WORKING WITH SOIL LIMITATIONS FOR ORCHARD CROPS

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Fruit growers throughout the world are aware of the importance of deep, uniform and friable soils which are necessary to support bountiful crops for many years. Through the rootsystem, the soil must provide adequate moisture and nutrients to satisfy canopy foliage and crop needs. These ingredients plus oxygen are also necessary to encourage good root development. When any of these ingredients arelacking, the root system and subsequently, the canopy suffer and it is expressed as stress symptoms. The characteristics of the soil profile, which refers to the vertical cross-section of the soil from the surface into the underlying unweathered material, plays an important role in fruit tree performance and longevity. A soil profile is made up of three layers, or horizons: A, B and C. The A horizon (topsoil) is the surface layer where components have been removed. The B horizon (subsoil) is the part of the profile where materials from the A horizon have accumulated (iron, aluminum, lime and colloids). The C horizon is the geological substratum and, in Michigan, consists of unconsolidated mineral deposits of glacial origin: pure sand; sand and gravel; friable sandy clay; silt and compact, massive clay. A desirable orchard soil profile possesses a deep (2 meters), uniform A and B horizon with gradual, vertical changes in physical characteristics. These conditions foster root development which encourages roots to forage the full depths for nutrients and water (Fig. 1).

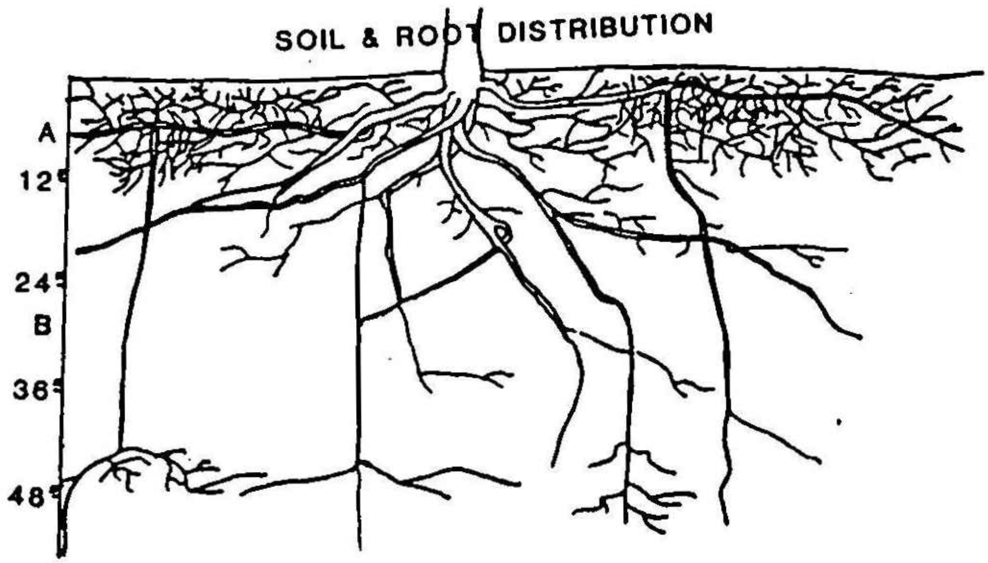

Fig. 1. Example of fruit tree root distribution in a deep desirable orchard soil.

In Michigan and in other areas, where soils have derived from glacial action, the characteristics of the B horizon can change drastically, both vertically and horizontally, from one tree to the next. This situation is becoming very common among declining cherry orchards in Michigan . Among these orchards, trees are obviously stressed due to limited root development caused by excessive or inadequate moisture and oxygen. There are generally three common soil scenarios which limit root growth:

1. Fine-textured soils with poor internal drainage throughout the profile (Fig. 2).

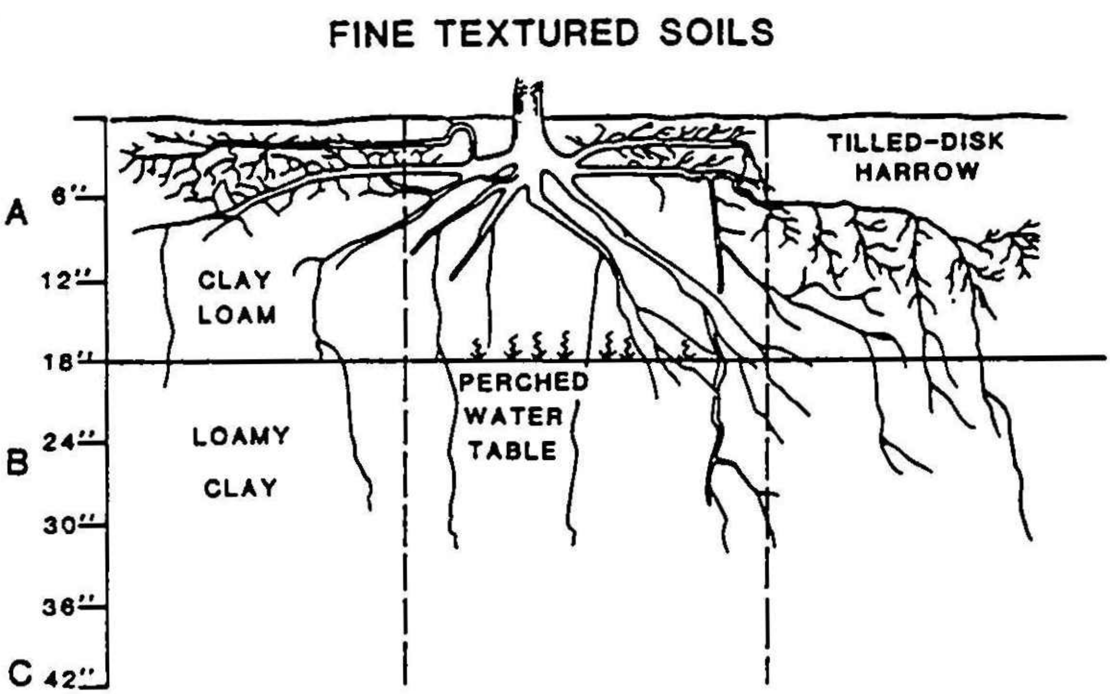

Fig. 2. Fruit tree root response to 3 types of the fine textured soil.

2. Panned soils with dense, compact, or cemented subsoils or layers (claypans, hardpans, fragipans) (Fig. 3).

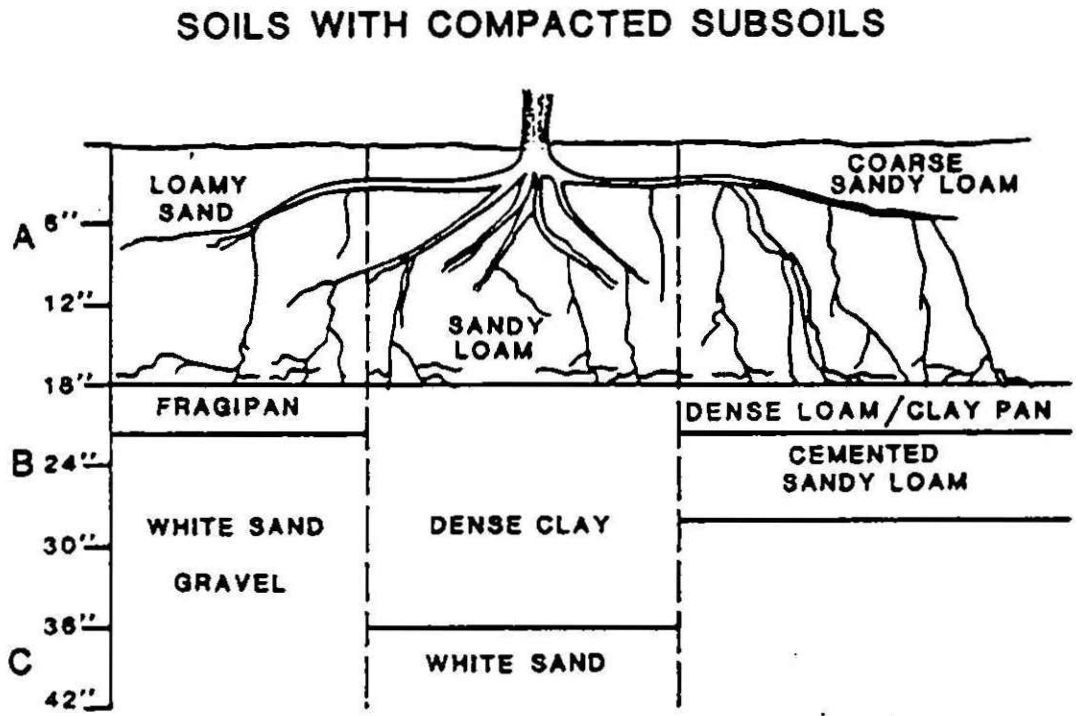

Fig. 3. Fruit tree root response to 3 types of the panned soil scenario.

3. Layered soils have abrupt significant changes in soil texture which causes "wetting-front instability" (Fig. 4,5).

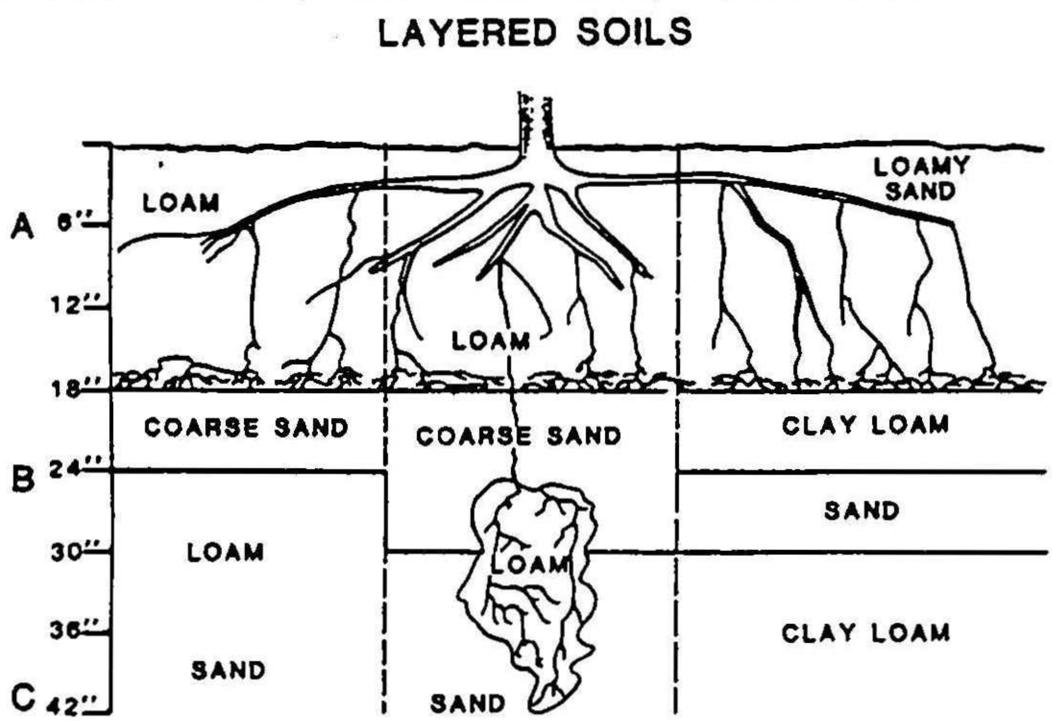

Fig. 4. Fruit tree root response in 3 types of layered soil scenario.

WETTING-FRONT INSTABILITY

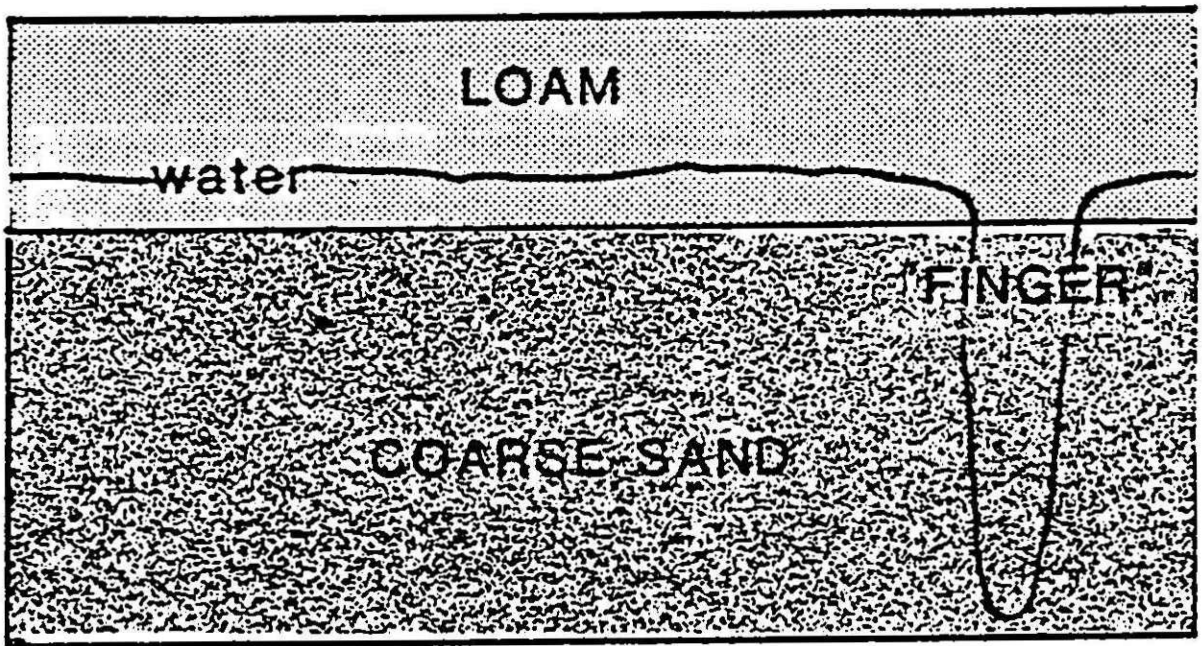

Figure 5. Wetting-Front Instability and the finger development in layered soil, Hill and Parlange (1972).

Wetting-front instability is defined as disruption of water movement from a fine textured layer to a coarse layer which percolates in concentrated locations as in finger-like ("fingers") protrusions through a profile. Hill and Parlange (1) postulate that this phenomenon is caused by an instability at the air/water interface which is gravity driven and is more pronounced as the pore size of the coarser sand increases. In the orchard, where this situation exists, water movement into the sand is slow and appears to temporarily "hang up" (perch) at the interface until several centimeters of soil above the boundary is saturated. The location and development of sinker roots in these soils can often be found in the "fingers". This phenomenon can cause root rotting above the interface in the wet spring and/or a moisture deficit in the sand layer below during the summer.

Methods to Reduce Limitation Effects

Site Selection. Obviously, proper site selection is the more important and simplest measure to avoid the aforementioned problems. Unfortunately, a fruit grower may not have this option and is relegated to making the most of a marginal site.

Rootstock Selection. For some crops, growers can use rootstock which possess genetic tolerance to wet soils and/or have vigorous root systems which tolerate shallow soils. Under these conditions for apple, MM 111 and M7 would be superior to M26 and MM106; plum root rather than peach for plum scions; and Mazzard better than Mahaleb for cherry. The shallow rooting Mazzard in shallow soils must be irrigated or mulched in order to prevent drought stress. Mahaleb rootstock would be satisfactory for layered soils under arid conditions. Mahaleb roots will not tolerate perched water layers under more humid conditions. As of yet, peach growers can not depend on this tool to circumvent limited soils. There are, however, plum parentage rootstocks under experimentation which are compatible with peach.

Tile Drain System. Drain systems which are properly designed can alleviate prolonged periods of wetness. They are most effective in fine-textured soils. These systems have a questionable track record in panned and layered soils. Water may continue to perch above lateral lines (usually set at 1-1½ meters deep) and percolate slowly.

Subsoiling. Deep ripping (1-1½ meters) and subsoiling or chiseling (plow) (less than 1 meter) can be effective in breaking up panned and to a certain extent layered soils. The most convenient time to perform this practice is prior to planting. Once the trees have been planted, plowing is restricted to row middles and near canopy drip-lines. Unfortunately, subsoiling is a temporary aid in encouraging deeper root growth and improved moisture drainage. Depending upon the makeup of the soil, sealing of a fractured pan can occur within a few months to a year afterward. Most soil scientists suggest that this operation best be performed when the soil is dry.

Soil Mixing. Soil mixing is becoming very popular in California for panned and layered soils as a preplant operation. This practice is performed by using either a slip-plow or a back-hoe. A slip plow is a large deep (2 meters plus), angled plow which is pulled by a large power source. The A and B horizon is mixed rather than momentarily fractured as in subsoiling. The same beneficial effect can be gained by digging a trench 1 meter wide, 1½ to 2 meters deep and 2 meters long with a back-hoe prior to planting. Trees planted on these sites often times make a 100% increase in growth over undisturbed sites. This newly adopted method has not been evaluated long enough in established orchards.

Raised Beds. Also known as growing trees on ridges, this technique is gaining popularity in many areas of the world. Farmers for hundreds of years have long reported the benefits of growing trees in marginal soils on raised beds. Surprisingly, there has been little research conducted to empirically assess the virtues and ramifications. Beds are formed by continued plowing or by the use of land moving equipment. Root systems appear to benefit from a doubling of top soil components down the tree row and from the water shedding effect into adjacent troughs.

An experimental plot, established in 1981 at the Clarksville Horticultural Experiment Station, Clarksville, Michigan, compares bed design and crop performance of apple, cherry and peach on a poorly drained soil site. As of 1983, the young apple and cherry trees are beginning to show preference for the medium bed design and the peach appears to prefer the control or flat conditions. Cherry and peach guard trees have succumbed only in flat treatments thus far. Preliminary observations at this time suggest that under these soil conditions, trees planted on the high bed may warrant supplemental irrigation to avoid drought. Soil temperatures monitored during 1983 indicate that beds tend to be slightly colder and that this phenomenon is closely linked to soil moisture content (Tables 1,2,3).

Table 1. Effects of raised beds on annual trunk size and annual shoot length of 'Redchief'[y] apple

	Trunk cross section area (cm^2)			Average annual shoot length (cm)[x]	
	1981	1982	1983	1982	1983
High	1.4	3.7	14.7	55	56
Medium	1.5	4.0	17.0	59	55
Flat	1.5	3.7	10.2	60	41

[x] Mean of 5 shoots per tree

[y] MM106 rootstock

Table 2. Effects of raised beds on annual trunk size and annual shoot length of 'Montmorency'[y] tart cherry

	Trunk cross section area (cm^2)			Average annual shoot length (cm)[x]	
	1981	1982	1983	1982	1983
High	1.7	6.6	15.5	95	50
Medium	2.0	7.3	17.8	98	63
Flat	1.4	5.6	14.8	87	57

[x] Mean of 5 shoots per tree

[y] Mahaleb seedling rootstock

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Table 3. Effects of raised beds on annual trunk size and annual shoot length of 'Redhaven'[y] peach.

	Trunk cross section area (cm^2)			Average annual shoot length (cm)[x]	
	1981	1982	1983	1982	1983
High	2.0	12.2	21.3	105	68
Medium	2.7	13.4	20.6	107	71
Flat	1.7	13.1	25.1	98	77

[x] Mean of 5 shoots per tree

[y] Halford seedling rootstock

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