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SOIL COMPACTION: CROP RESPONSE AND REMEDIATION

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Poor soil structure and compacted soil layers that restrict water drainage and root penetration are common soil quality problems on NY vegetable farms. The **causes of soil compaction** include:

- vehicle traffic, especially heavy loads with poor weight distribution on wet soils
- low organic matter content
- excessive tillage which pulverizes soil aggregates and increases oxidation (i.e., loss) of organic matter

Soils vary in their susceptibility to compaction. Fine textured (clay) soils are very susceptible, particularly when they have low organic matter content and are not well-aggregated. Coarse textured (sandy) soils depend less on aggregation, but often exhibit subsoil compaction or plow pans, and also are susceptible to crusting problems. Medium textured soils vary in their susceptibility, with well-sorted alluvial soils less likely to become compacted than, for example, poorly sorted soils derived from glacial tills. These latter soils have more interlocking among the various particle sizes and can easily become impenetrable by roots.

Compaction has a negative effect on several soil properties:

- reduces water infiltration rate
- slows drainage; prolongs flooding duration
- reduces aeration (soil porosity)
- soil biology
  - -slows activity of many beneficial microbes
  - -stimulates (anaerobic) denitrifying bacteria and some soilborne pathogens
- increases penetration resistance
- narrows the "nonlimiting water range" available to plants
- increases the potential for topsoil erosion, and chemical runoff

The **effect of soil compaction on plants** includes the following:

- restricted root growth (due to physical resistance of soil at penetrometer resistances > 300 psi, and due to lack of oxygen)
- slower leaf expansion (can occur at very early stages)
- increased tendency for
  - - flood damage and root disease
  - - nutrient deficiency
  - - drought stress during low rainfall periods
  - - pest damage and weed competition (because plants grow more slowly and may be less vigorous)
- reduced yields, quality, and delayed maturity

Current recommendations for **prevention of soil compaction** include:

- improve timing and minimize field traffic
- use designated lanes
- use lighter equipment where feasible
- improve weight distribution
  - - lower tire pressure
  - - tracked or 4-wheel drive vehicles
  - - trailer equipment rather than 3-point hitch
- install drainage systems where appropriate

Current recommendations for **remediation of soil compaction** include:

- properly timed conventional, deep, and/or frost tillage
- cover/rotation crops to break up compacted layers and improve other soil quality features such as organic matter content and biological activity
- integrate mechanical and biological approaches

Results of 1992-94 field study (vegetable crop response)

A three-year field study conducted on an Eel silt loam soil at the Cornell Vegetable Research Farm in Freeville, NY compared cabbage, snap bean, cucumber, and sweet corn for their growth and yield response to an artificially compacted soil layer beginning at about the 6 inch depth. Slower growing cabbage seedlings in compacted plots were more subject to flea beetle damage than the uncompacted controls. This was more of a problem in direct-seeded cabbage than in transplanted cabbage. Prolonged flooding after heavy rainfall events in compacted areas had a more adverse effect on cabbage and snap bean than on cucumber or sweet corn. Symptoms of nutrient deficiencies were observed in compacted plots in some years, particularly in snap beans and sweet corn. Maturity of cabbage, snap bean, and cucumber was delayed by compaction in all years. The average reduction in total marketable yield in (direct-seeded) compacted plots was 73, 49, 41, and 34% for cabbage, snap bean, cucumber and sweet corn, respectively. Yield reduction in transplanted cabbage (evaluated in 1993 only) was 29%. These results indicated that yield response to compaction in the field is often associated with crop sensitivity to secondary effects of compaction, such as prolonged flooding after rainfall events, reduced nutrient availability or uptake, and prolonged or more severe pest pressure.

Results of on-going USDA/SARE-funded field study (remediation)

We are currently (1997) in the second year of this three-year project. Collaborators include Cornell faculty members D. Wolfe, H. Van Es, and G. Abawi; Cornell Cooperative Extension Vegetable Specialists L. Stivers, D. Riggs, and L. Pedersen, and several grower cooperators. The objectives are:

(1) evaluate several cover crops and rotation sequences for their effect on soil quality and compaction;

(2) identify and integrate effective mechanical procedures for remediation of compaction with biological approaches.

(3) quantify the relationship between soil management practices and the occurrence of soilborne pathogens and severity of root diseases.

Our cover crop evaluations to date suggest that, for growers willing to take land out of production for one summer, sudangrass, hubam sweet clover, and perennial ryegrass are particularly effective at improving soil quality and increasing yield potential. All are relatively easy to establish under NY conditions, although weed competition at early stages can sometimes be a problem. Sudangrass, particularly when mowed once during the season, produces deep roots capable of penetrating compacted layers, and produces abundant above-ground biomass. Hubam sweet clover does not produce as much root growth as sudangrass, but is a nitrogen-fixing legume. Perennial ryegrass produces substantial below-ground as well as above-ground biomass. Perennial ryegrass can also be grown as a fall cover crop. Ryegrain, hairy vetch, and rye/vetch mixtures are other fall cover crops that have performed well, particularly when planted in early to mid September. They can produce sufficient biomass in the fall to minimize winter soil erosion, and produce additional biomass in the spring. In one trial, beets planted after ryegrain had significantly less root disease. Yellow mustard is an attractive fall cover crop option because of its deep, penetrating tap root. However, we have encountered some problems in establishing a good stand in some sites in some years. Also, yellow mustard winter kills, and must be planted relatively early. Various other*Brassica* species have looked promising as fall covers, but will require more evaluation.