Soil Structure and Crop Production

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Soil Structural Studies have been conducted to determine the effects of mulches on alleviating sugarbeet stand loss from soil crusting, the effect of seedbed firmness on sugarbeet stand establishment, and the effect of soil compaction on potato production. Results indicate marginal potential for anti-crust mulching in a dry year, point to enhanced sugarbeet stand establishment in firm seedbeds in a dry spring, and indicate an overall negative response of potatoes to compaction.

The 1976 and 1977 growing seasons have seen the establishment of a broad new program in the area of soil structure and crop production. Greatest emphasis has been on seedbed preparation, crust prevention, compaction and root-aeration, all of which are tillage related.

Red River Valley soils derive predominently from the fine-textured sediments (high in clay) of glacial Lake Agassiz. The structural nature of these

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soils presents a number of problems related to germination, emergence, stand establishment and root development. Along the edges of the valley, soils are coarser textured (high in sand), deriving from remnant beach terraces of Lake Agassiz. These sandier soils present problems related to their unconsolidated nature (lack of structure), resulting in stand losses from blowing and drought.

Data presented offer a glimpse at several newly established and continuing research programs. These results should be regarded as preliminary, keeping in mind that ultimate conclusions may differ from those presented below as additional data are accumulated.

Soil Crusting

In 1976 investigation of crust alleviation was initiated using a mulching technique which has met with some success in other states on a variety of crops (5,9). First year findings were summarized in the North Dakota-Minnesota 1976 Sugarbeet Research and Extension reports. The premise of the work is that emergence problems of delicate seedlings could be alleviated by banding a small amount of granular, crusting-resistant material directly over seeds at planting. The mulch is then covered with a small amount of soil and firmed with a press wheel to prevent blowing of the mulch. Seedling emergence through the banded mulch is enhanced partially due to the friable character of the mulching material and partially due to crack formation over the mulch as the soil dries.

For successful field application, banding materials must be cheap, lightweight, readily available, and easy to apply with minimum inconvenience. These goals may not be easily achieved.

In 1976, treatments were hand imposed to simulate normal field application method. American Crystal Variety "2-B" was planted at 22-inch row spacing, six seeds per foot in six-row subplots of 20 feet each. Prior to planting, part of the seed was pelleted through the courtesy of Germain's Inc. for a comparison of emergence with use of pelleted vs. non-pelleted seed. Following planting and treatment application, the plots were sprayed with water at close proximity over the rows with a pressurized high-volume sprayer, simulating a ¼" rainfall to create surface dispersion, resulting in an emergence-limiting crust. The experiment was conducted at two locations: Mapleton, on the Merton Sheldon farm and Casselton, on the Sinner Brother's farm. Unseasonably dry conditions resulted in generally poor emergence at Mapleton, rendering the data from that location questionable. Conditions at Casselton were favorable.

The following five treatments were replicated four times at each site.

1. Control (non-mulched, non-coated seed)
2. No mulch, coated seed
3. Perlite mulch, non-coated seed
4. Vermiculite mulch, coated seed
5. Vermiculite mulch, non-coated seed

Emergence and plant development were monitored throughout the season. At harvest, beet samples were analyzed for per cent sugar and impurities.

Emergence, or stand count, is given in figure 1 for Casselton. No significance at the 0.05 level was shown at either site. However, plant emergence on the control and vermiculite noncoated seed treatments was higher than the perlite mulch or coated seed treatments. The generally arid conditions following planting probably contributed to reduction in emergence of the perlite mulched and coated seed treatments. While the vermiculite mulch seemed to retain sufficient moisture to promote good seed germination (at least as good as the control plots), the perlite material was not as hygroscopic and produced a drier condition in proximity with the seed. These results might be different with more nearly average rainfall, decreasing the effect of moisture in the mulched treatments. Also, the degree of crusting produced by the sprayer was not sufficient to markedly lower emergence in the control treatments.

Dry root weights, root volume, dry top weights, and leaf area were not significantly different among treatments for any of the growth parameters. No discernable trends in the effects of mulching or seed pelleting on these growth parameters could be found. It seems that the vigor of the plants after emergence was not appreciably enhanced nor de-

Table 1. Influence of mulch treatments and seed coating on yield, per cent sugar, impurity index and extractable sugar at the Sinner Brothers' farm, Casselton.

Site Location	Treatment	Yield, T/A	Sugar,%	Impurity Index	Extractable Sugar, T/A
Casselton	Control	14.16	14.55b	682	1.85
	No mulch, coated seed	12.33	14.38b	682	1.58
	Perlite, uncoated seed	14.06	15.20a	604	1.94
	Vermiculite, coated seed	12.60	14.45b	628	1.65
	Vermiculite, uncoated seed	14.96	15.55a	607	2.11

Means within the same column followed by the same letter are not significantly different at the 0.05 level of probability. Means within the same column followed by no letter are not significantly different.

creased by either the mulch treatments or the use of pelleted seed. It is worth noting that severe hail pruning occurred on July 8 at the Casselton site. Any growth differences between treatments which may have been evident to that point in the season were reduced by the pruning.

Results of harvest and sugar analyses are given in Table 1. Sugarbeet yield was not significantly different among treatments at either site. At Casselton, the vermiculite, non-coated seed treatment showed the highest yield. The two coated seed treatments gave the lowest yields. At Mapleton, the yield from the vermiculite, non-coated seed treatment was again highest with the yields from the remaining treatments only slightly lower. Lower yields occurred at Mapleton and can be attributed to the lower moisture conditions and poorer stand at that site.

Extractable sugar at Casselton seems related to yield. The vermiculite, uncoated seed treatment was significantly higher than the two coated seed treatments. Control and perlite treatments were also higher than the coated seed treatments although not significantly so. Extractable sugar from the Mapleton site was not significantly different between treatments. Extractable sugar at Mapleton was approximately one-half that of Casselton due to the lower yields.

In summary, plant emergence from the vermiculite, non-coated seed treatment was only slightly better than the control with the perlite and coated seed treatments resulting in poorer emergence. Growth indices showed no definite differences in growth between the control and the various other treatments. With respect to sugarbeet yield and sugar analyses, the vermiculite, uncoated seed treatment at Casselton yielded consistently higher, and the two coated seed treatments consistently lower. At Mapleton, yield and sugar analysis data were less consistent. Under improved moisture conditions where the mulch treatments would not limit moisture to the seeds and in the presence of a more pronounced soil crust, these results would possibly not hold true. While the study indicates some promise for the technique, more data must be collected over a variety of growing conditions to verify the existing results, and hopefully to identify the mechanism of response.

The relevance of comparisons of seed-coating materials is probably of minor importance since this problem is secondary to more pressing tillage and soil structure work. At this writing there seems to be no significant enhancement of emergence by any of the seed coating types observed. Germination retardation does not appear to be a problem except perhaps in some dry situations. The major advantage may accrue from ease of handling in some space-planting systems, however greater weight, smaller actual seed size, and lower seed numbers per volume of seed may negate some aspects of this potential benefit.

Seedbed Preparation

A major factor in successful sugarbeet production is the preparation of a seedbed which maximizes seedling germination, vigor, and stand establishment. The definition of such an optimal seedbed, however, is somewhat debatable. In manipulating a seedbed the single factor which is most directly altered by cultural practices is "tilth". A range of conditions can be created which can be qualitatively defined as varying from a "loose" to a "firm" condition. Any seedbed created within this range of conditions will vary in soil-physical properties, so seedling emergence and stand establishment will vary as a result.

A range of loose vs firm conditions was established in a field study in 1977 at the NDSU Seed Farm at Casselton. Plant response to the soil conditions created by tillage variables was observed and correlated with such soil physical properties as bulk density and soil moisture.

Treatment of the study area included fall plowing and two passes in the spring with a Rau Kombi. Seedbed treatments were then as follows:

1. Planting into the Rau Kombi seedbed (control)
2. Same as 1, then firmed with a packer wheel.
3. Roto tilled to a depth of 5 inches and planted.
4. Same as 3, then firmed with a packer wheel.

All plots were 12 22-inch rows, 50 feet long, planted on April 22, 1977 to American Crystal 2B seed (ACH-17). Treatments were replicated 11 times. At planting there was considerable difference in the tilth of the individual treatments, particularly between treatments 1 (firm with small clods), 3 (loose and granulated), and 4 (granulated, but firm). There was not much visual difference between 1 and 2. Observation of soil properties and plant response were made periodically throughout the growing season.

Spring of 1977 was considerably dryer than normal, and as a result it could be expected that the firmer seedbeds would have an advantage related to soil moisture conservation and more intimate soil-seed contact. A heavy seeding rate was used (approximately 16 seeds per foot) which helped provide a good indication of emergence. Some highlights of this first year's data are presented in Table 2.

Table 2. Plant Counts Expressed as Plants/100 Feet as Affected by Seedbed Firmness.

Treatment	May 9	June 1
1	246 a	384 c
2	223 a	354 d
3	81 b	394 c
4	101 b	324 d

Note: Data on the same date with different letters are significantly different at the 1% level of probability.

May 9 data indicate a much lower rate of germination in the "loose" seedbeds (3 & 4). This is most likely related to a difference in soil moisture observed following planting in the 0 to 6-inch depth increment (Table 3). The differences in plant counts had considerably diminished by June 1. Those observed are believed to be related to the ribbed configuration of the packing wheel. It is believed alignment of the ribs occasionally fell directly over the seed row, burying seed, which resulted in skips observed later in the season.

Table 3. Gravimetric Soil Moisture Content, Casselton, 1977

Date	Depth	Treatment 1 & 2	Treatment 3 & 4
April 27	0-6"	25.1%	23.0%
May 17	0-3"	18.0%	14.1%

Interestingly 0 to 6-inch bulk densities as measured May 17 (following a rain shower) were not significantly different between treatments (all values at approximately .9 g/cm³). Because soil water content was different between loose and firm seedbeds without observable differences in bulk density it is likely the main difference between treatments resulted from a change in pore geometry. Such a change in pore geometry could lower water holding capacity in the surface soil layer of a loose seedbed and affect germination by creating a less intimate soil-seed contact.

Even after several rainfall events soil moisture in the 0 to 3-inch depth remained significantly depressed.

In addition to the lower soil moisture levels encountered in the "loose" seedbeds, it was observed that after a hard rain shower the "loose" seedbeds crusted more severely than the "firm" seedbeds, contributing further to the slower emergence.

In this experiment the high initial seeding rate was thinned to approximately 77 plants per 100 ft. There were no statistically significant differences in yield at harvest. Overall average net yield was 20.5 tons acre. Had the seeding rate more closely reflected commercial rates the depressed germination rate in "loose" treatments would have resulted in spottier stands, which would probably have affected yield. Furthermore, these data represent results obtained from planting in an exceedingly dry spring. As this study continues in 1978 the year promises to present an opportunity to obtain data under far wetter conditions. It is likely results will be different and could be entirely reversed in such a situation, where compaction, crusting, and poor aeration could result from the production of too firm a seedbed due to tillage of a wet soil.

A further examination of the harvest data from this study, presented in Table 4, reveals a generally negative response to the "looser" seedbeds (Tmts 3 & 4). There is a trend toward depressed yield in treatments 2 and 4 which again probably relates to skips created by occasional alignment of the ribbed packer with the rows. Per cent sugar was slightly higher in the "firmer" seedbeds (Tmts 1 and 2) which is attributed to the earlier stand establishment. However, the extractable sugar per acre was not significantly different between treatments. The various indices of impurity generally indicated greater impurity in the "loose" seedbeds (Tmts 3 and 4); no concrete explanation is offered for this response, though it may relate to drier soil conditions early in the season.

Compaction Study

Soil compaction refers to the reduction of porosity in soil. Several soil properties can be substantially altered when soil becomes compacted: 1) bulk density or the weight of a given volume of soil increases, 2) soil strength or hardness increases, 3) soil-moisture properties are changed in a variety of ways depending on the initial soil condition, though generally the amount of water held at saturation is reduced, and 4) amount of soil air held in the soil is limited, particularly in the presence of high

Table 4. Harvest Data for Seedbed Preparation Study, Casselton, 1977

Harvest Parameter	Treatments: Firm 1	Firm 2	Loose 3	Loose 4	Stat. Sig Roto Tilled (1&2 vs 3&4)	Packed 1&3 vs 2&4)	Interaction
Extbl. Sugar (T/A)	2.9	3.0	2.9	2.5	NS	NS	NS
Yield (T/A)	20.3	20.6	22.1	19.0	NS	TREND	5%
NO³ (ppm)	221	297	551	510	1%	NS	NS
Na (ppm)	326	389	532	501	1%	NS	NS
K (ppm)	1832	1986	1971	2017	1%	NS	NS
Sugar (%)	16.0	15.9	14.9	15.1	1%	NS	NS
Sugar Loss (T/A)	.310	.334	.392	.332	TREND	NS	5%

moisture percentages. These changes in properties can have a variety of effects on plant response to soil compaction.

Various physiological responses of crops common to the Red River Valley have been observed as a result of soil compaction or related changes in the soil-root environment (2, 3, 4, 6, 7, 8). In addition to yield reduction, such quality components as size, shape, and specific gravity of potatoes, sprangling and sugar content in sugarbeets are adversely effected.

In the first year of a continuing compaction study at the potato research farm near Grand Forks, soil and plant properties effected by soil compaction and crop sequence in a potato, sugarbeet, wheat rotation are being studied.

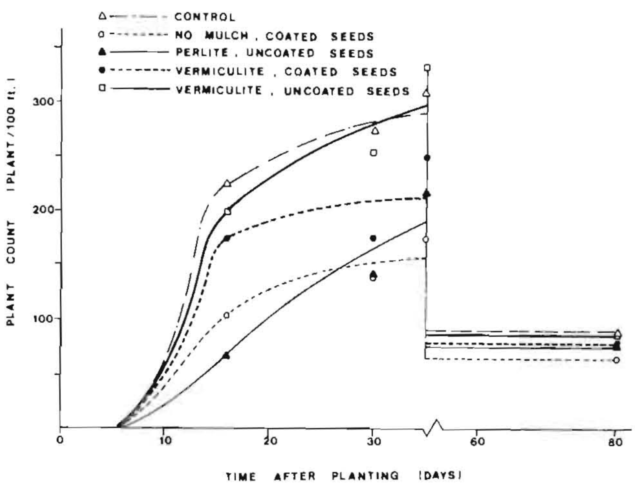

Figure 1. Plant emergence data, Casselton, ND. Plants were thinned on day 35.

In 1977 Norchip potato, American Crystal 2B sugarbeet, and Kitt wheat were grown side by side in a field study. Soil in one treatment was uniformly compacted by repeated passes of a loaded truck over the compacted treatments (gross wt-approx 30,000 lbs), and then planted. Early results indicate significant changes in soil properties due to compaction which were reflected in plant response. Soil strength was greatly influenced, as can be seen in Figure 2. On both dates soil strength was significantly greater in compacted plots. Soil strength also increased later in the season due to soil water depletion. Compaction caused significantly higher soil moisture at all depths throughout the season. This is probably related to an increase in small pores and hence more capillarity in compacted treatments, plus a reduction in root penetration and plant water use from the lower profile.

The yield of U.S. No. 1 potatoes per acre was reduced from 127.2 cwt to 96.3 cwt in the compacted plots while the numbers were reduced from 39,890/A to 30,261/A. Specific gravity dropped due to compaction from 1.092 to 1.089. Weight and number of culls, knobby potatoes, cracked or green potatoes increased throughout (though not significant statistically) with soil compaction.

More intensive monitoring as this experiment progresses should prove increasingly valuable in light of current concerns over compaction from new large scale equipment.

Upcoming 1978 field work will focus on various tillage problems per se, with increased attention to reduced tillage systems.

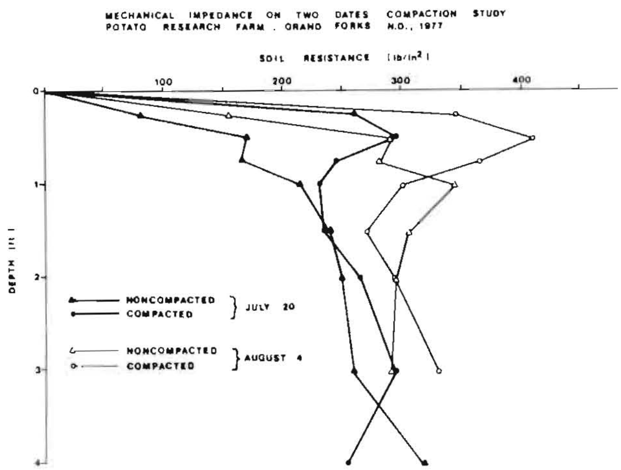

Figure 2. Mechanical impedance with depth, Grand Forks, ND, as affected by soil compaction and soil moisture on two dates.

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