RUSSET BURBANK ROOTING IN SANDY SOILS WITH PANS FOLLOWING DEEP PLOWING[1]

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Abstract

A dense, 5 cm plow pan is commonly found on Plainfield loamy sands in Wisconsin. Measurements have shown that when potatoes are grown on these soils, little root growth exists below the plow layer. To determine if rooting below the plow layer is restricted by the plow pan, soil was plowed with a moldboard "breaker" plow to 40 cm, 12 cm below the plow pan. No significant increase in the root density below the conventional plow layer resulted from destroying the pan.

Resumen

En Suelos franco-arenosos de Plainfield, Wisconsin, se forma comunmente un pan denso de 5 cm de grosor. De acuerdo a datos tomados cuando las papas son cultivades en esos suelos, se he encontrado que hay un crecimiento muy reducido de raíces debajo de la capa arable. Para determinar si el enraizamiento bajo la capa arable es restringido por la presencia del pan, el suelo fue arado profundamente con un arado subsolador a 40 cm; alcanzando hasta 12 cm bajo el pan. No se encontró aumento significativo en densidad de raíces debajo de la capa arable que pudiera atribuirse a la destrucción del pan.

Introduction

Published work reviewed by Lesczynski and Tanner (3) indicated that when potato is grown on most mineral soils, the majority of the roots are in the plow layer although root penetration to 1.5 meters has been reported (9). Lesczynski and Tanner (3) found nearly a ten-fold decrease in root density in the soil below the plow layer. This decreased root density may have been caused by a dense plow pan less than 5 cm thick found on these soils. This pan appears to have been formed by translocation of fine particles through the plow layer (10) and shear at the plow bottom from plowing at the same depth. Because of shallow rooting, these soils hold only 16 to 19 mm of water that is readily extractable by Russet Burbank potatoes. The shallow rooting requires frequent irrigation and increases nitrogen leaching

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from the root zone (6, 7). Deeper rooting would simplify both irrigation and nitrogen management and could result in decreased irrigation frequency and nitrate leaching.

DeRoo and Waggoner (2) found that loosening the plow pan of a sandy loam with a fork substantially increased Katahdin root penetration through the pan into deeper soil. Linford and McDole (4) found that the rooting depth of Russet Burbank potatòes was more restricted on sandy soils than silt loams. They found that chiseling sandy soils to a depth of 30 to 45 cm increased the depth of root penetration 30 to 75%, although the density of deeper roots was not measured. Bishop and Grimes (1) found that precision tillage (pre-plant chiseling to 60 cm depth in potato bed center) improved rooting below 30 cm. Tuber production was also increased by 6-10% in the year precision tillage was performed.

Most studies of rooting describe general features of the root system and depth to which roots are found. However, the density of the root system is very important since uptake of water and nutrients varies with length of roots in a volume of soil (5). The purpose of the experiment reported here was to see if destruction of the plow pan would significantly increase the density of Russet Burbank potato roots below the plow layer.

Materials and Methods

Potatoes, *Solanum tuberosum* L., Russet Burbank, were grown on Plainfield loamy sand (sandy, mixed, mesic, Typic Udipsamment) at the Hancock Experimental Farm in central Wisconsin. Row spacing was 91 cm (3 ft) with seed spaced 30 cm (1 ft) apart within rows, resulting in 35,800 hills /ha (14,500 hills/acre). The experimental area had been planted to potato the two previous years and to cabbage three years previously. On 17 April 1974, 336 kg/ha (300 lb/acre) of 0-0-60 was broadcast on a 15 x 23 m (50 x 75 ft) area. The area was then plowed with a moldboard "breaker" plow to 40 ± 1 cm to destroy a 5 cm thick plow pan beginning at 22 to 23 cm. The following day 336 kg/ha of 0-0-60 was broadcast on the deep-plowed area and an equal adjacent unplowed area. The deep-plowed area thus received 672 kg/ha 0-0-60 prior to planting in order to assure that inverting deeper, less-fertile soil did not limit supply of potash. Both areas were then plowed conventionally to 23 cm at a right angle to the direction of deep plowing. Potatoes were planted on both areas 29 April with 700 kg/ha (624 lb/acre) 5-10-30 starter. Plants on both areas were 50% emerged 28 May. Both areas were hilled and 336 kg/ha (300 lb/acre) of 33-0-0 sidedress turned into the hill 11 June. Vines were killed 9 September. While the above design did not provide for statistical replication of treatments, it is our belief that a more arduous, complete experiment would be justified only if the deep plowing caused a physically significant increase in deeper rooting.

On 27 April bulk density was measured on both areas with a 7.5 cm diameter x 7.5 cm long core sampler; penetration force also was measured with a Cornell penetrometer (8). A second set of bulk density and penetrometer measurements was taken on 14 September after vine kill. Root length density was measured as described by Lesczynski and Tanner (3) at four times during the growing season (6 and 19 June, 3 and 29 July).

In order to determine if the root distributions measured on the Experimental Farm were representative of the central Wisconsin sandy soils, on 30 July root length density samples were collected on three commercial farms growing Russet Burbanks. The field of grower A had been planted to potatoes, corn, and snap beans in 1971, 1972, and 1973, respectively; field preparation consisted of plowing followed by disking. The field of grower B had been planted to snap beans for the preceding three years and field preparation was plow-packing. The field of grower C had been in potato, cucumbers, and potato for the preceding three years; field preparation was chiseling to 28 cm followed by disking.

We wished also to determine if water stress of Russet Burbank potatoes during the main root growth period prior to tuber bulking could cause deeper root penetration. In 1975 we sheltered an area 21 m wide (seven rows) by 7.3 m (24 ft) long with movable shelters which were moved over the crop during rains and irrigation. An area was sheltered from emergence (28 May) until the crop wilted on 24 June. Wilting was slow because of little water use by small plants and less solar radiation and lower temperatures than normal. Root length densities were measured five weeks after the stress period. We assumed that if deep rooting were to be increased by gradually increasing stress during the main period of root development, it should have been evidenced by this imposed drought.

Results and Discussion

Bulk density and penetrability measurements are shown in Figure 1. Because early sampling was prior to hilling and late sampling included measurements in the hills, measurements are referenced to the bottom of the conventional plow layer. None of the bulk density differences between conventional plowing and deep plowing was significant ($p = 0.1$) as measured by a T-test except those in the layer immediately below the plow layer at the pan. In fact, differences elsewhere were not significant at $p = 0.05$. The more sensitive penetrometer measurements were significantly different ($p = 0.01$) at the plow layer/subsoil interface and at all depths below the interface. Both bulk density and penetrometer measurements showed significant ($p = 0.05$) consolidation of the plowed soil over the growing season.

The yields of U.S. #1 potatoes on the deep-plowed and conventionally-plowed areas were 50.2 and 49.0 metric tons/ha (448 and 437 cwt/acre), respectively. Root development as measured by root length densities (cm

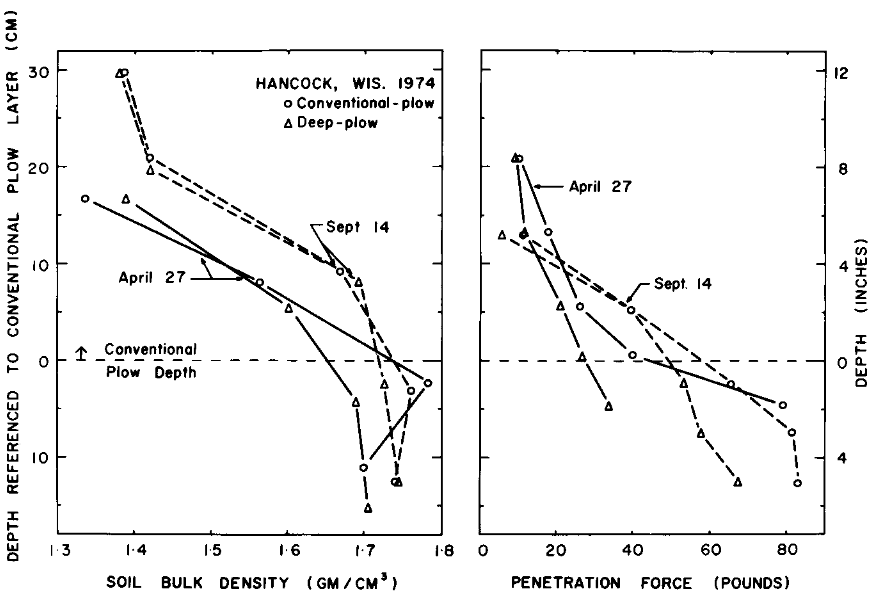

FIG. 1. Depth distribution of bulk density and penetration force on deep- and conventionally-plowed areas before planting and at the end of the growing season.

root per cubic cm of soil) increased rapidly, following trends observed by Lesczynski and Tanner (3). Root length densities on 3 July and 29 July were not significantly different ($p = 0.1$), and the densities for 29 July are shown in Figure 2. Surprisingly, the differences at depths below conventional plowing were small and did not differ statistically, whereas significant ($p = 0.1$) but moderate (20%) increases occurred in the upper layers.

The volume-mean of the root length density for the plow layer and for 25 cm below the conventional plow layer in both treatments is given in Table 1 along with similar data for the three commercial grower fields. In all fields there is a six-fold or more decrease in root length density in the 25 cm below the plow layer as found by Lesczynski and Tanner (3). The difference between the deep-plowed and conventionally-plowed treatments is well within the variation between different fields.

Our data indicate that deep plowing produces insufficient benefits to deep rooting to justify either deep plowing as a practice or further experimentation, at least for Russet Burbank potatoes on this sandy soil.

The comparison of root growth of stressed and unstressed potato is in Table 2. While stressing appears to have increased rooting, it is well within normal field variation. Certainly penetration below the plow layer was not increased sufficiently to affect water and nitrogen uptake from deeper layers significantly. It is of interest that Weaver (9) found that prolonged stress of Bliss' Triumph potato decreased root growth relative to well-watered plants.

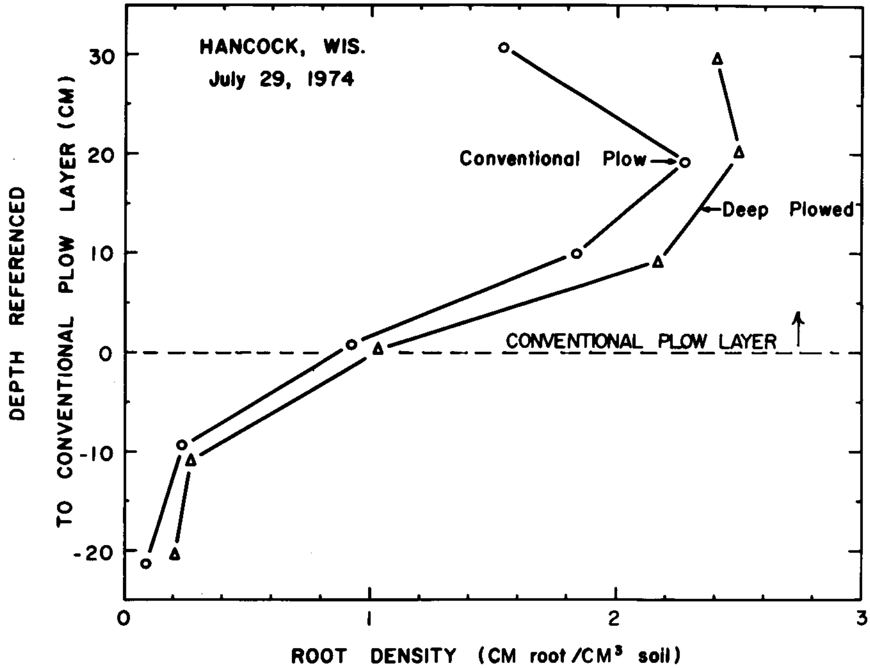

FIG. 2. Root-length density distribution of Russet Burbank potatoes with conventional and deep plowing.

TABLE 1. — *Mean root length densities (cm root/cubic cm soil) for the deep-plowed and conventionally-plowed areas and three grower fields.*

Location	Root length densities	
	Plow layer	25 cm below P.L.
Deep-plowed	2.13	0.35
Conventionally-plowed	1.79	0.31
Grower A	2.40	0.32
Grower B	3.17	0.40
Grower C	1.93	0.13

TABLE 2. — *Root length density of irrigated and slowly stressed potato.*

Treatment	Plow layer	25 cm below P.L.
Irrigated	2.11	0.09
Stressed	2.48	0.15

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