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Punch Planting to Establish Lettuce and Carrots Under Adverse Conditions[1]

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ABSTRACT

It was observed in both the greenhouse and field that lettuce and carrots may be established by planting single seeds in holes punched through the soil crust. When the holes are not back-filled, seeds planted as deep as 60 mm will produce healthy plants in a few days. Preliminary experiments indicate that in some climatic regions a practical field management system could be developed which will eliminate emergence problems arising from soil crusting and premature drying of shallow seedbeds. The open hole punch method may also prove useful in controlling the temperature and salinity adjacent to the seed and in reducing initial tillage and irrigation requirements.

Additional index words: soil crust, soil moisture, seedbed, salinity, soil temperature, minimum tillage.

BECAUSE lettuce and carrot seeds are small and produce physically weak seedlings, it is not always easy to establish a stand in the field. Since these seeds are ordinarily planted only a few millimeters deep, they are subject to desiccation before a root system can be established. Moreover, the germinating seedlings may experience great difficulty in penetrating even a mild soil surface crust.

Arndt (1965a, 1965b) has published two papers in which he has reviewed the present knowledge of soil crusting in addition to presenting significant new material concerning the mechanics of seedling emergence through a crust. Even so, the statement made by Petezval and Lutz (1957) still sums up the situation, i.e., "Different soils respond differently to the environmental conditions to which they are subjected. The hardness of the crust on any particular soil is a result of the complex physical and physical-chemical processes or reactions which are controlled by the proportions and nature of the soil components and by external conditions." While a soil crust may stop seedling emergence by limiting oxygen diffusion or by becoming too dry, the harm generally results from a mechanical impedance. For example, Hanks and Thorp (1956) found that the oxygen diffusion rate had to drop below 10^{-6} $g/cm^2/min$ before seedlings were affected and Doneen and MacGillivray (1943) showed that most vegetable seeds germinated well so long as the soil moisture content does not drop below the permanent wilting point. In general, it is not that seedlings cannot develop enough force to break through a crust but rather that the horizontal seedbed constrains are not sufficient to direct the pressures from the growing seedling upward. Gill and Bolt (1955) have said that the average axial pressure developed by germinating grass seedlings is around 7.5 bars, which, for a growing point with a 2 mm^2 tip, is enough to break through any of the crusts studied by Arndt (1965). This was recognized by Carnes (1934) when he recommended packing the soil to provide a firm foundation for seedling pressure to develop upward against the surface crust. The use of soil conditioners and surface mulches has been studied as possible alternative solutions. While Bennett et al. (1964) found that soil conditioners could increase emergence from a normal 10% up to around 50% on some soils, the practice is still not entirely satisfactory.

The concept of a firm seedbed and the beneficial effects from soil conditioners and mulching, combined with labor shortages and costs have resulted in an effort to develop machinery that will plant single seeds in holes punched at desired intervals along the row. However, one unanswered question in this type of planting system is: What should the seed be covered with so that a high percentage of emergence will be assured? It has been noted at this Center

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that the lettuce and carrot seeds, among others, will develop normally and produce healthy plants when the hole is not backfilled at all, providing the hole has a satisfactory diameter-to-depth ratio. Lettuce and carrot seeds contain sufficient energy to grow 40 to 80 mm high without energy from photosynthesis. Thus, it seemed possible that these seeds could be planted in holes 60 mm deep with a reasonable chance for emergence.

EXPERIMENTAL PROCEDURE

A box with the sides 0.70 × 1.80 m and 0.35 m deep was placed on the greenhouse bench. It was packed with Portneuf silt loam soil and several crops were grown before beginning the experiments reported here. Since the study was carried out in the winter, a bank of lights (800 watts) with aluminum reflectors was mounted over the box to provide additional radiation energy to the soil surface. These lights burned continuously from 5:00 AM to 8:00 PM. An 8-inch fan was available for blowing air across the soil surface to increase the drying capacity of the microclimate. The evaporation from a free water surface was 18 mm per day under these conditions and 9 mm per day when the fan was not used.[3]

The box was divided into four sections, each section containing a replicate in which 20 seeds per row were planted. The following five experiments were carried out:

1. The soil surface was shaped as shown in Fig. 1a and sprinkled with water. As soon as the soil was dry on top, holes 60 mm deep were punched through the crust along the peak of the ridge with a tapered rod. The rod diameter was 5 mm at the bottom and 9 mm at the top. A single seed was dropped in each hole. The seeds were not covered with any material. As shown in the diagram, the crust was broken up on the other side of the irrigation furrow and worked into a suitable seedbed. Twenty lettuce seeds were then planted in the conventional manner and firmly covered with 5 to 10 mm of moist soil. This will hereafter be referred to as the "normal" method of planting. The irrigation furrow was filled with water once each day so that the surface of the normally planted row remained moist and did not crust over. The surface of the punch-planted ridge remained dry and crusted. The fan was not used.

2. The planting arrangement was the same as described in Treatment 1. Immediately following planting, the surface was sprinkled with 12 to 18 mm of water in about 20 min. The spray was of fine droplets and soil conductivity was such that excessive washing and erosion did not occur. The soil received no further application of water. The fan was not used after the first 24 hours required to dry the soil surface.

[3] This was measured in a tube filled with water which was buried in the soil so that its top was level with the surface. The tube had a 5-cm inside diameter and was 20 cm deep.

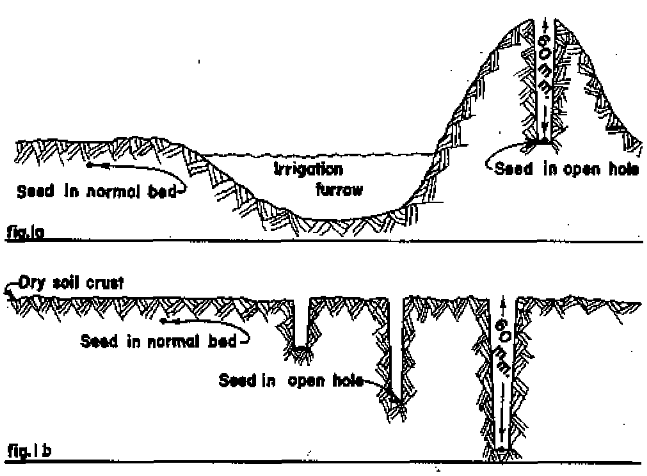

Fig. 1. A cross-sectional diagram of seed placements in the greenhouse emergence trials.

3. The shaping and planting procedures were the same as described in Treatment 2, but immediately after planting the surface was lightly sprinkled with approximately 3 mm of water, just enough to moisten the surface. The furrows were filled with water once a day. The treatment differed from No. 1 in that the fan was allowed to run continuously, increasing the drying rate at the surface so that a crust did form over the normally planted row. Because of the fan, this row did not sub up enough so that the surface became moist following the irrigations.

4. The soil was leveled, smoothed, and flooded with water and then allowed to dry on the surface. As soon as the soil was dry on top, a normal planting was made by breaking up the crust, forming a moist seedbed wide enough for single rows. Plantings in holes 20, 40, and 60 mm deep were made by laying individual seeds on the surface crust and punching them down with the probe previously described. The planting arrangement is diagrammed in Fig. 1b. No water was added after planting. This treatment was carried out using both carrot and lettuce seeds.

5. This treament was the same as No. 4 except that the surface was sprinkled with 10 mm of water in a fine "nonerosive spray" immediately after planting.

Soil and air temperatures were measured intermittently throughout the daylight period with thermocouples. Notes were made of visual observations of the germination and emergence processes, but the most interesting data were counts of the seedlings which had emerged approximately 10 days after planting.

RESULTS

The number of plants which emerged out of the 20 seeds planted in each row are shown in Table 1 for each of the five treatments. Typical afternoon soil surface temperatures are also shown in this table.

In Treatment 1, which provided nearly optimum growing conditions for the normal method of planting, normally planted seeds appeared to give slightly better results than the seeds that were dropped into the 60-mm holes. Ten days after planting date, the seedlings from normal-planted rows appeared larger and more vigorous than those planted in holes. While germination times appeared to be quite similar, the seedlings in holes required several extra days to reach the surface and so were farther behind in photosynthesis.

In Treatment 2, the normal planting did not yield any seedlings. It appeared that the principal problem was caused by the seedbed drying out before the seed could germinate. Those that did germinate were unable to penetrate the crust. Sprinkling the soil surface following planting did not reduce germination or emergence from the holes as much as one might have thought. While some soil did wash in on top of the seeds, drying of this soil was very slow since it was still several centimeters below the surface. Consequently, the seedling emerged through the covering soil before it hardened. In cases where the soil washed in to cover the seeds with a 3- or 4-cm thick layer, the chances of seedling emergence were slight.

Table 1. Observations of seedling emergence under various environmental conditions in the greenhouse. Treatments are described in the text.

Treatment	Number of plants emerging from 20 seed rows																Temp. C*
	Normal				60-mm				40-mm				20-mm				
	Lettuce†																
1	17	16	20	15	14	15	15	15	--	--	--	--	--	--	--	--	30
2	0	0	0	0	12	8	9	11	--	--	--	--	--	--	--	--	37
3	7	1	0	3	16	17	12	17	--	--	--	--	--	--	--	--	20
4	0	0	0	2	9	4	2	4	13	10	7	10	13	11	10	12	34
	Carrots‡																
4	0	0	0	0	10	6	4	6	3	2	0	1	0	0	0	1	34
5	0	0	0	1	11	7	10	12	13	9	9	16	1	2	2	2	33

* Representative daytime surface temperatures. † Great Lakes variety, 85% guaranteed germination. ‡ Nantes Coeless variety, 80% guaranteed germination.

Fig. 2. Carrot seedlings emerging from 40-mm deep holes during Treatment 5. Note the poor physical condition of the soil for normal seedling emergence.

The poor results of seedling development under normal planting in Treatment 3 were due primarily to the crust which formed on the surface. Many of the seeds were able to germinate as the moisture subbed up daily into their seedbed from the irrigation furrow, but the seedlings did not have the physical strength to break through the 3- or 4-mm crust which had formed over them.

In Treatment 4, the failure of the normal planting appeared to be primarily caused by the seedbed drying out before the seeds could germinate and establish a root system. Ten days after planting, the soil was dry to a depth of 6 to 8 cm.

Treatment 5 produced better carrot stands than No. 4 because the water added immediately after planting caused the soil to remain moist in the 20- to 40-mm zone long enough for some germination to occur. Carrot seedlings emerging from the 40-mm holes are shown in Fig. 2. This photograph shows the poor conditions of the soil for normal seedling emergence.

In addition to the elimination of the crusting problem and the promotion of better seedbed moisture conditions, the punch planting method also had a beneficial temperature effect on the lettuce seeds. The temperature was 2 or 3 C less in the 60-mm deep hole than was the temperature around the normally planted seeds. This is an important consideration in some areas of the Southwest where irrigation is required for cooling.

In addition to the greenhouse experiment, preliminary plantings were made in the field during April and May 1966. During this period, evaporation from a Weather Bureau pan rose from 7 mm per day to 9 mm per day. The mean air temperatures rose from 8 to 18 C. Holes of various diameters and depths were punched through the soil crust and a variety of seeds dropped into them. The seeds were not covered other than with what dust might fall in from the surface. Carrots, lettuce, sweet corn, sugar beets, cabbage, potatoes, and beans all produced plants from seeds planted in this manner, provided there was moist soil at the bottom of the hole at the time of planting and provided the hole was not filled in before seeding emergence. Beans

Fig. 3. Beans which grew from seeds dropped in holes 15 to 25 cm deep.

appeared to do especially well planted 15 to 25 cm deep in holes 2 cm in diameter. Some of these plants are shown in Fig. 3. The foremost row grew from seeds planted 20 cm deep.

CONCLUSIONS

The punch planting method allows seeds to be placed much deeper in the soil than the conventional practice of covering them in a seedbed. Problems of crusting and premature seedbed desiccation may be significantly reduced by the punch method, particularly for weak seedlings such as lettuce and carrots. It offers a practical method for controlling both the seed's temperature and the depth of soil where rooting occurs, particularly for plants such as corn and beans, which can be planted 15 to 25 cm deep. The method may also prove useful in conservation of irrigation water early in the season and in promoting a minimum tillage program. The author feels that punch planting without backfilling the holes has immediate practical application in areas where a stable soil crust can be formed and where heavy, erosive rains are not apt to occur during the germination and emergence period.

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