficulty with stoppage of the seed tube, used to supply water, by soil. If the planter was allowed to roll backwards just a few inches the seed tube was almost certain to become stopped with soil.

Experiment II

A split plot experiment was conducted during the 1951-1952 season utilizing different tillage methods for incorporating green manure crops into the soil as the main treatments and different green manure crops and wheat straw mulch as the subtreatments.

A field of Brookston clay loam soil, which had been summer fallowed in 1951, was selected for this experiment. The plots were plowed in September 1951 with a moldboard plow and no other seedbed preparation was used prior to seeding the green manure crops. The plots were fertilized and seeded at recommended rates the next day after plowing. Wheat straw was spread on designated plots at the rate of two tons per acre.

Yields, as green weight and oven dry weight, of green manure crops were taken in November by harvesting the entire plant (top and roots). These weights are shown in Table II.

The total dry weight of wheat straw was taken as 90 percent of the total rate applied to the plots. Some cold damage was noted on the young field pea seedlings which partially accounts for the low yield of this crop.

Additional harvests were made in May to determine the spring growth of rye and barley. Winter damage to the other crops prevented them from making any appreciable spring growth. Total green weight and dry weight of rye was 22,430 pounds and 5884 pounds, and of barley 11,055 and 2399 pounds per acre.

TABLE II

TOTAL GREEN WEIGHT AND TOTAL OVEN DRY WEIGHT, IN POUNDS PER ACRE,
FOR WHEAT STRAW AND GREEN MANURE CROPS -- 1951

Green Manure Crop	Total Green Weight	Total Oven Dry Weight
Wheat straw	--	3600
Rye	2480	466
Ryegrass	1137	231
Barley	3249	554
Oats	4428	801
Oats and peas	1575	318
Field peas	146	32

The different tillage methods used to incorporate the green manure crops and wheat straw included, (a) disking the material to the extent that it was partly uncovered and partly just covered with soil (rough); (b) mixing the material, by disking, into the top three to five inches of soil (medium rough); and (c) plowing the material under with a mold-board plow (plowed). On May 14, one-third of each plot received one of these tillage treatments.

Due to a rainy season immediately following the tillage treatments planting of sugar beet seeds was delayed until early June. Prior to seeding the sugar beets, the entire field was tandem disked and fertilized. Each plot consisted of six rows, 26 feet long.

Stand counts of sugar beet seedlings were taken three weeks after planting (two weeks after beets had started to come up) on 10 feet of each of the four middle rows. Total stand count per plot for six replications is shown in Table III.

TABLE III
STAND COUNT OF SUGAR BEET SEEDLINGS -- 1952

Green Manure Treatments	Tillage Methods			Average Per Replication
	Rough	Medium Rough	Plowed	
Wheat straw	949	1131	1105	176.9
Rye	722	696	891	128.3
Ryegrass	1115	998	956	170.5
Barley	1120	1006	1311	190.9
Oats	1033	930	937	161.1
Oats and peas	1001	811	1037	158.3
Peas	922	872	944	152.1
Average per replication	162.6	153.4	170.9	
L. S. D. (5%)				32.99

Treatment differences for tillage methods were not statistically significant.

Stand count for 10 feet of four rows per treatment per six replications.

The sugar beets were blocked and thinned by hand labor, then cultivated and hoed throughout the growing season to control weeds. Differences in growth conditions of sugar beets one month after blocking and thinning are shown in Figures 2 and 3.

Figure 2. Two middle rows of beets growing on rye plot.

- Top: Plot portion receiving the rough tillage treatment. Note the large amount of rye remaining on the plant bed.
- Middle: Plot portion receiving the medium rough tillage treatment. Note the small amount of rye remaining on the plant bed.
- Bottom: Plot portion receiving the plowed tillage treatment. Note the absence of rye on the plant bed.



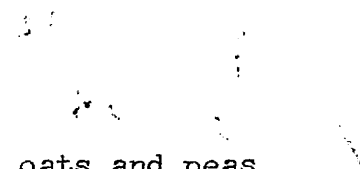


Figure 3. Two middle rows of beets growing on oats and peas plot. Note the absence of plant residue on surface of plant bed.

Top: Plot portion receiving the rough tillage treatment.

Middle: Plot portion receiving the medium rough tillage treatment.

Bottom: Plot portion receiving the plowed tillage treatment.



The four middle rows of each plot were harvested on October 20 and 21, and the number of marketable beets and the weight of marketable beets per plot were recorded. These results are shown in Table IV.

TABLE IV
NUMBER OF MARKETABLE BEETS AND WEIGHT OF MARKETABLE BEETS,
IN POUNDS -- 1952

Green Manure Treatments	Tillage Methods						Average Per Replication	
	Rough		Medium Rough		Plowed			
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Wheat straw	375	243	370	237	409	277	64.1	42.0
Rye	400	274	337	217	424	309	64.5	44.4
Ryegrass	475	321	433	291	501	359	78.3	53.9
Barley	469	320	441	268	477	327	77.0	50.8
Oats	420	301	434	290	417	301	70.6	49.5
Oats and peas	421	295	392	268	449	315	70.1	48.8
Peas	449	291	394	239	465	304	72.7	46.3
Average Per replication	74.0	48.7	69.1	43.1	77.4	52.2		
L. S. D. (5%)							10.40	6.80

Treatment differences for tillage methods were not statistically significant.

Discussion

In no case was any one tillage treatment significantly better than the other tillage treatments. However, the slight differences obtained were always in favor of plowing under the green manure and wheat straw residues.

Stand Counts

The emergence rate of sugar beet seedlings, as shown in Table III, was significantly higher on plots planted to barley than on plots planted to rye or field peas, and significantly higher on plots receiving a wheat straw mulch or planted to ryegrass than on the rye plots. Stand counts for other green manure treatments were approximately equal.

Number of Marketable Beets

Data presented in Table IV show that the number of marketable beets harvested from the ryegrass and barley plots was significantly greater than from the wheat straw and rye plots. There was no significant difference between number of marketable beets harvested from the other plots.

Weight of Marketable Beets

The weight of beets, harvested from plots planted to rye and plots planted to peas was significantly less than the weight of beets harvested from plots planted to ryegrass, and significantly less from the wheat straw plots than from the ryegrass, barley or oat plots. Weight differences of beets harvested from other green manure plots were not significant.

It appears, from the results of this experiment, that too much green plant material or too little green plant material, from spring growth, resulted in poor seedling emergence and yield of sugar beets. Significant improvement did result where intermediate amounts, as was furnished by barley and ryegrass, were incorporated into the soil prior to planting sugar beets. The low yield of harvested beets on the wheat straw plots may have resulted from the large amount of dry, carbonaceous material supplied by this treatment. The breakdown of this material did not begin in time to interfere with seed germination. In fact, the moisture relationship was increased due to the mulch, affording better conditions for germination. The reduction in stand count, number of marketable beets and weight of marketable beets from plots planted to rye was apparently caused by the soil drying out at a faster rate and the slow breakdown of such large amounts of green material. Perhaps if the rye had been plowed or disked before too much spring growth had taken place, these reductions would not have occurred.

Experiment III

A field seeded to alfalfa in May 1950 and cut for hay was used for an experiment to determine the effects of, (1) various methods of handling the hay, (2) different methods of land preparation or tillage treatments for planting sugar beets, and (3) applications of Krilium soil conditioning materials on sugar beets. In 1951, two cuttings were made and the hay removed. The experiment, which was conducted during

the 1952-1953 season, included twenty treatments, replicated six times, and arranged in a randomized block design.

The treatments used in these tests were as follows:

One cutting of alfalfa (June 19), all hay left on plots in 1952.

1. Fall plowed
2. Spring plowed
3. Field cultivated and planted to rye in fall; rye field cultivated in spring
4. Fall field cultivated
5. Spring field cultivated
6. Fall plowed and treated with CRD-186
7. Spring plowed and treated with CRD-186
8. Spring plowed and treated with CRD-189
9. Spring field cultivated and treated with CRD-186
10. Spring field cultivated and treated with CRD-189

Three cuttings of alfalfa, (June 19, August 5, September 16), all hay removed in 1952 (to reduce stand and growth).

11. Spring plowed
12. Spring field cultivated

Two cuttings of alfalfa, (June 19, August 5), all hay removed in 1952.

13. Fall plowed
14. Spring plowed
15. Spring field cultivated

Two cuttings of alfalfa, (June 19, August 5), first cutting removed, second cutting left on plots in 1952.

16. Fall plowed
17. Spring plowed
18. Field cultivated and planted to rye in fall; rye field cultivated in spring
19. Fall field cultivated
20. Spring field cultivated

Cutting dates in 1952 and yields of alfalfa are shown in Table V.

TABLE V

DATES OF CUTTING AND AVERAGE YIELDS OF ALFALFA, IN POUNDS OF GREEN MATERIAL PER ACRE, FOR THREE CUTTINGS -- 1952

June 19	August 5	September 16
17,480 pounds	4,577 pounds	5,815 pounds

Leaving the first cutting of hay on the plots produced an average of approximately 16 percent more growth of alfalfa in second growth than removing the first cutting, and the plants were much taller and dark green color as compared with the smaller, light colored plants on plots having this first cutting of hay removed. The percent soil moisture was also higher (16.73%) when the hay was left on the plot than when the hay was removed (14.21%).

On August 13, plots 3 and 18 were prepared for planting rye by tandem disking and field cultivating, and planted to Balbo rye at the rate of two bushels per acre. Plots 1, 6, 13 and 16 were plowed and plots 4 and 19 were field cultivated on September 12.

On April 15, the rye growing on plots 3 and 18 was field cultivated, and all plots receiving the spring plowing treatment were plowed. Rye yields on plot portions on which the alfalfa hay was not removed was 2.5 times greater (7800 pounds green weight per acre) than on plot portions on which the hay was removed (3073 pounds per acre). During the second week of May, plots previously field cultivated and plots to be field cultivated in the spring were field cultivated. At this time the plots previously plowed were disked. The entire field was then corner-disked to level plots for planting. Sugar beets were seeded in all plots on May 15.

The Krilium soil conditioner treatments were applied to designated plots on May 16, by sprinkling the dry material over the planted beet rows in a band approximately one inch wide. The rate of application was 10 pounds per acre, unmixed with soil.

Seedlings had begun to emerge on all plots on May 22.

Plowing and field cultivating did not kill all the alfalfa plants. Observations were made on the number of alfalfa plants remaining in each plot. At the same time notes were taken on the amount of weed growth in each plot. Visual vigor readings, using an arbitrary standard, on sugar beet plants were made when stand counts were taken, again just after blocking and thinning, and later mid-way of the growing season.

The vigor readings and observation ratings are given in Table VI.

The weed population was determined for all treatments, by counting the number of grass plants and broad leaved weeds in one-foot square areas. The average weed population for a one-foot square area is given in Table VII. The predominating weed species observed in the field included barnyard-grass, Echinochloa crusgalli (L) Beauv., nut-grass, Cyperus esculentus L., foxtail-grass, Setari spp., tickle-grass, Panicum capillare L., purslane, Portulaca oleracea L., yellow wood sorrel, Oxalis stricta L., lambs-quarters, Chenopodium album L., dandelion, Taraxacum officinale Weber, and wild buckwheat, Polygonum convolvulus L. There were also small patches of nut-grass, field bindweed, and quack-grass through the field.

As a further measure of the effects of the different treatments stand counts of sugar beet seedlings were taken on the four middle rows of each plot before blocking and thinning. The results of these stand counts are given in Table VIII.

Discussion

The subsequent growth of alfalfa and the growth and yield of rye was best on plot portions receiving one cutting of alfalfa with the hay left on the plot. This may be attributed to the higher percentage soil moisture maintained on these plots after the hay was cut.

None of the treatments appeared to affect time of seedling emergence.

TABLE VI

VISUAL ESTIMATES OF VIGOR OF BEET SEEDLINGS, SIZE OF WEEDS AND
NUMBER OF ALFALFA PLANTS REMAINING

Treatments		Beet Vigor			Weed Size		Alfalfa Population	
	Tillage	Krillium	June 6	July 7	August 24	June 12	June 12	
Alfalfa								
1 cutting, none removed	F. P.		Average	Average	Average	Small	Intermediate	
	Sp. P.		Average	Good	Good	Intermediate	Low	
	Fd. C. + rye		Good	Average	Average	Intermediate	High	
	F. Fd. C.		Weak	Weak	Weak	Large	Low	
	Sp. Fd. C.		Average	Average	Weak	Large	High	
	F. P.	CRD-186	Average	Average	Average	Small	Intermediate	
	Sp. P.	CRD-186	Good	Good	Good	Small	Intermediate	
	Sp. P.	CRD-189	Good	Good	Good	Intermediate	Low	
	Sp. Fd. C.	CRD-186	Average	Average	Average	Large	High	
	Sp. Fd. C.	CRD-189	Average	Average	Average	Intermediate	High	
3 cuttings, all removed	Sp. P.		Good	Average	Good	Intermediate	Low	
	Sp. Fd. C.		Average	Average	Weak	Intermediate	Low	
2 cuttings, all removed	F. P.		Average	Average	Weak	Small	Intermediate	
	Sp. P.		Average	Average	Average	Small	Low	
	Sp. Fd. C.		Good	Average	Average	Intermediate	Intermediate	
2 cuttings, 1st removed	F. P.		Average	Average	Average	Small	Low	
	Sp. P.		Average	Average	Average	Intermediate	Intermediate	
	Fd. C. + rye		Weak	Average	Average	Large	Intermediate	
	F. Fd. C.		Weak	Weak	Weak	Intermediate	Low	
	Sp. Fd. C.		Average	Average	Average	Intermediate	High	

F. P. = Fall plowed Fd. C. = Field cultivated Sp. Fd. C. = Spring field
 Sp. P. = Spring plowed F. Fd. C. = Fall field cultivated

TABLE VII
AVERAGE WEED POPULATION ON SUGAR BEET PLOTS -- 1953

Treatments	Alfalfa		Grass Plants	Broad-leaved Weeds	Total Grass and Broad- leaved Weeds
	Tillage	Krilium			
1 cutting, none removed	F. P.		15.5	10.2	25.7
	Sp. P.		12.7	20.8	33.5
	Fd. C. + rye		14.2	9.8	24.0
	F. Fd. C.		15.7	18.3	34.0
	Sp. Fd. C.		17.2	13.7	30.8
	F. P.	CRD-186	23.8	12.0	35.8
	Sp. P.	CRD-186	13.1	10.7	23.8
	Sp. P.	CRD-189	17.0	8.8	25.8
	Sp. Fd. C.	CRD-186	21.2	14.3	35.5
	Sp. Fd. C.	CRD-189	18.2	11.0	29.2
3 cuttings, all removed	Sp. P.		14.5	6.5	21.0
	Sp. Fd. C.		18.7	13.8	32.5
2 cuttings, all removed	F. P.		20.7	8.7	29.3
	Sp. P.		24.3	6.3	30.7
	Sp. Fd. C.		19.2	7.5	26.7
2 cuttings, 1st removed	F. P.		12.0	9.3	21.3
	Sp. P.		24.5	7.8	32.3
	Fd. C. + rye		13.8	7.3	21.2
	F. Fd. C.		19.0	13.3	32.3
	Sp. Fd. C.		20.5	11.3	31.8
L. S. D. (5%)			N. S.	7.1	N. S.
Summary of results:					
1 cutting, none removed			16.8	13.0	29.8
3 cuttings, all removed			16.6	10.2	26.7
2 cuttings, all removed			21.4	7.5	28.9
2 cuttings, 1st removed			18.0	9.8	27.8
All fall plowed			18.0	10.0	28.0
All spring plowed			17.7	10.2	27.9
All fall field cultivated			16.9	14.7	27.9
All spring field cultivated			19.1	11.9	31.1
Fall field cultivated + rye			14.0	8.6	22.6
Fall field cultivated, no rye			17.3	15.8	33.2
All CRD-186			19.4	12.3	31.7
All CRD-189			17.6	9.9	27.5

F. P. = Fall plowed F. Fd. C. = Fall field cultivated
 Sp. P. = Spring plowed Sp. Fd. C. = Spring field cultivated
 N. S. = Not significant

TABLE VIII
STAND COUNTS OF SUGAR BEET SEEDLINGS BEFORE
BLOCKING AND THINNING -- 1953

	Treatments		Average Beet Seedlings
	Alfalfa	Krilium	
1 cutting, none removed	Tillage		
	F. P.		225.7
	Sp. P.		242.7
	Fd. C. + rye		314.0
	F. Fd. C.		224.8
	Sp. Fd. C.		241.2
	F. P.	CRD-186	201.0
	Sp. P.	CRD-186	290.7
	Sp. P.	CRD-189	285.2
	Sp. Fd. C.	CRD-186	283.3
	Sp. Fd. C.	CRD-189	299.2
3 cuttings, all removed	Sp. P.		242.0
	Sp. Fd. C.		325.0
2 cuttings, all removed	F. P.		279.2
	Sp. P.		254.3
	Sp. Fd. C.		321.7
2 cuttings, 1st removed	F. P.		249.7
	Sp. P.		285.7
	Fd. C. + rye		232.8
	F. Fd. C.		251.0
	Sp. Fd. C.		266.0
Summary of results:			
1 cutting, none removed			260.8
3 cuttings, all removed			283.5
2 cuttings, all removed			285.1
2 cuttings, 1st removed			255.8
All fall plowed			238.9
All spring plowed			266.7
All fall field cultivated			255.7
All spring field cultivated			289.4
Fall field cultivated + rye			273.4
Fall field cultivated, no rye			237.9
All CRD-186			258.3
All CRD-189			292.7
Treatment differences were not statistically significant.			

F. P. = Fall plowed F. Fd. C. = Fall field cultivated
Sp. P. = Spring plowed Sp. Fd. C. = Spring field cultivated

Stand count per 20 feet of four rows per treatment per six replications.

Number of Alfalfa Plants Remaining After Tillage

As would be expected, plots receiving three cuttings of alfalfa were practically void of alfalfa plants following tillage treatments. Results presented in Table VI show that, in general, plots which were spring plowed had fewer alfalfa plants remaining than fall plowed plots, but plots which were fall field cultivated had fewer remaining than spring field cultivated plots. In no case, however, did alfalfa present physical difficulties in the culture of the sugar beets that followed.

Weed Size and Weed Population

Data presented in Table VI show that plowed plots had smaller weeds than field cultivated plots. The weeds growing on fall plowed plots were smaller than the weeds growing on spring plowed plots, and smaller on fall field cultivated than on spring field cultivated plots. Planting rye in fall field cultivated plots did not affect weed size.

Results of weed counts given in Table VII show that the treatments included in this experiment had no significant effect on number of grass plants and total weeds per plot. However, planting rye in fall field cultivated plots resulted in significantly fewer broad-leaved weeds than when leaving the plots unplanted.

Vigor of Sugar Beet Seedlings

As shown in Table VI, vigor of sugar beet seedlings appeared to be associated with tillage treatments rather than with alfalfa treatments or soil conditioner treatments. Based on visual vigor readings, using an arbitrary standard, "good" sugar beets were produced on fall plowed

plots and "weak" sugar beets on plots field cultivated in the fall.

"Average" beets were produced on all other plots. Growing rye on fall field cultivated plots had no effect on vigor of sugar beets.

Stand Counts of Sugar Beet Seedlings

No statistical stand count differences were obtained between plots receiving the various treatments. However, results presented in Table VIII show that a slightly higher rate of sugar beet seedling emergence resulted when all hay was removed than when all or part of the hay was left on the plot, and a higher rate on CRD-189-treated plots than on CRD-186-treated plots. In either case, seedling emergence appeared to be more closely associated with tillage treatments, the small differences obtained being in favor of spring tillage. Planting rye on fall field cultivated plots resulted in a slight increase in seedling emergence over fall field cultivated plots not planted with rye.

A considerable amount of damping-off occurred during the early part of the growing season. Although there was no correlation between treatments and disease infestation, the effect of disease organisms was a factor in beet stand on those plots having a low rate of sugar beet seedling emergence.

In field trials with sugar beets, Afanasiev et al. (2) found that seedling diseases were lowest when beets followed potatoes and highest when beets followed beets or alfalfa. Afanasiev (1) reported that low temperature and low moisture are favorable to sugar beets, from the standpoint of freedom from seedling diseases, and resistance to damping-off diseases is enhanced by prompt emergence and subsequent growth.

During the course of the experiment reported here, conditions of high temperature and average moisture prevailed during the germination period which may partially account for the disease infestation. The rapid growth following germination aided some of the seedlings to overcome or "grow-out-of" the disease attack.

Although treatment differences for the most part were not statistically significant, and the results of this experiment are inconclusive, the amount of green plant material incorporated into the soil in the spring again appeared to be a factor influencing sugar beet seedling emergence. When only a small amount of material was available, as in the case of fall plowing or field cultivating, low stand counts were obtained. Likewise, if a large amount of green plant material was available, as in the case of removing none or only part of the alfalfa hay, stand counts were low. Spring tillage, following removal of two or three cuttings of hay, added an intermediate amount of green plant material to the soil, resulting in higher stand counts. When rye was grown on fall tilled plots, and incorporated into the soil before too much spring growth occurred, increased seedling emergence was obtained.

Experiment IV

In order to investigate the effects of Krilium¹ soil conditioner materials on germination and uniformity of stand of sugar beets,

¹ Krilium is the collective trade name given to soil conditioner materials released by Monsanto Chemical Company.

greenhouse and field experiments were carried out. These chemicals are presumed to alter the soil structure, aeration, and moisture condition surrounding the planted seed.

Two different Krilium materials, CRD-186 and CRD-189, were used in these experiments. CRD-186 is a modified vinyl acetate maleic acid compound, white in powder form and easy to mix with soil. CRD-189 is a hydrolyzed polyacrylonitrile compound, yellow in powder form, and very difficult to mix with damp soil. Chemically they are long-chain polymers with extremely high molecular weights. Functionally the conditioners are water-soluble polyelectrolytes.

Preliminary greenhouse tests, with Krilium soil conditions, were conducted in 1951 and 1952.

Results of these preliminary tests, where Krilium was mixed with the soil, showed that water infiltrated faster and penetrated to a greater depth on the CRD-186 and CRD-189-treated soil than on untreated soil. Under conditions of puddled soils, the degree of crusting and cracking was less on soils treated with Krilium. However, under conditions of normal soil moisture, soil cracking was negligible on treated soils. Failure to crack may be attributed to the faster rate of water infiltration, and infiltration to a greater depth, into the treated soil. CRD-189 appeared to be slightly more effective than CRD-186 in controlling cracking.

Greenhouse tests were conducted to determine the effects of mixing various rates of CRD-186 and CRD-189 into soil on sugar beet seedling emergence. Results of stand counts were inconclusive, and none of the

Krilium treatments produced germination and emergence earlier than the untreated check.

It was also desired to study the effects of row applications of Krilium soil conditioner materials. Because this would involve applications of very small amounts of material, soil conditioners were mixed with hydrated lime and 0-20-0 fertilizer to increase the volume for a more uniform distribution.

Duplicate greenhouse tests were set up, using different rates of CRD-186 and CRD-189 and three placement variables. Soil conditioners were mixed, at the rate of one and two pounds per acre, with 100 pounds of lime and 100 pounds of fertilizer for uniform distribution. For comparison, Krilium was applied alone at rates of one and one-half pounds and three pounds per acre. These treatments were applied (1) by spreading the material over the planted beet row, (2) by placing the material over seeds in opened furrows and before seeds were covered with soil, and (3) mixing the material with soil before planting the seeds. An untreated check was included for comparison.

Stand counts of sugar beet seedlings were used as the means of evaluating the results. These stand counts are shown in Table IX.

Discussion

Results of sugar beet seedling emergence, shown in Table IX, are inconclusive when comparing applications of CRD-186 and CRD-189 to the planted beet rows or applications over the seeds in opened furrows.

TABLE IX

SUGAR BEET SEEDLING EMERGENCE ON SOIL TREATED WITH CRD-186 AND CRD-189
AVERAGES FOR TWO REPLICATIONS

Carrier	Treatments Rate of Krilium	CRD	Kriliium on Top of Soil		Kriliium on Seed in Furrow		Kriliium Mixed With Soil	
			Average Emergence	Seedlings Actually Growing	Average Emergence	Seedlings Actually Growing	Average Emergence	Seedlings Actually Growing
Lime	1 pound	186	11.5	9.5	11.0	9.0	11.5	9.0
		189	10.0	6.0	12.5	10.0	11.0	10.5
	2 pounds	186	9.5	7.5	8.5	4.5	11.0	9.5
		189	11.0	8.0	10.5	7.5	15.0	13.0
Fertilizer	1 pound	186	11.0	8.5	10.5	9.0	13.0	10.5
		189	16.0	9.5	8.5	6.5	13.0	11.0
	2 pounds	186	11.5	9.5	12.5	11.0	11.5	9.0
		189	10.5	8.5	16.0	14.0	13.5	9.0
None	1.5 pounds	186	14.0	9.5	12.5	10.0	11.5	7.5
		189	11.0	6.0	14.0	11.0	11.0	9.5
None	3 pounds	186	11.5	10.5	14.5	10.0	11.5	9.5
		189	11.5	9.5	9.0	6.0	13.5	11.0
Check			12.0	9.2	10.7	9.5	9.7	7.7
Summary of results:								
Check			12.0	9.2	10.7	9.5	9.7	7.7
Lime			10.5	7.7	10.6	7.5	12.1	10.5
Fertilizer			12.2	9.0	11.9	10.1	12.7	9.9
1-pound rate			12.1	8.4	10.4	8.6	12.1	10.2
1.5 pound rate			12.5	7.7	13.2	10.5	11.2	8.5
2-pound rate			10.6	8.4	11.6	9.2	12.7	10.1
3-pound rate			11.5	9.2	11.6	8.9	11.7	9.2
CRD-186			11.5	9.2	11.6	8.9	11.7	9.2
CRD-189			11.7	7.9	11.7	9.0	12.8	10.7

When Krilium was mixed into the soil to a depth of two inches, all treatments resulted in a higher sugar beet seedling emergence than in the untreated check, and a higher number of seedlings were actually growing at the end of the tests on all treated rows, except those treated with 1.5 pounds of CRD-186 alone.

A more uniform stand of beets resulted from mixing CRD-186 with the top two inches of soil and with spreading CRD-189 over the planted rows than all other treatments.

Field Experiments With Krilium

A series of field experiments were conducted to further determine the effects of Krilium soil conditioners on sugar beet seedling emergence and uniformity of stands.

Experiment 1. A replicated split plot experiment was set up in the spring of 1952 to determine the field response of sugar beets, growing on a Brookston clay loam soil, to applications of Krilium soil conditioner materials. The field was fall plowed and disked, then left to fallow over winter. In the spring, the fallowed plots were given the same three tillage treatments as were applied to the green manure crops in Experiment II.

Soil conditioners were mixed at the rate of one pound or two pounds with 100 pounds of lime or fertilizer. This mixture was applied at the rate of one pound and two pounds per acre of CRD-186 and CRD-189. Other treatments included lime alone, fertilizer alone, CRD-186 alone, CRD-189 alone and an untreated check. The treatments were applied by spreading the material over the planted sugar beet rows in a two-inch band.

Results of stand counts, taken on 10 feet of row, are shown in Table X.

The sugar beets were blocked and thinned, and cultivated throughout the growing season.

The number of marketable beets and the weight of marketable beets were taken at time of harvest. These results are given in Table XI.

Discussion

None of the treatments produced sugar beet seedling emergence earlier than the untreated check, and none of the treatments produced a stand count, number of marketable beets, or weight of marketable beets significantly better than the check.

Stand Count

Although the differences were not statistically significant, data presented in Table X show that a lower rate of seedling emergence resulted from the medium rough tillage treatment than from the rough or plowed tillage treatments. All Krilium treatments produced a slightly higher stand count than the untreated check.

Number of Marketable Beets

As shown in Table XI none of the tillage methods used has a significant effect on the number of marketable beets. The average number of marketable beets was higher for all treatments than for the untreated check. Applications of CRD-189, regardless of the mixing agent used, resulted in a larger number of marketable beets than applications of CRD-186.

TABLE X

STAND COUNT OF SUGAR BEET SEEDLINGS ON KRILIUM TREATED PLOTS -- 1952

Krilium Treatments	Tillage Methods			Average Per Replication
	Rough	Medium Rough	Flowed	
Check	74	63	81	36.3
Lime alone	84	64	104	42.0
Fertilizer alone	94	79	79	42.0
L + 1# CRD-186	102	106	125	55.5
L + 2# CRD-186	91	90	96	46.2
F + 1# CRD-186	113	75	91	46.5
F + 2# CRD-186	94	72	91	42.8
L + 1# CRD-189	120	82	127	54.8
L + 2# CRD-189	84	101	87	45.3
F + 1# CRD-189	89	76	100	44.2
F + 2# CRD-189	90	78	90	43.0
CRD-186, 2#	100	77	96	45.5
CRD-189, 2#	90	88	104	47.0
Average per replication	47.1	40.4	48.9	
Summary of results:				
Check				36.3
Lime				40.6
Fertilizer				43.7
CRD-186				47.3
CRD-189				46.9
1-pound rate				49.0
2-pound rate				45.0

Treatment differences were not statistically significant.

Stand count for 10 feet of row per treatment per two replications.

TABLE XI

NUMBER OF MARKETABLE BEETS AND WEIGHT, IN POUNDS, OF MARKETABLE
BEETS ON KRILIUM TREATED PLOTS -- 1952
AVERAGE OF TWO REPLICATIONS

Krilium Treatments	Tillage Methods						Average Per Replication	
	Rough		Medium Rough		Plowed			
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Check	36	23	37	25	34	22	17.8	11.7
Lime alone	43	23	35	27	50	24	21.3	12.3
Fertilizer alone	48	27	48	27	53	29	24.8	13.8
L + 1# CRD-186	44	26	49	23	53	26	24.3	12.5
L + 2# CRD-186	48	27	58	28	53	28	26.5	13.8
F + 1# CRD-186	50	30	61	29	62	29	28.8	14.7
F + 2# CRD-186	46	22	47	29	54	23	24.5	12.3
L + 1# CRD-189	70	29	70	26	56	26	32.7	13.5
L + 2# CRD-189	59	30	54	30	51	30	27.3	15.0
F + 1# CRD-189	56	26	59	31	59	32	29.0	14.8
F + 2# CRD-189	52	29	59	26	44	25	25.8	13.3
CRD-186, 2#	57	33	41	28	45	32	23.8	15.5
CRD-189, 2#	48	21	46	21	44	19	23.0	10.2
Average per replication	25.3	13.3	25.5	13.5	25.3	13.3		

Summary of results:

Check	17.8	11.7
Lime	26.4	13.4
Fertilizer	26.6	13.8
CRD-186	25.6	13.6
CRD-189	27.6	13.4
1-pound rate	28.7	13.9
2-pound rate	26.0	13.6

Treatment differences were not statistically significant.

Weight of Marketable Beets

The average weight of marketable beets from plots receiving the three tillage treatments was essentially the same. Except for the application of CRD-189 alone, the average weight of marketable beets was lower for the untreated check than for all other treatments.

It is interesting to note that the treatments producing the most marketable beets did not produce the largest weight of marketable beets. This may be due to the higher competition between beet roots in those plots producing a larger number of plants.

Experiment 2. A replicated randomized block experiment was carried out in 1952 to study the effects on emergence and yield of sugar beets when larger amounts of Krilium soil conditioners were applied to the planted sugar beet rows.

The experiment was conducted on a field which had been planted to oats in the fall of 1951. The soil was of a Brookston clay loam type. The area was plowed and tandem disked in the spring to prepare the soil for planting. Krilium soil conditioner materials were mixed in various proportions with hydrated lime and 0-20-0 fertilizer, and applied in a manner described in Experiment 1.

Emergence rates of sugar beet seedlings, taken on 10 feet of row, are shown in Table XII. The sugar beets were blocked and thinned by hand labor, then cultivated during the growing season. Yields were taken on 20 feet of row at time of harvest, and these results are also included in Table XII.

TABLE XII

EMERGENCE RATES OF SEEDLINGS, NUMBER OF MARKETABLE BEETS
AND WEIGHT (POUNDS) OF MARKETABLE BEETS -- 1952
AVERAGES FOR THREE REPLICATIONS

Treatment	Stand Count	Number of Beets	Weight of Beets
Check	31.7	14.3	12.0
CRD-186, 5#	30.7	17.0	13.7
L + 5# CRD-186	39.0	18.7	13.7
L + 10# CRD-186	35.0	17.0	13.3
CRD-186, 10#	39.0	17.7	13.3
L + 15# CRD-186	44.3	24.0	14.0
L + 20# CRD-186	32.0	17.3	12.3
CRD-186, 15#	49.3	20.0	14.3
F + 5# CRD-186	34.3	21.7	16.3
F + 10# CRD-186	43.7	19.0	14.3
CRD-186, 20#	40.3	20.3	14.0
F + 15# CRD-186	39.0	16.7	11.3
F + 20# CRD-186	48.3	18.3	15.7
CRD-189, 5#	39.3	20.7	16.0
L + 5# CRD-189	44.3	18.7	14.3
L + 10# CRD-189	43.7	23.0	14.0
CRD-189, 10#	35.3	20.3	16.7
L + 15# CRD-189	36.0	15.7	14.0
L + 20# CRD-189	43.3	20.3	12.0
CRD-189, 15#	40.0	20.0	14.7
F + 5# CRD-189	50.7	19.0	16.3
F + 10# CRD-189	51.0	18.0	15.0
CRD-189, 20#	46.0	22.3	16.7
F + 15# CRD-189	25.7	19.0	14.3
F + 20# CRD-189	38.7	20.0	14.7
Lime alone	39.3	23.3	16.7
Fertilizer alone	38.3	21.7	16.7
Summary of results:			
Check	31.7	14.3	12.0
CRD-186	39.6	19.0	13.8
CRD-189	41.2	19.7	14.9
5-pound rate	39.7	19.3	15.0
10-pound rate	41.3	19.2	14.4
15-pound rate	39.0	19.2	13.8
20-pound rate	41.4	19.7	14.2
Lime	39.6	19.8	13.9
Fertilizer	41.1	19.3	14.9

Treatment differences were not statistically significant.

Stand count for 10 feet of row per treatment per two replications.

Discussion

Results given in Table XII show that, in no case did treatments have a significant effect on stand count, number of marketable beets or weight of marketable beets.

Stand Counts

Data presented in Table XII show that all treatments, except application of five pounds of CRD-186 alone and fifteen pounds of CRD-189 mixed with fertilizer, produced a higher rate of sugar beet seedling emergence than did the untreated check.

Number of Marketable Beets

All treatments produced more marketable beets than did the untreated check.

Weight of Marketable Beets

Differences in weight of marketable beets were not statistically significant for any treatment. However, the small differences obtained were in favor of the treated plots.

Again, the factor of plant competition was apparent on plots producing a large number of marketable beets, the weight of marketable beets being less from plots having a high number of marketable beets than from plots having fewer marketable beets.

In comparing Experiment 1 and Experiment 2, the data indicate that, in general, applications of CRD-186 and CRD-189 at the one and two pound rates are just as effective as applications at the higher rates.

Experiment 3. A third field experiment was set up in 1952 to study the effects of mixing Krilium soil conditioners with the soil on sugar beet seedling emergence.

A field of Miami clay loam soil, which had grown a crop of sugar beets in 1951, was selected for the tests. The experiment included five treatments, replicated four times, and arranged in a randomized block design.

The plots, which had been plowed in early spring, were double disked and harrowed prior to treating. Krilium soil conditioners, CRD-186 and CRD-189, were applied, broadcast, to the plots and disked into the top three inches of soil just prior to planting sugar beet seeds. The check plot received the same disking treatment as the treated plots. Stand counts, taken on five feet of the two middle rows of each four row plot, and used as the means of evaluating the results, are shown in Table XIII.

TABLE XIII

EMERGENCE OF SUGAR BEET SEEDLINGS ON KRILIUM TREATED PLOTS -- 1952

Treatments	Average Emergence
Check	112.5
CRD-186, 0.02% (200 lbs./acre)	103.0
CRD-189, 0.02% (200 lbs./acre)	108.7
CRD-186, 0.05% (500 lbs./acre)	95.0
CRD-186, 0.10% (1000 lbs./acre)	122.5
L. S. D. (5%)	14.14

Stand count for 5 feet of two rows per treatment per four replications.

Discussion

Broadcast applications of 0.10 percent CRD-186 gave a higher rate of sugar beet seedling emergence than the untreated check. All other treatments depressed seedling emergence. Treatments of 0.05 percent CRD-186 resulted in a significantly lower stand count when compared with the untreated check and 0.10 percent CRD-186 treatment. Treating the soil with 0.02 percent CRD-186 resulted in a significantly lower stand count than treating the soil with 0.10 percent CRD-186.

Experiment 4. A second field experiment was set up in 1953 to study the effects of mixing CRD-186 and CRD-189 with the soil on sugar beet seedling emergence. These tests were conducted on a portion of the alfalfa field used in Experiment III, and included nine treatments, replicated four times, and arranged in a randomized block design.

The alfalfa sod was plowed under in May. The plowed area received two diskings and two cultipackings. Soil conditioners were applied, broadcast, to the plots and disked into the soil to a depth of approximately three inches. The check plots received the same disking treatments as the treated plots.

A week after planting, 1.16 inches of rain fell. Following this rain a difference in degree of wetness and drying out was noted in the various plots. These differences were recorded in photographs and are shown in Figures 4, 5 and 6.

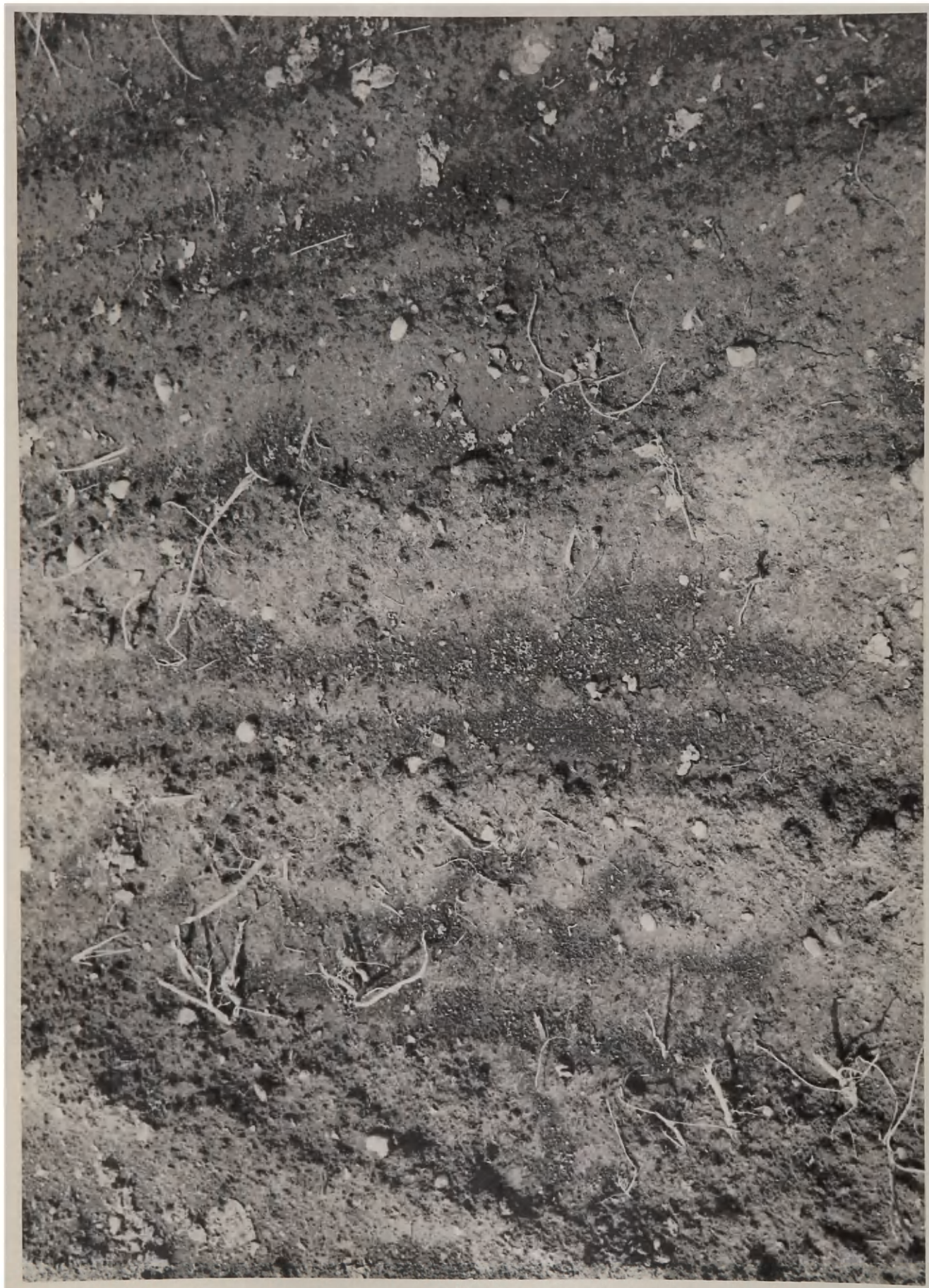
Figure 4. Plot receiving 0.07 percent CRD-186. (Photograph taken at right angles to the tillage rows). Note the dry surface and the fine structure of the soil.



Figure 5. This plot received 0.05 percent CRD-189.
Note the partially dry surface and gummy spots
(outlined with ink) throughout the plot, result-
ing from poor mixing of soil and Krilium.



Figure 6. Untreated check plot.
Note the wet surface and lack of good soil
structure.



As a measure of the effects of the various treatments, stand counts of sugar beet seedlings, the number of one-foot units having no beets, and the weight of twenty sugar beet seedlings per plot were taken. These results are given in Table XIV.

TABLE XIV
EFFECTS OF KRILIUM TREATMENTS ON SUGAR BEETS -- 1953

Krilium Treatments	Stand Counts of Seedlings	No. of 1-foot Units Having no Seedlings	Weight of 20 Seedlings
Check	228.7	13.5	35.8
CRD-186, 0.02%	238.7	14.5	53.3
CRD-189, 0.02%	260.0	13.7	38.3
CRD-186, 0.05%	253.5	13.7	49.4
CRD-189, 0.05%	211.7	22.2	41.4
CRD-186, 0.07%	187.0	21.0	35.7
CRD-189, 0.07%	292.5	10.7	63.7
CRD-186, 0.10%	221.5	17.5	55.4
CRD-189, 0.10%	236.5	18.0	44.4
Summary of results:			
Check	228.7	13.7	35.8
CRD-186	225.2	16.5	48.4
CRD-189	250.2	16.0	46.9
0.02% rate	249.3	13.8	45.8
0.05% rate	232.6	17.7	45.4
0.07% rate	239.7	15.8	49.7
0.10% rate	229.0	17.7	49.9

Treatment differences were not statistically significant.

Stand count for 10 feet of four rows per treatment per four replications.

Discussion

Differences between treatments were not statistically significant, nor are any trends evident.

Stand Counts

In all cases, except at the 0.05 percent rate, applications of CRD-189 gave higher rates of sugar beet seedling emergence than applications of CRD-186.

Number of 1-foot Units Having No Beets

Applications of 0.07 percent CRD-189 resulted in fewer units without beets than did the untreated check. The number of units for all other treatments were higher than for the check.

Weight of Sugar Beet Seedlings

All treatments, except applications of CRD-186 at the 0.07 percent rate, resulted in a higher weight of sugar beet seedlings than the untreated check, and, except at that rate, applications of CRD-186 gave lower weights of seedlings than applications of CRD-189.

A comparison of Figures 4 and 6 show that the surface of plots treated with CRD-186 dried out much faster and the surface soil was in a much finer state of aggregation than on the untreated plots. A considerable amount of difficulty was experienced in getting complete and thorough mixing of soil and CRD-189. The CRD-189 material tended to take up moisture at a rapid rate and form large gummy spots through the plot. This situation was very evident following heavy rains, and as a result,

surface drying was not uniform. The degree of poor mixing is shown in Figure 5. These same conditions were found in greenhouse tests.

Summary of Tests with Krilium Soil Conditioners

No significant responses to sugar beet seedling emergence or sugar beet yields were obtained in any of the Krilium tests reported here. This is in agreement with the findings of other research workers (3,63,100).

The high cost of these synthetic soil-aggregating chemicals would prohibit their use on large fields of sugar beets, even as surface applications for control of crusting. It is the opinion of this author that they can never, in their present form, fill the role of organic matter in the soil. While organic matter decomposes and loses its aggregating effects quicker than the chemical soil conditioners, it provides food for the microorganisms without which a soil cannot be productive.

Experiment V

A portion of the field, used in Krilium field Experiment 3 and involving the same seedbed preparations, was utilized for a randomized block experiment to test the effects of seed soaking and pre-planting germination on the emergence of sugar beet seedlings. Six treatments, replicated six times, made up the experimental design.

The soaked seeds were prepared for planting in a manner outlined by Hunter (50). Pre-planting germinated seeds were prepared by placing dry sugar beet seeds between moist germinating pads in a laboratory germinator.

Approximately 19 percent of the seeds which were germinated for 48 hours had sprouts averaging $1/4$ inch in length. These seeds were extremely wet when taken from the germinator and were dried in the sun, on cotton bags, for a period of 15 minutes to facilitate planting. None of the seeds receiving other treatments had sprouted and were dry enough for immediate planting.

The rate of sugar beet seedling emergence was taken one week and two weeks after planting, counting the same row for each treatment on both dates. Results of these stand counts are given in Table XV.

TABLE XV

STAND COUNTS OF SUGAR BEET SEEDLINGS ONE WEEK AND TWO WEEKS AFTER
PLANTING, ON PLOTS RECEIVING SOAKED SEED AND GERMINATED
SEED TREATMENTS -- 1952

Seed Treatments	One Week After Planting Average	Two Weeks After Planting Average
Check (dry seeds)	180.7	173.8
Seed soaked -- 6 hrs.	151.0	145.2
Seed germinated -- 12 hrs.	174.8	165.3
Seed germinated -- 24 hrs.	233.2	228.7
Seed germinated -- 36 hrs.	236.7	222.8
Seed germinated -- 48 hrs.	187.3	176.8

Treatment differences were not statistically significant.

Stand count for 50 feet per row per treatment per six replications.

Discussion

Planting dry seeds or seeds which had been germinated for a period of 24 hours prior to planting gave an earlier emergence than did the other treatments.

Data presented in Table I show that although differences were not statistically significant, germinating sugar beet seeds for periods of 24 hours, 36 hours and 48 hours resulted in a higher rate of seedling emergence when compared with the check treatment. Soaking seed for six hours or germinating seed for 12 hours depressed seedling emergence.

It is interesting to note that stand counts were higher the first week than the second week after planting. Daily counts were not made, therefore, the peak stand may not have been obtained. We would expect a certain percent of seedlings to die or to be killed during the process of germination and emergence. However, this loss may be decreased. Results of this experiment show that seedling loss was reduced when the sugar beet seeds were germinated for a period of 24 hours or soaked in running water for a period of 6 hours prior to planting.

Experiment VI

A third portion of the field, utilized for Krilium field Experiment 1, was used for an experiment to determine germination and emergence of different sized sugar beet seeds.

The graded seed for this test was supplied by Mr. J. G. Lill, Agronomist, Sugar Plant Investigation, United States Department of Agriculture. Processed seeds which passed through a 7-mesh screen and remained on a 9.5-mesh screen were graded as "small size"; those remaining on the 10-mesh screen were graded as "medium size"; those remaining on the 11-mesh screen were graded as "large size"; and those passing through the 11-mesh screen were graded as "very large size". Unprocessed or whole seeds were also included as a treatment.

The seedbed was prepared by plowing, double disking and harrowing with the spring-tooth harrow. Each plot, three rows wide and 50 feet long, was replicated six times. The graded seeds were planted with a single-row Planet Junior seed drill, and different planter plates were used in the planter to allow as uniform a seeding rate as possible.

Stand counts of sugar beet seedlings were taken one week and two weeks after planting. These stand counts are given in Table XVI.

TABLE XVI

STAND COUNT OF SUGAR BEET SEEDLINGS, ONE WEEK AND TWO WEEKS AFTER PLANTING, ON PLOTS PLANTED TO DIFFERENT SIZE SEEDS -- 1952

Graded Seed Treatments	One Week After Planting Average	Two Weeks After Planting Average
Small size	103.7	85.8
Medium size	93.2	71.2
Large size	181.2	73.7
Very large size	93.7	73.7
Whole seed	355.0	299.2
L. S. D. (5%) (including whole seed)	69.2	105.2
L. S. D. (5%) (omitting whole seed)	57.2	49.6

Stand count for 50 feet per row per treatment per six replications.

Discussion

Data in Table XVI show that a significantly higher stand count was obtained from planting whole seeds than from planting processed and graded seeds. The analysis, omitting whole seed, showed a significantly higher rate of seedling emergence on plots planted to "large size" seed when compared with the other graded seed treatments.

The reduction in stand of sugar beet seedlings during the second week was greatest on plots planted to whole seed and plots planted to "large size" seed; these seeds produced significantly more seedlings than the other sizes. The loss was least in plots planted to "small size" seed, suggesting that most of the seedlings produced by this grade were vigorous and healthy enough to survive and continue growing.

Experiment VII

A replicated split plot experiment was set up in the spring of 1953 to determine the effects of different tillage practices, as applied to seedbed preparation, and soaked seed versus dry seed on the emergence and uniformity of stand of sugar beet seedlings. Each treatment was applied to plots eight rows wide, with rows 44 feet long, and replicated four times. The experiment was set up on a field containing a red clover-ladino clover sod.

The four tillage treatments used for preparing the seedbed were as follows:

1. To prepare a loose and wet seedbed. This method consisted of pulling a commercial Valley Clodbuster behind a moldboard plow to pulverize and moderately pack the soil before it dried out after plowing. Planting followed within an hour.

2. To prepare a firm and wet seedbed. The method consisted of plowing, followed by two double diskings and two harrowings with the spring-tooth and two harrowings with the spike-tooth harrow. Planting followed at once.

3. To prepare a firm and dry seedbed. This treatment was the same as Treatment 2 above, but planting was delayed three days.

4. To prepare a loose and dry seedbed. The same operation as outlined in Treatment 1 above was used, but planting was delayed three days.

Designated plots were prepared for planting, using Tillage Treatments 3 and 4 on Monday, June 1. This allowed sufficient time for the surface soil to dry out before planting. The remainder of the plots were prepared for planting on Wednesday, June 3, using Tillage Treatments 1 and 2. Immediately following these operations on Wednesday, one-half of each plot was planted with soaked seed and the other half with dry seed. Sugar beet seeds used in the soaked seed treatment were prepared for planting in a manner outlined by Hunter (50). Johnson (54) states that the reason for quick planting on seedbeds prepared with a minimum amount of tillage is to take advantage of moisture and the mellow condition which exists for at least a short time after a good job of plowing.

Two days after planting, 1.16 inches of rain had fallen.

Differences were noted in earliness of sugar beet seedling emergence. These differences are shown in Table XVII.

TABLE XVII
THE ORDER OF SUGAR BEET SEEDLING EMERGENCE

Treatments	Days After Planting			
	5 days	6 days	7 days	8 days
<u>Dry seed</u>				
Loose-wet	X			
Firm-wet		X		
Firm-dry			X	
Loose-dry			X	
<u>Soaked seed</u>				
Loose-wet			X	
Firm-wet			X	
Firm-dry				X
Loose-dry			X	

Visual estimates of vigor of sugar beet seedlings and size of weeds were taken on plots receiving the different treatments. The results of these estimates are given in Table XVIII.

While making visual observations of plots receiving the loose-wet treatment, it was noted that beets growing in the outside rows of each 4-row beet drill width were better as to emergence, uniformity of stand and vigor than those growing in the two inside rows. Close inspection revealed that the outside rows had been planted in a strip compacted by the rear wheels of the tractor pulling the beet drill. It was further

TABLE XVIII
VISUAL ESTIMATES OF VIGOR OF BEET SEEDLINGS AND SIZE OF WEEDS -- 1953

Treatments	Beet Vigor			Weed Size
	6-25-53	7-9-53	8-24-53	6-26-53
<u>Dry seed</u>				
Loose-wet	Good	Good	Good	Small
Firm-wet	Average	Average	Average	Intermediate
Firm-dry	Average	Average	Average	Large
Loose-dry	Weak	Weak	Weak	Intermediate
<u>Soaked seed</u>				
Loose-wet	Good	Good	Good	Small
Firm-wet	Average	Average	Average	Intermediate
Firm-dry	Average	Average	Average	Large
Loose-dry	Weak	Weak	Weak	Intermediate

noted that a better stand of beets occurred in the middle rows where the front wheels of the tractor gave a similar compaction. Figure 7 shows two outside drill rows of sugar beets growing on plot receiving the loose-wet treatment.

The degree of compaction was not measured. Pendleton (78) reports that driving tractor wheels over rotary-tilled soil when in a moist condition resulted in compacting the surface three to six inches to about the original tilth; the six to nine inch layer remained unpacked. Cook (18) has found that after "once-over" tillage the tractor which pulls the

Figure 7. Outside rows of two four-row drill widths.
Note the thick, uniform stand of sugar beet
seedlings as compared with seedlings in
adjacent rows.



planter or drill leaves deep wheel tracks because the soil is loose, thus some of the rows from a grain drill will come in these depressions, resulting in uneven seed coverage.

Results of stand counts on five feet of each planter row, taken on a compacted portion and a non-compacted portion of loose-wet plots and planted with dry seed, are shown in Table XIX.

TABLE XIX

STAND COUNT OF SUGAR BEET SEEDLINGS ON COMPACTED AND NON-COMPACTED PORTIONS OF PLOTS RECEIVING LOOSE-WET TREATMENT -- 1953

Planter Row	Compacted Portion of Row	Non-compacted Portion of Row
1	42	23
2	37	26
3	32	18
4	31	20

As a further measure of the effects of treatments included in this experiment, the number of one-foot units having no beets, the emergence rates of seedlings, on twenty feet of each of eight rows, and the weight, in grams, of eighty sugar beet seedlings per plot were recorded. Every fifth seedling in each of eight rows was taken until eighty were gathered for weighing.

Because the planting rate of soaked seed was six pounds per acre and of dry seed was eight pounds per acre, the results were analyzed

separately as two randomized block experiments. The effects of the various tillage treatments on plots planted with dry seed are shown in Table XX and the effects on plots planted with soaked seed are shown in Table XXI.

TABLE XX
THE EFFECTS OF VARIOUS TILLAGE TREATMENTS ON SUGAR BEETS
FROM PLANTINGS WITH DRY SEEDS -- 1953

Tillage Treatments	No. of 1-foot Units Having No Seedlings	Stand Counts of Seedlings	Weight of 80 Seedlings
Loose-wet	37.2	1131.2	91.5
Firm-wet	34.0	1169.5	95.4
Firm-dry	63.0	804.0	96.0
Loose-dry	122.5	420.0	71.3
L. S. D. (5%)	66.63	671.46	N. S.

N. S. = No significance

Stand count for 20 feet of eight rows per treatment per four replications.

TABLE XXI
THE EFFECTS OF VARIOUS TILLAGE TREATMENTS ON SUGAR BEETS
FROM PLANTINGS WITH SOAKED SEEDS -- 1953

Tillage Treatments	No. of 1-foot Units Having No Seedlings	Stand Counts of Seedlings	Weight of 80 Seedlings
Loose-wet	63.5	482.0	65.7
Firm-wet	89.0	483.0	78.2
Firm-dry	75.2	414.7	115.1
Loose-dry	88.2	417.5	78.7

Treatment differences were not statistically significant.

Stand count for 20 feet of eight rows per treatment per four replications.

Discussion

Time of Seedling Emergence

Time of seedling emergence is determined in many instances by soil moisture conditions immediately after the seed is planted. The rains one day and two days after planting may have overshadowed the soaked seed treatment included in this experiment. The order of seedling emergence, as shown in Table XVII, cannot be explained. It is possible that the shock of soaking or toxicity of material released during the soaking period delayed the germination of seeds receiving this treatment. Or, the rain could have provided a better moisture condition for the unsoaked seeds than for the soaked seeds.

It is noted, however, that the rain water ran into and collected in the depressions made by the tractor wheels on the loose-wet plots, thus furnishing more moisture for the germination of seeds planted in these depressions. On other portions of plots receiving the same tillage treatment moisture infiltration was more rapid and probably seeped to a depth below the planted seed.

Vigor of Sugar Beet Seedlings

As shown in Table XVIII, visual estimates of vigor of sugar beet seedlings, using an arbitrary standard, indicated a higher score for plots receiving the loose-wet treatment and a lower score for plots receiving the loose-dry treatment. Close observations throughout the season correlated with the data obtained on the vigor of sugar beets. Stands always appeared more uniform on the loose-wet seedbed. There is no doubt,

however, that the difference in planting rates of dry seed and soaked seed accounts for at least part of the response differences noted.

Size of Weeds

The differences in weed growth on the various plots should be stressed. Plots having a loose-wet soil condition were relatively free from weeds at the time stand counts were taken. This permitted the seedlings to get a good start in growth before weed seeds germinated and became a problem. Plots receiving the firm-dry treatment had the most weeds and the largest weeds. The weed seeds germinated before the sugar beet seeds, offering competition to the young beet seedlings. Of the other two tillage treatments, plots having a loose-dry seedbed had fewer weeds than those having a firm-wet seedbed.

Soil Compaction

Results of stand counts given in Table XIX show that a higher rate of seedling emergence was obtained on compacted portions than on non-compacted portions of planted rows. It is the opinion of the author that a lack of uniform rate and depth of planting or a lack of uniform seed distribution resulted from loose-wet tillage practices as applied to seedbed preparation. This opinion was also shared by Dr. R. L. Cook, of the Soil Science Department, Michigan State College, in a recent personal conversation. It may be possible, then, to overcome this lack of uniformity by packing the soil immediately in front of each disk opener, gaining, at the same time, a better seed-soil contact. Dr. Cook also stated that

he had noticed similar earliness and better germinations of corn seedlings in rows compacted by tractor wheels pulling the corn planter.

This packing action was effective, but to a lesser degree, on plots receiving the loose-dry tillage treatment, and least effective on firm-wet and firm-dry plots. The latter two groups of plots had already received considerable packing.

The effects of the various tillage treatments on sugar beets from plantings with dry seeds are shown in Table XX.

Units Having No Seedlings

As shown in Table XX, significantly fewer units without beet seedlings resulted from the loose-wet and firm-wet treatments than from the loose-dry and firm-dry treatments.

Stand Counts

The rate of seedling emergence was significantly higher on the loose-wet and firm-wet plots than on the loose-dry plots. Stand counts were intermediate on firm-dry plots.

Weight of Seedlings

No significant weight differences were obtained for any of the tillage treatments. The small differences that were obtained, however, were in favor of plots receiving the firm-wet and firm-dry treatments.

Effects of the various tillage treatments on sugar beets from plantings with soaked seeds are shown in Table XXI. Differences between treatments, for all measurements made, were not statistically significant,

nor are any trends evident. The small differences noted between stand counts or plots planted with soaked seeds suggest that approximately 500 sugar beet seeds were planted and most of them germinated and came up on all plots.

In comparing the variability of the results, data in Table XX and Table XXI show that sugar beets varied much more in response to plantings made with dry seeds than to plantings made with soaked seeds.

SUMMARY

A series of greenhouse and field experiments was conducted from 1951 to 1953 to determine the effect of various seedbed preparation techniques, soil conditioning materials, green manure crops and seed treatments on the emergence and uniformity of stand of sugar beets. The rate of emergence of sugar beet seedlings, weight of sugar beet seedlings, number of one-foot units having no seedlings, number of marketable beet roots and weight of marketable beet roots were used as a means of evaluating the results.

The results may be summarized as follows:

1. Additional cultipacking of sugar beet seedbeds which had been prepared in a conventional manner, or applying a small amount of water (22 gallons per acre) in the seed furrow immediately after dropping the seed and before covering the seed with soil, did not increase the rate of sugar beet seedling emergence.
2. An intermediate amount of green plant material added to the soil in the spring resulted in a significant improvement of stand count of sugar beet seedlings and yield of marketable beet roots in comparison with large amounts or small amounts of green plant material.
3. No method of tillage for seedbed preparation was found that gave better stands, vigor or yields of sugar beets over that of plowing in the spring.

4. Alfalfa sod, either plowed or field cultivated in the fall or spring, presented no physical difficulties in the culture of sugar beets that followed.
5. Planting rye in fall field cultivated alfalfa plots reduced the broad-leaved weed population.
6. Emergence of sugar beet seedlings was as high on plots where all the alfalfa hay was removed as on those where all or part of the hay was left the previous year.
7. When soil conditioners CRD-186 and CRD-189 were applied in small amounts on or in the row or in large amounts broadcast and disked into the surface soil, no improvement in emergence or yield of sugar beets was found in these experiments.
8. Planting partially germinated sugar beet seeds did not increase rate or earliness of seedling emergence.
9. Sugar beet seedlings emerged earlier from loose-wet and firm-wet seedbeds than from firm-dry and loose-dry seedbeds.
10. Rapid emergence of sugar beet seedlings compared with weed seedlings made weed control easiest on the loose-wet seedbed.
11. At all times throughout the growing season the beets appeared most vigorous on the loose-wet plots.
12. A high rate of sugar beet seedling emergence resulted from compacting the row with tractor wheels in the process of planting on the loose-wet seedbeds.
13. A more uniform stand and a higher rate of seedling emergence was obtained when loose-wet and firm-wet seedbeds were used than when the seedbeds were loose-dry or firm-dry.

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