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White Spots, Deep Tillage and Water Infiltration Of the Portneuf and Related Silt Loam Soils

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The Problem

The Portneuf silt loam and related soils of southcentral Idaho have formed from wind-laid material (loess) deposited over the thick lava of the Snake River Plains. Extensive areas of these soils are irrigated cropland. They are considered some of the most valuable and productive soils in Idaho. The soils have a lime (calcium carbonate) cemented hard-pan layer beginning about 14 inches below the surface and extending to depths of 30 or 40 inches in the soil. The hard layers allow irrigation water to move down but restrict most plant roots. Because of this, the water and nutrients that move through and below the hard layers are only slowly available to most annual crop plans.

These high silt soils are extremely susceptible to erosion, especially under the common methods of furrow irrigation. Land grading has further depleted the valuable topsoil on many fields. If the fields are cut and graded, or severely eroded, material from the hard layers may be brought to the surface by tillage. Because of the hard layers' high lime content and low organic matter, the surface color becomes lighter and is known as a white spot. Crop yields from white spots are reduced.

The loss of valuable topsoil and the resultant depleted soil fertility are considered the most important soil problems in this region of Idaho. Methods for eliminating soil erosion caused by irrigation and for improving the already eroded and denuded white spot soils are urgently needed.

Experimental Studies

Hardpan layers can be broken up by various deep tillage methods. Once the layer is broken, it does not reform, at least within 10 years. We studied the effects of several deep tillage methods. These included:

1. Subsoiling and ripping to a depth of 30 inches with standard subsoil shanks and with subsoil shanks fitted with wide duck foot tillage tools run on a spacing of 21 inches in two directions.
2. Subsoiling with a cable-laying machine (48 inches deep on 24-inch centers, with a vibrating chisel shank when the hard layer was dry).
3. Mixing the soil completely to depths of 32 inches with a backhoe.
4. Mixing to 48 inches to simulate deep plowing the entire profile including hardpan layers.
5. Trenching the soil to 48 inches on 24-inch centers, with the trenches cut 6 inches wide and refilled with mixed soil excavated from them.

In deep tillage tests started in 1965, subsoiling and subsoil ripping with duckfoot tillage tools to 30 inches did not affect water infiltration or crop yields. Deep mixing of the soil profile to 32 inches broke up the hardpan layers and increased deep root growth, but brought the white material to the surface and decreased water infiltration rates (Fig. 1).

Yields of dry beans the first year after mixing were reduced even when various amounts of phosphorus, zinc and manure were added. However, alfalfa grown in the second and third years produced normal yields. Dry field beans grown in the fourth year on the mixed soil were slightly stunted and had smaller and darker leaves, but yields were not reduced.

In a second 3-year test, subsoiling to 48 inches, trenching to 48 inches on 24-inch centers and complete mixing of the soil profile to 48 inches were studied under two irrigation levels. One irrigation treatment maintained soil moisture slightly less than optimum levels with normal irrigation sequences. The second irrigation treatment omitted some irrigations during the latter half of the growing season to create dryer surface conditions and encourage more soil water use from greater depths.

The deep subsoil chiseling and trenching increased depth of rooting of annual crops (Fig. 2), but had only minor effects on water uptake and crop yields under adequate irrigation. Mixing to 48 inches decreased yields of winter wheat, sugarbeets and field corn. Under low irrigation or stressed treatments, all crop yields were decreased except in the trenched low irrigation treatment. In this treatment, corn showed a beneficial response to trenching when the low irrigation treatments were compared to the low irrigation control and mixed treatments (Fig. 3). Breaking the hardpan layer led to increased roots below 24 inches, but did not prevent a marked loss in crop yield from reduced irrigation. Therefore, we concluded that when adequate irrigation water was available, tillage below 18 inches was not beneficial for normal soil that had not been cut or severely eroded.

White Spot Management

Long-time observations and experience by farmers and all research studies on white spot soils indicate that improving the cut or eroded areas is difficult. While we believe that all causes of unproductiveness of these soils are not yet known, knowledge of how they have responded in research studies does aid in making recommendations for managing the affected soils.

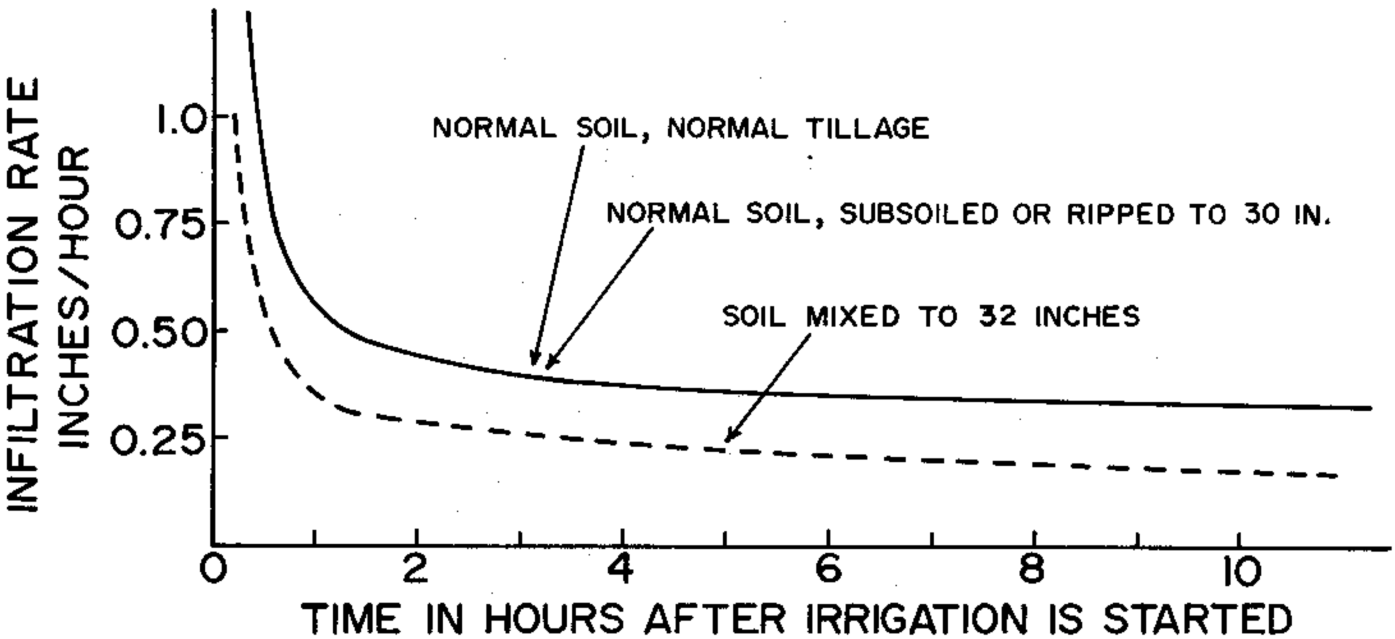

Fig. 1. Approximate rates of water infiltration into Portneuf soil from corrugates on 24-inch centers that have not been distributed since the previous irrigation. Subsoiling does not increase infiltration, but deep soil mixing does reduce water intake. The water infiltration rate will be greater than shown by these curves the first time a corrugate is filled with water, or when trash accumulates in the corrugate. The infiltration rate will slowly decrease with the length of time water runs in the corrugate and also as the season progresses if the soil is not tilled.

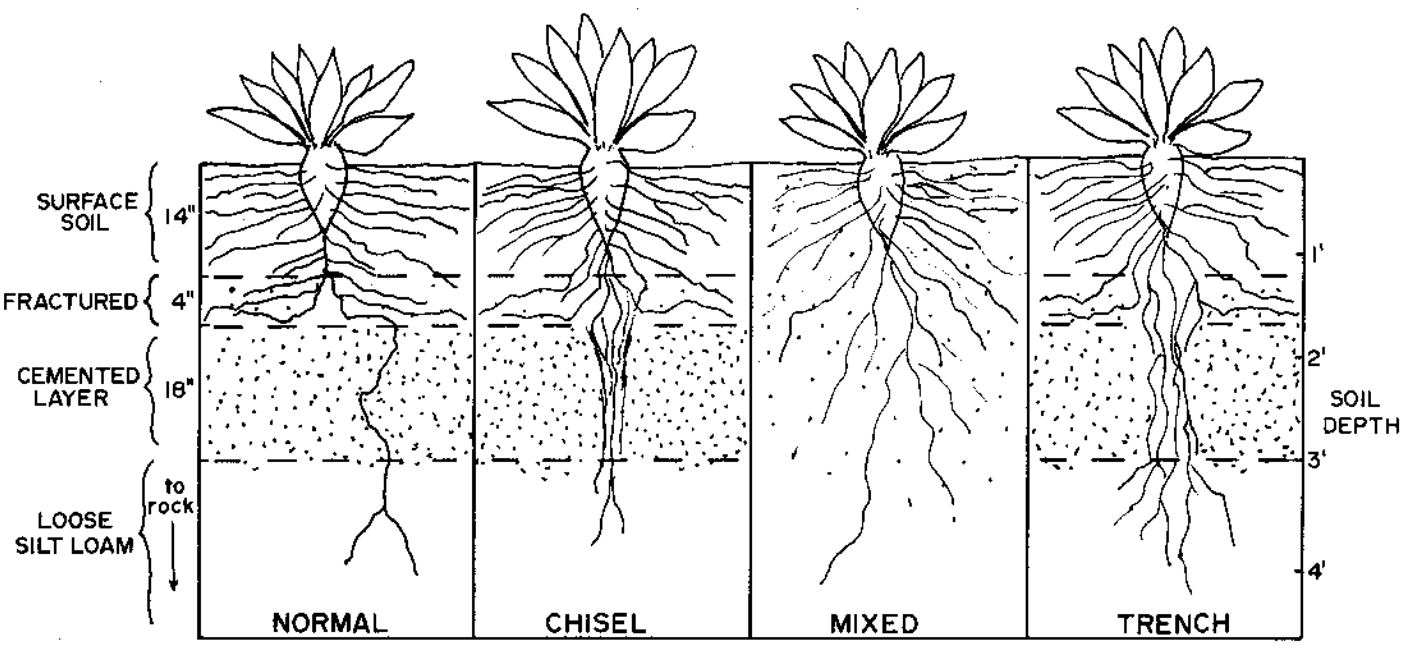

Fig. 2. Cross-section sketch of soil layers and rooting patterns of sugarbeets in the Portneuf silt loam after various tillage treatments.

Deepening the Soil Root Zone

The shallow hard layer is the most apparent adverse physical characteristic of white spot soils. Subsoiling and trenches to increase deep rooting and to increase nutrient and water availability on normal soils have not significantly increased either total water uptake or yield of annual crops. However, deep tillage on severe white spots with extremely shallow hardpan layers and limited rooting volume has not been studied specifically. In cut or eroded areas that have less than 14 inches of soil above the hard layer, enlarging the root zone to increase depth of rooting and recovery of stored water should be advantageous.

If the low lime material from below the hard layer can be brought to the surface by deep plowing, this may be beneficial in the long run. On the other hand, if the bottom of the hard layer is too deep to plow through, it may be better to deepen the root zone by subsoiling. This will bring white material to the surface.

Chemical Properties and Soil Fertility

Except for the high lime content within the hardpan layers, Portneuf soils do not appear to have any unfavorable chemical characteristics. White spots have high lime in the surface soil which leads to iron deficiency in some ornamentals, grapes, berries and fruit trees. These susceptible plants generally respond to addition of iron chelates. Portneuf soils require the addition of adequate nitrogen, phosphorus and sometimes zinc for growth of common field crops. Even when complete fertilizers are applied to white spot areas, production is generally reduced for a period of years after the areas are formed. The value of exotic or small quantities of unusual additives has not been demonstrated.

Organic Matter and Soil Amendments

Light color, cooler soil, reduced water infiltration rates, reduced internal water movement and limited root zones contribute to reduced plant growth and yield on white spots. Adding manure to the white spots will add needed nutrients and possibly improve infiltration rates temporarily, but will not permanently correct the problem. Gypsum and ferric sulfate applications to improve infiltration have been tested in the laboratory, but are not expected to improve the high lime white spots.

The lower temperatures of the white soils are attributed to both the light color that reduced heat absorption from sunlight and possible higher water retention at the soil surface that slows warming. Spring soil temperatures are reduced 2 to 3° F. This delays germination and reduces seeding vigor of many crops. Work on other soils has shown that banding lamp black, asphalt emulsions and similar materials over the seed rows may hasten emergence of some early-seeded crops. Such practices may be considered but they were not studied in these tillage tests and likely would not be economically feasible for field crops.

Summary and Conclusions

Since plant growth and production on white spots are reduced, farmers should make every effort to prevent their occurrence. Water distribution systems should be designed and operated to apply water uniformly without erosion. Land leveling or grading should be reduced or eliminated or methods should be devised to remove and then replace the topsoil.

Once formed, a white spot cannot be returned to the full productive potential of the original soil in a period of 2 or 3 years with any known economically feasible treatment. We further suspect that mixing the high lime hard layer with the surface soil has detrimental effects that are not yet fully understood. Fertility and deep tillage studies provide the basis for the following suggestions concerning soil and irrigation management problems that are likely to occur after serious erosion or cutting:

1. When erosion cannot be prevented, consider using grass tailwater strips or constructing ponds to trap sedi-

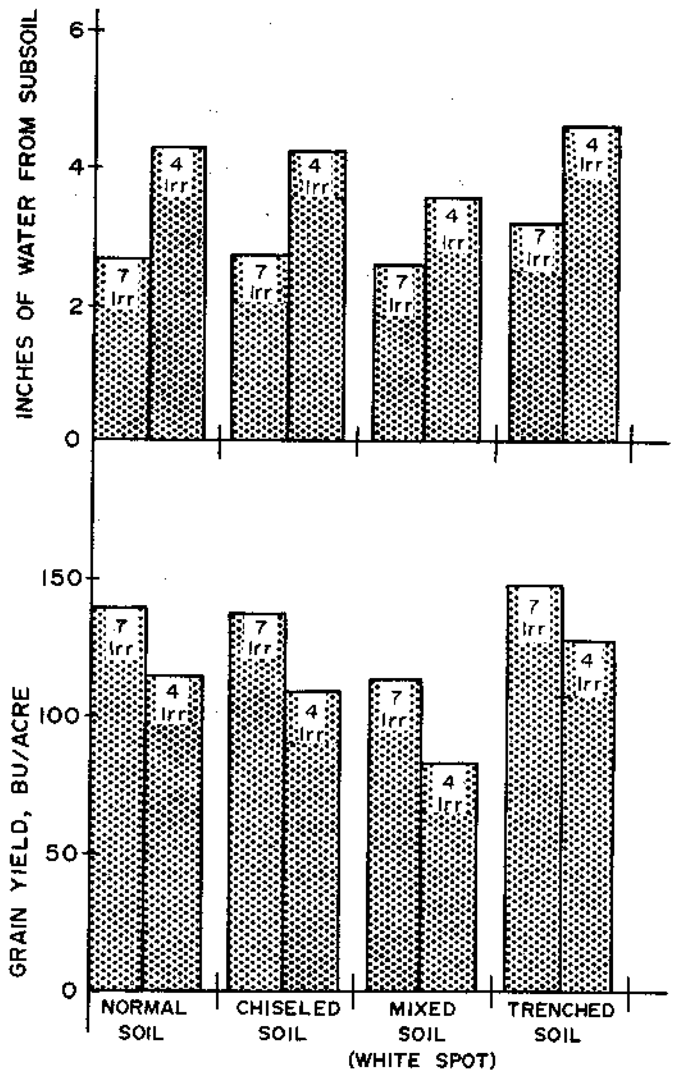

Fig. 3. Average corn yields and the amount of soil water removed below 2 feet between July 28 and November 3 in the fourth cropping season after deep tillage. The total water used by the crop ranged from 21 inches on lowest-yielding plots to 27 inches on highest-yielding plots.

Fig. 4. White spots on the surface signal the high lime content and low organic matter of hardpan layers in southcentral Idaho's valuable Portneuf silt loam soil areas.

ment that can be returned to the white spots. Add farm manure and incorporate crop residues to add plant nutrients, possibly improve water infiltration and reduce further erosion and depletion of the soils.

2. On the white spots already denuded of topsoil that have less than 14 inches of friable soil over the hardpan, heavy ripping or subsoiling may help by increasing the depth of rooting and available soil water. If the soil is so shallow that the hard layer can be plowed under and the low lime soil beneath it brought up, deep plowing may be a long-term solution. On the other hand, if plowing into this hard layer only brings the white material to the surface, subsoiling would be better than plowing.

3. Newly formed white spots are generally deficient in phosphorus and nitrogen, sometimes zinc. Adequate fertilizer should be applied, based on soil analyses. Water infiltration will be reduced. Irrigation management should allow for this and for the shallow root zones. Tillage operations that bring more white material to the surface should be avoided as this will lower soil temperatures in the spring.

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