N.C. STATE UNIVERSITY
DEPARTMENT of SOIL SCIENCE

Tillage Options in the N.C. Piedmont: Constraints and Potential for Soybean Production

Robert Walters, Research Specialist ♦ Department of Soil Science, North Carolina State University, Raleigh, N.C.

Soybean and Tillage Field Day ♦ 05 September 2012 ♦ Upper Piedmont Research Station, Reidsville, N.C.

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Rationale

North Carolina is one of the 18 largest soybean producers in the United States. However, N.C. has the lowest 10- and 20-year yield trends, the 3rd lowest 5-year trend and, the lowest yield trend in all three categories compared to peer producers in other southern states: AR, KY, LA, MS, TN (**Figure 1**).

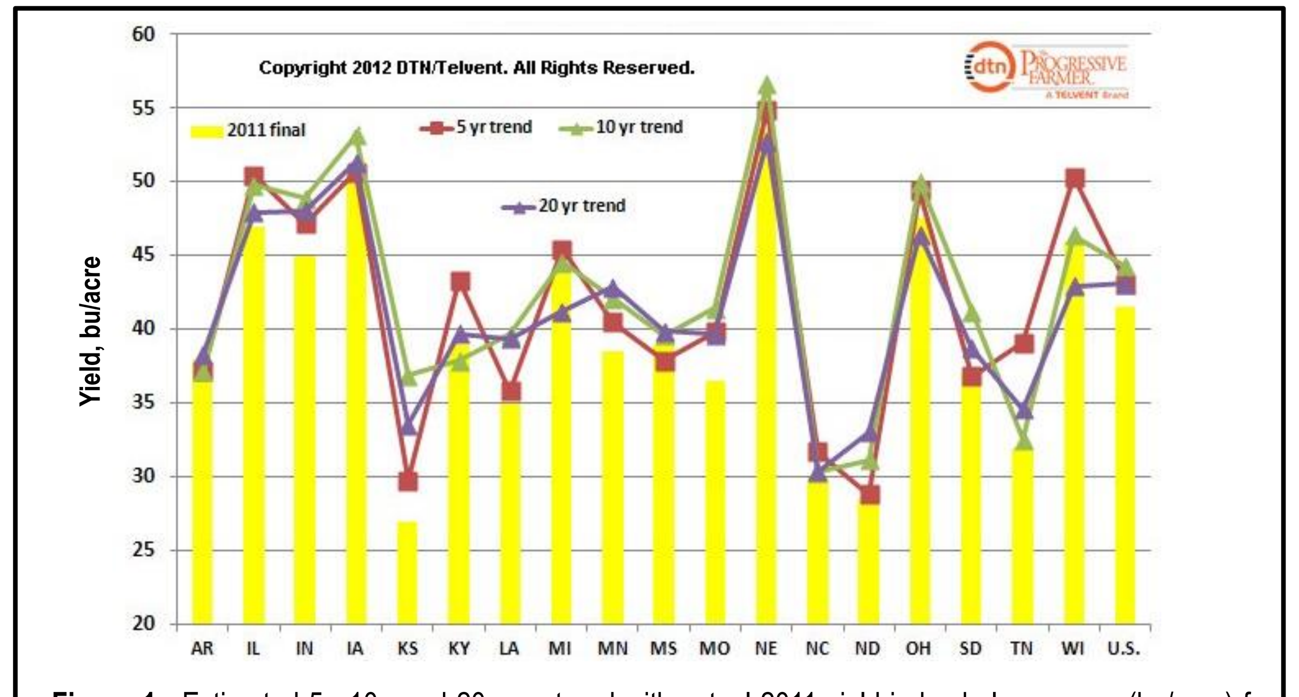


Figure 1. Estimated 5-, 10-, and 20-year trend with actual 2011 yield in bushels per acre (bu/acre) for top 18 soybean producing states in the U.S. *Image source: www.dtnprogressivefarmer.com; Data source: USDA-NASS.*

North Carolina's average soybean yield in 2011 was 30 bushels per acre for all production categories (full-season, double crop, irrigated and non-irrigated); yield trend over the past decade has been flat (**Figures 2a** and **2b**).

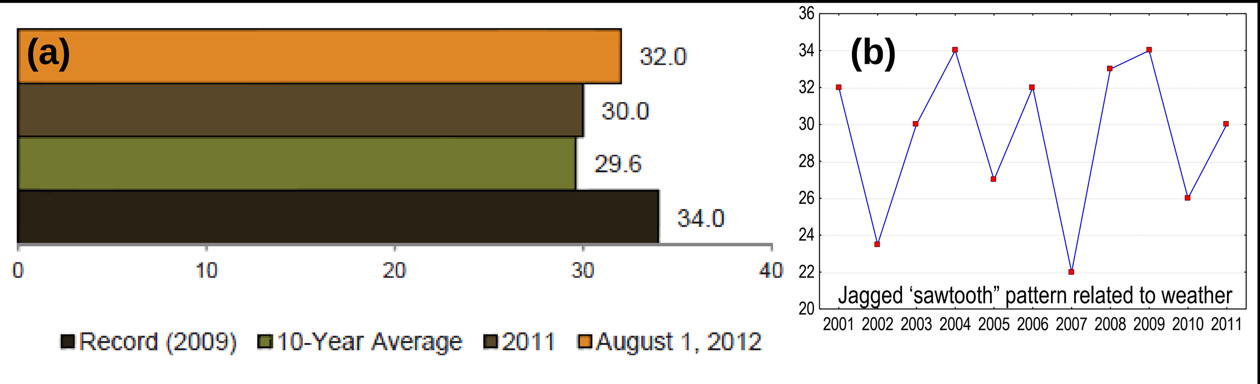


Figure 2. (a) Soybean yield (bushels/acre) in North Carolina: state record (2009), 2011, 10-year average and predicted 2012 yield; and **(b)** North Carolina trend 2001-2011. *Source: USDA-NASS News Release, August 12, 2012 and USDA-NASS.*

Average soybean yield for Rockingham County (site of the Upper Piedmont Research Station) in 2010 was 28 bushels per acre and, 18 bushels per acre in 2011 for all production categories. Top soybean producers in N.C. regularly crack the 80+ bushels per acre threshold, indicating that higher yields are attainable. We point up that the top three N.C. producers in 2011 all were in the N.C. Piedmont and Mountain regions (Union and Yadkin Counties). Kip Cullers, of Purdy, MO holds the world record for soybean, producing a whopping160.1 bushels per acre in contest plots in 2010. The soybean champ said the key to realizing higher soybean yield is keeping plants healthy and stress-free the entire growing season.

Soil moisture stress is a major factor limiting soybean yield in N.C. Ideally, all soybean acres would be irrigated. But for reasons of economic cost or lack of storage water, most soybeans in the Piedmont are rain-fed. Here, we discusses the effect of tillage on soil water, research findings from our long-term tillage plots, and potential for realizing higher soybean yield in the N.C. Piedmont.

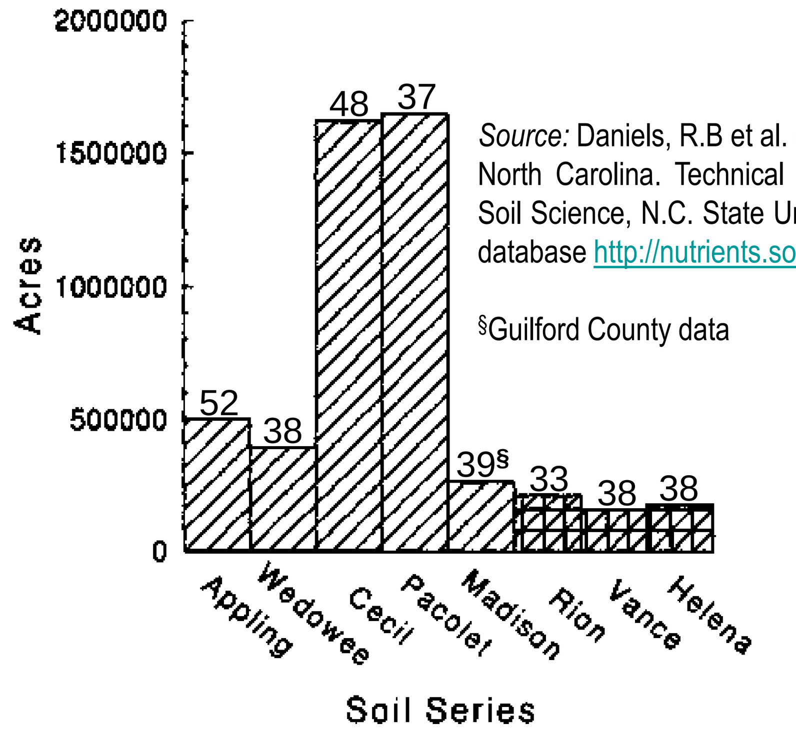
Soil: The Ideal and the Real

What would an 'ideal' soil look like? Here's our profile:

- Deep rooting zone, easily permeable to air, water, and roots
- Good water-holding capacity
- Balanced nutrient supply
- Good aggregate structure resistant to erosion

Most agricultural soils in the Piedmont fall short of this ideal! **Figure 3** shows a breakdown of the dominant soils in the N.C. Piedmont felsic crystalline soil system and their soybean yield potential for Rockingham County (full-season, non-irrigated, representative slope).

Figure 3.



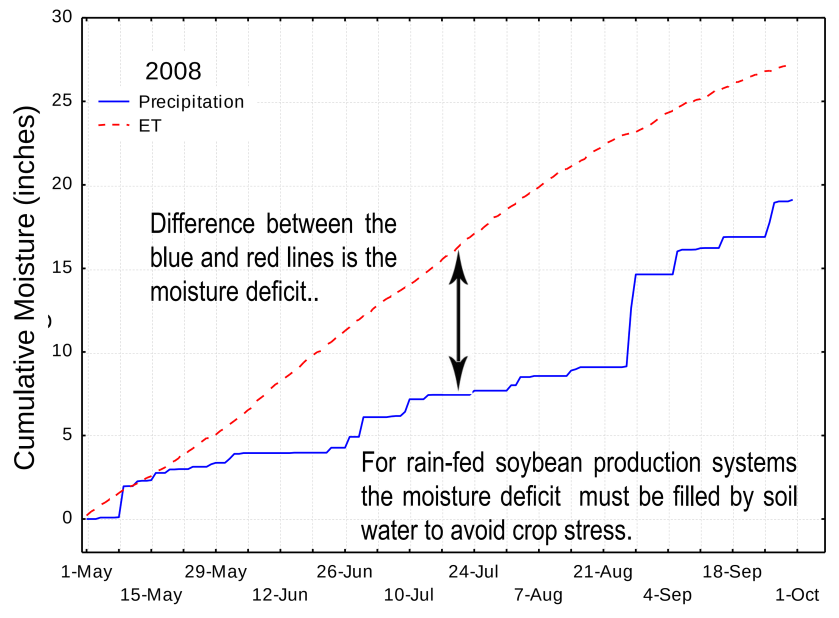
Source: Daniels, R.B et al. (1999) Soil Systems in North Carolina. Technical Bulletin 314. Dept. of Soil Science, N.C. State Univ. and Realistic Yield database http://nutrients.soil.ncsu.edu/yields/

§Guilford County data

The chart in **Figure 3** shows a range of soybean yields from 33 to 52 bushels per acre. The largest acreages are occupied by the Cecil and Pacolet series, many which are under row crop production. All the soils in **Figure 3** have one thing in common: a sandy loam to sandy clay loam surface texture (uneroded). *Then why the large spread in soybean potential??*

The answer lies in the subsoil, specifically differences in physical and chemical properties that influence crop rooting and water holding capacity, two key properties of our 'ideal' soil.

Weather: Future Uncertain, but Predictable Events



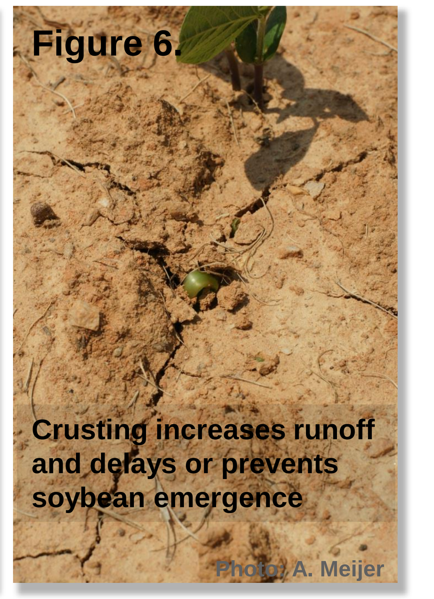
Weather is a wildcard variable that farmers have no control over. Some weather events are, however, quite predictable. The chart at left shows cumulative evapotranspiration (ET) vs. actual precipitation at the UPRS in 2008. Rainfall below ET during the soybean season (May-Oct) is normal in the N.C. Piedmont.

Tillage and Soil Water

Tillage strongly influences the amount of water that enters the soil via infiltration. Infiltration occurs at the soil surface. Inversion tillage often buries all the residue from last season's crop, leaving a clean surface. Heavy rains beating down on the exposed mineral soil causes slaking of structural aggregates. The result is a hard, thick surface crust (**Figures 5** and **6**).

Figure 5.

Figure 6.



Our research group has monitored profile soil water in the Reidsville tillage plots beneath two corn crops (2009, 2011) and three soybean crops (2008, 2010, 2012) weekly at 4, 8, 12, 18, 24, and 36" depth with a Dynamax PR2/6 capacitance probe http://dynamax.com/products/soil-moisture. **Figures 7a-d** show profile moisture beneath soybean measured at 06, 12, and 19 July 2012. No rainfall was recorded at the research station between 06-12 July; on 13 July there was 0.06 inches of rain followed by a brief, very intense storm on 14 July that dropped 3.43 inches. See chart annotations below for the interpretive summary…

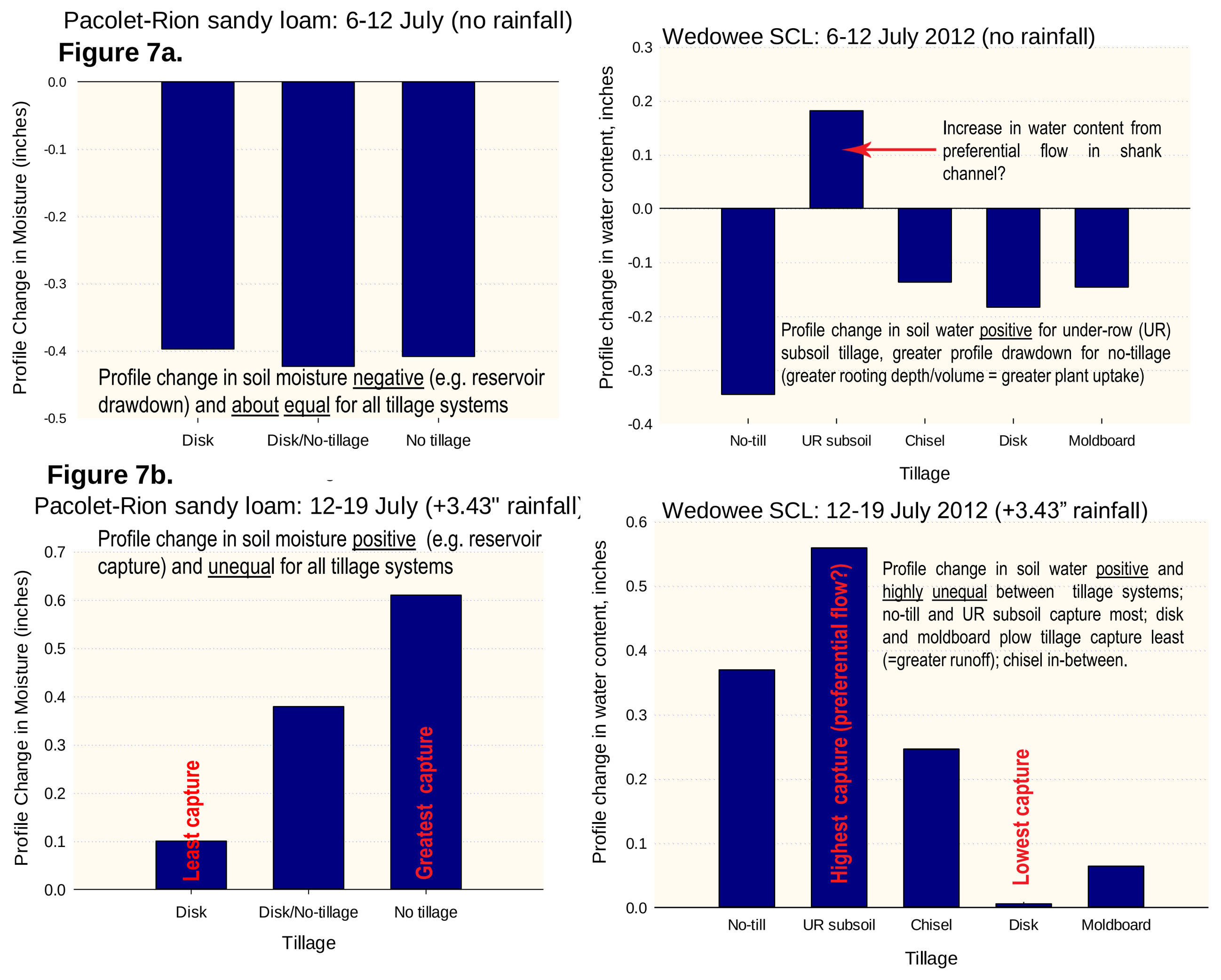
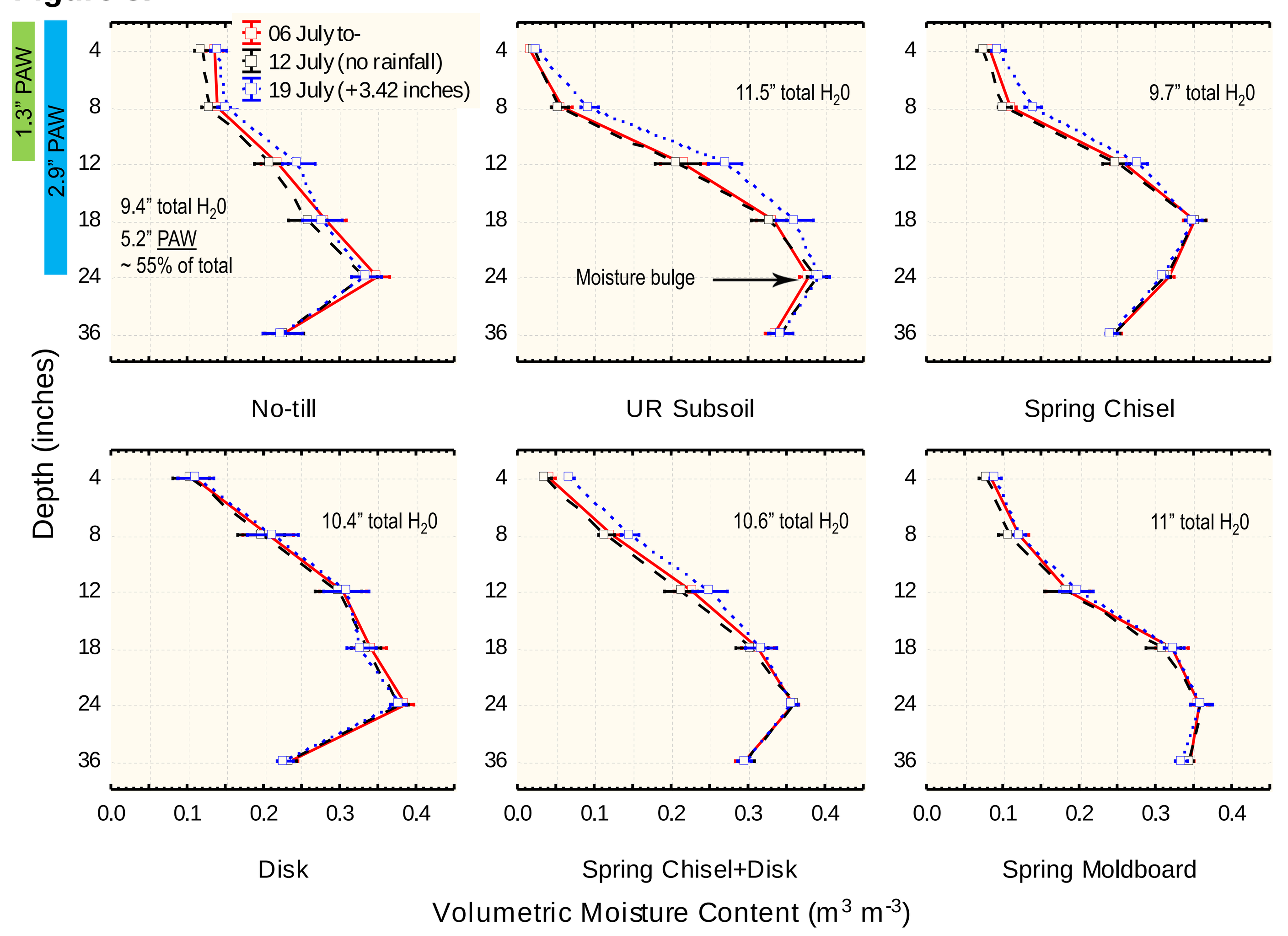


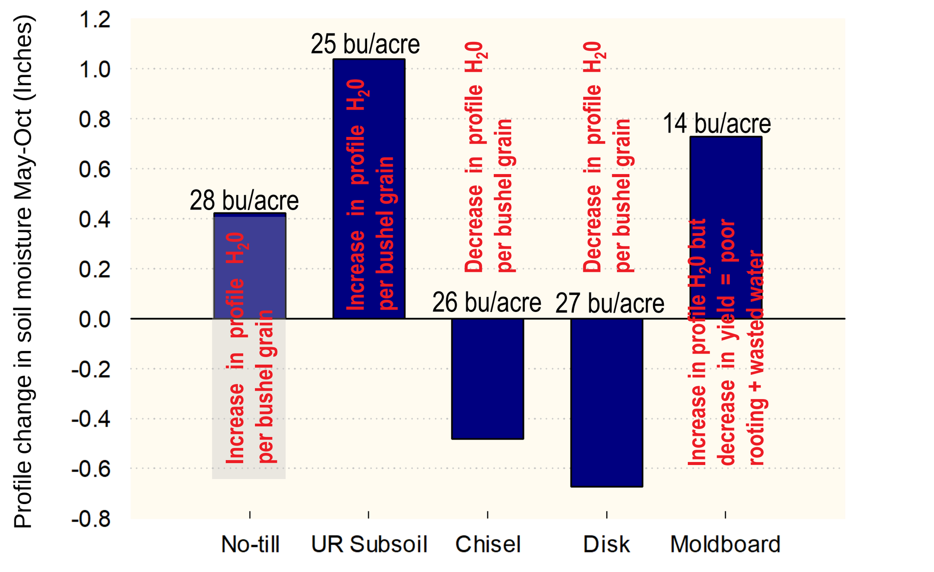
Figure 8.



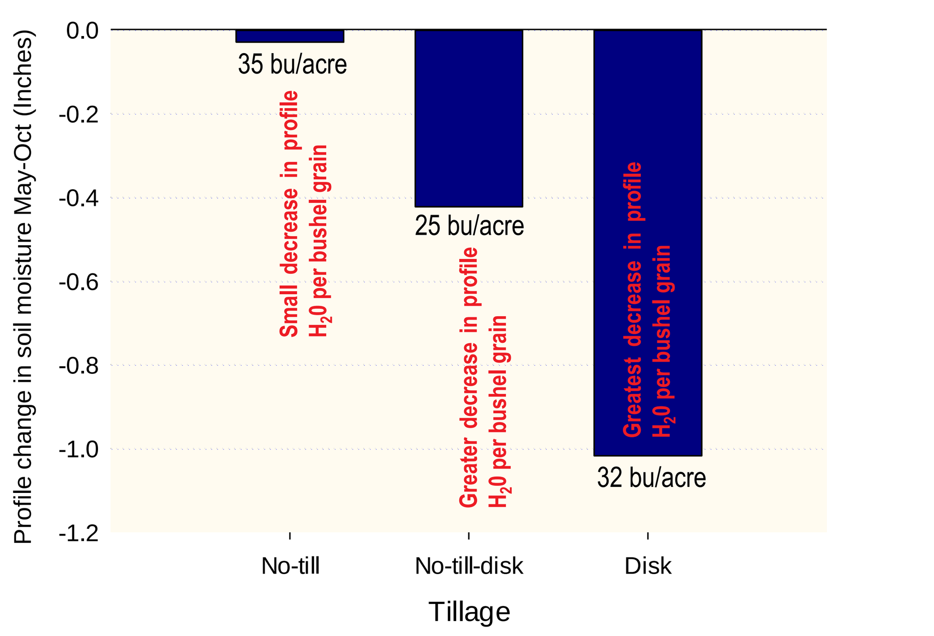
Panels in **Figure 8** (above) show typical profile moisture in a Wedowee sandy loam soil beneath soybean at three measurement dates between growth stages R1 (beginning bloom) to R2 (full bloom). Important findings from these data:

- Total measured profile H_2O (36-inch depth) on 19 July was 9.4 to 11.5 inches across six tillage systems.
- Based on measurement of soil available water capacity at each of six moisture measurement depths, the amount of profile plant available water (PAW) under no-till was 5.2 inches or ~55% of total profile H_2O.
- In all tillage systems there was a moisture 'bulge' or surplus in the subsoil around 18-24 inches deep; this is potentially available water depending on how deep the soybean roots penetrate.
- Under no-tillage, the upper 12 inches of soil had 1.3 inches of PAW; at critical soybean growth stages R1 (beginning bloom) through R6 (grain maturity), water use is 0.20-0.30 inches per day; if soybean roots are limited to the upper 12 inches of soil a recharge of 1.3 inches of H_2O is needed every 4 to 7 days to avoid crop stress. This represents a constraint for soybean production.
- Increasing rooting depth to 24 inches would increase PAW by 2.9 inches, enough H_2O to last 10 to 15 days without crop stress. This represents a potential for soybean production.
- Under no-tillage, profile water curve was steeper compared to other tillage systems; our interpretation is that more water is being extracted, and less water is accumulating in the profile under no-tillage.
- In all tillage systems, soil water content 24 inches deep was accumulating (=moisture content greater than field capacity=drainage water); soybean rooting through this depth is questionable.

Wedowee sandy loam 2-yr average (2008, 2010) cumulative profile change in soil moisture (May-Oct.) with average soybean yield



Pacolet-Rion sandy loam 2-yr average (2008, 2010) cumulative profile change in soil moisture (May-Oct.) with average soybean yield.



Interpretive Summary

- Moisture stress is a major factor limiting rain-fed soybean production systems in the N.C. Piedmont.
- Subsoil characteristics strongly affect soybean yield potential.
- We found a surplus of potentially available water 18 to 24 inches deep beneath soybean on a Pacolet and Wedowee sandy loam soil; other Piedmont soils with loamy, fine-textured B horizons are expected to have similar reserves.
- Tapping subsoil moisture may require modifying the subsoil via innovative non-inversion deep tillage to promote deeper soybean rooting.
- In rain-fed soybeans, no-tillage and non-inversion tillage represent the most efficient production systems in terms of yield and profile moisture utilization.
- A yield benefit associated with shallow (9-10") under-row, narrow point subsoiling vs. no-tillage has not been observed in the Reidsville tillage plots.