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SOIL INFLUENCES ON WATER UPTAKE PATTERNS IN COTTON

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Introduction

Most regions of the U. S. cotton belt make use of multiple irrigation scheduling procedures with few instances found in which one universally adopted method is used among growers. Both plant and soil based scheduling methods are being used with reasonable success throughout the cotton growing regions with numerous types of technologies used. Plant based approaches that make use of measurements of canopy temperature and leaf water potential have been highly successful in areas that do not rely on summer rainfall as a major component of ET. Growers and researcher that favor this method note the rapid and far-reaching information that integrates evaporative demand with plant available soil moisture to establish peak levels of crop water stress to develop scheduling thresholds.

Soil based irrigation scheduling methods are more widely accepted because they need not rely on current climatic conditions, instruments generally produce repeatable results and the timing of measurements is relatively flexible. Soil moisture methods for irrigation scheduling typically make use of estimates of plant available water (PAW) derived from field capacity (FC), crop permanent wilting point (PWP) and rooting depth. A percent depletion value is applied, above which there is an increasing risk of high water stress impacting crop losses. While this approach can be very useful to the agronomist, good initial estimates of rooting depth, field capacity and wilting point are necessary to minimize the risk of incorrectly estimating soil water reserves. During the process of establishing the soil specific parameters, it is also useful to develop an understanding of how these parameters change with time and location. This studies focus is to provide information that describes variation in cotton rooting depth during the season at specific sites and contrasts multiple sites that differ mainly in their soil conditions.

Materials and Methods

Neutron probe access tubes were installed to a depth of 2.4 meters and replicated two times for each irrigation treatment. A Cambell-Pacific 503 Hydroprobe was used to determine volumetric soil water content at 7- to 10-day intervals throughout the growing season. A 22cm reading represented soil moisture storage within the top 30cm, while a 46cm reading was used to represent soil moisture within the second 30cm zone; 30cm increments were used thereafter to represent corresponding depths to 2.4 meters for soil moisture content.

Neutron probe calibration was conducted independently at each study location with curves developed by taking 60cc soil samples every 30cm down to 120cm in the field; the samples were then weighed, dried, and then re-weighed. Standard gravimetric procedures were used to calculate volumetric soil moisture on the 20 to 25 samples collected during wet and dry soil phases. These data were then correlated with neutron probe counts taken from the same tube and depth, figure 1. Composite soil samples were collected for the 30, 60 and 90cm depths and an average texture was reported. Percent sand, silt, and clay were also determined at each site.

Plant available water was based on an estimated field capacity (FC) that was recorded 2 -3 days after an irrigation, and permanent wilting point (PWP) values were obtained at the end of the season within the top 60cm and applied throughout the rooting zone. Sites selected did not contain highly stratified soil conditions. Root zone depth and PAW within that zone were used to calculate the percent allowable depletion.

Leaf water potential readings using a pressure chamber were also monitored throughout the season to determine plant water status. These readings were taken from fully expanded leaves receiving full sun between 12 and 3:30 p.m. Seven to ten individual leaf measurements were recorded for each treatment and then averaged.

Results and Discussion

Plant water extraction data from the neutron probe were used to estimate rooting depth and activity which was dynamic in nature both within season and between seasons. Water extraction with similar sowing dates showed a range of 30 to 90cm on June 25th depending on the season. We found that effective rooting depth estimated for water extraction patterns increased at a rapid rate during the 120-day period following sowing, but then slowed dramatically during the last 45 days leading up to defoliation, figure 2. This rate of root growth was lower in early 1998 with July 1 rooting depth at 60cm, while the 1999 and 2000 seasons produced a 90 and 120cm root zone on this same site. The warm spring of the 2000 season resulted in above average early crop development and an extensive soil volume with which to extract water for crop evapotranspiration. Despite variations in annual weather, late season root water extraction depths were consistent on these clay loam soils with root activity observed between the 200 to 240cm zone. Plant water extraction patterns also varied depending on the water regime that was imposed.

Root zone estimates from four study sites in western Fresno Co. with varying soil textures are shown in Figure 3. Studies conducted in the same year with similar sowing dates found highly variable water extraction depths depending on soil type. The soil site which had a 46 percent clay content restricted root development early and mid-season to less than 0.5 meter, while the moderate clay content soils experienced the most rapid expansion of roots, allowing deep extraction of soil water.

Conclusion

Root growth and associated soil water extraction patterns are highly dynamic depending on soil type and season. Allowable depletion and plant water stress relationships were derived from neutron probe data recorded throughout the growing season. Close relationships between LWP and estimates of soil depletion were observed with low clay content soils; this relationship diminished as plant available water at field capacity increased. Figures 4 and 5. Our studies indicate the following:

1. Scheduling early season events will vary depending on season and soil type.
2. Soils with very high and very low clay content restrict the ability of the cotton plant to root deeply, thereby limiting plant available water. More frequent irrigations are necessary under these conditions.
3. Soil-based irrigation scheduling approaches are most effective on soils with low clay content and low plant available water conditions that may result from restrictions in root development.
4. Rooting depth of cotton is highly variable depending on soil type and soil properties.

References

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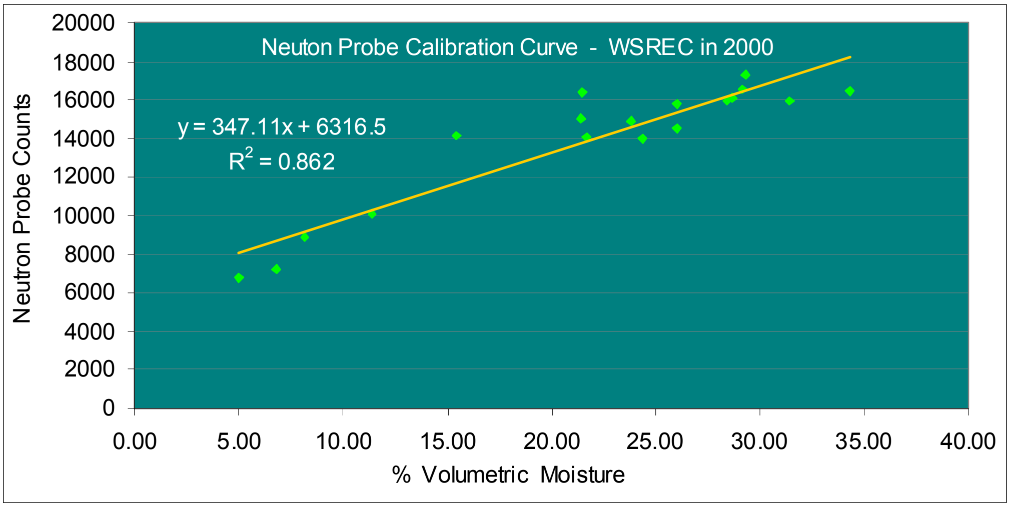


Figure 1. Neutron probe calibration curve developed rom Volumetric soil moisture measurements and neutron probe counts.

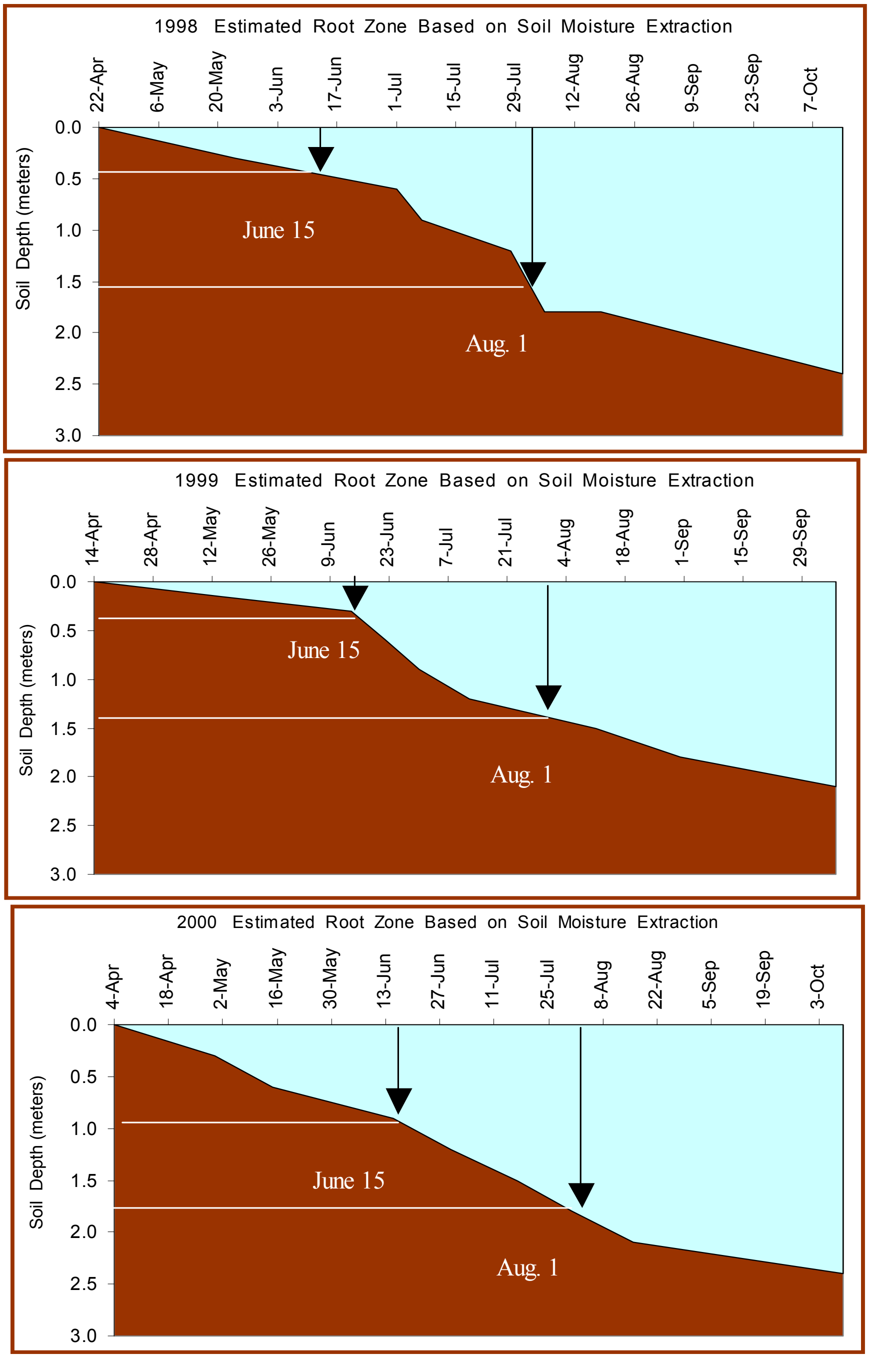


Figure 2. Water extraction depths based on neutron probe data from trials conducted in 1998, 1999, and 2000 on Panoche clay loam.

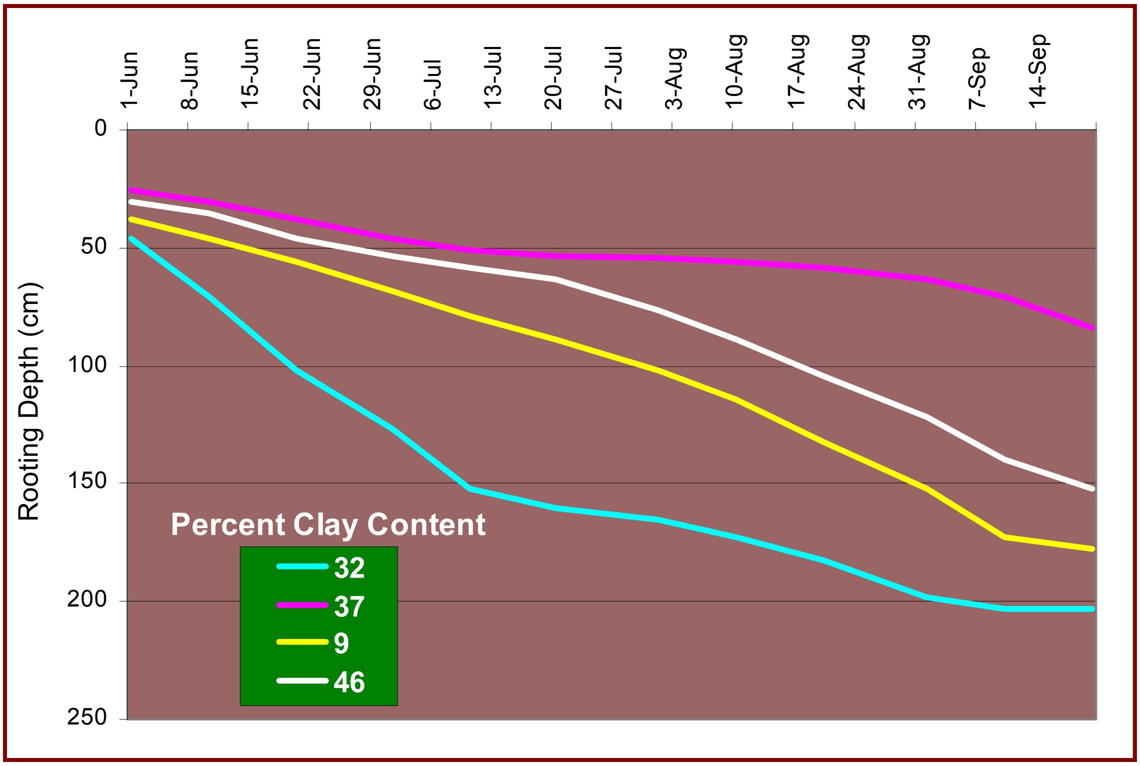


Figure 3. Root zone estimates based on neutron probe data from four study locations with varying percent clay content. All study sites located in western Fresno county in 1997.

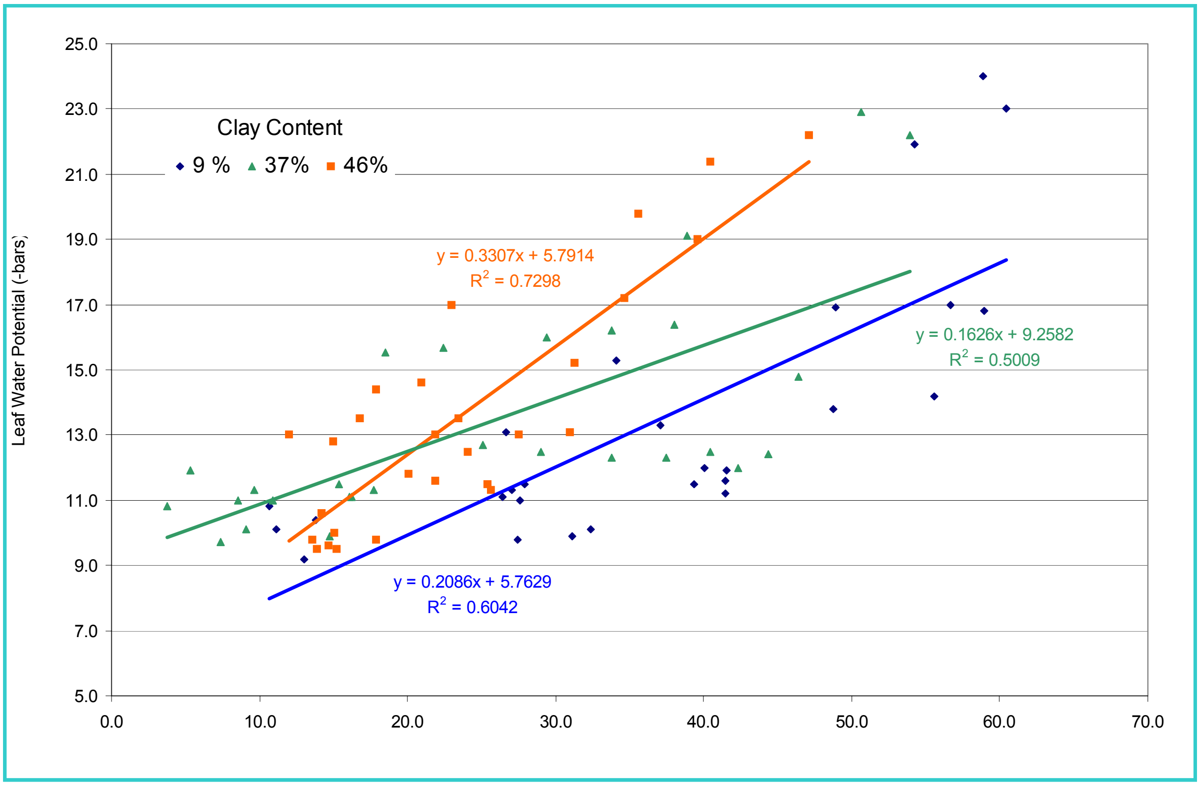
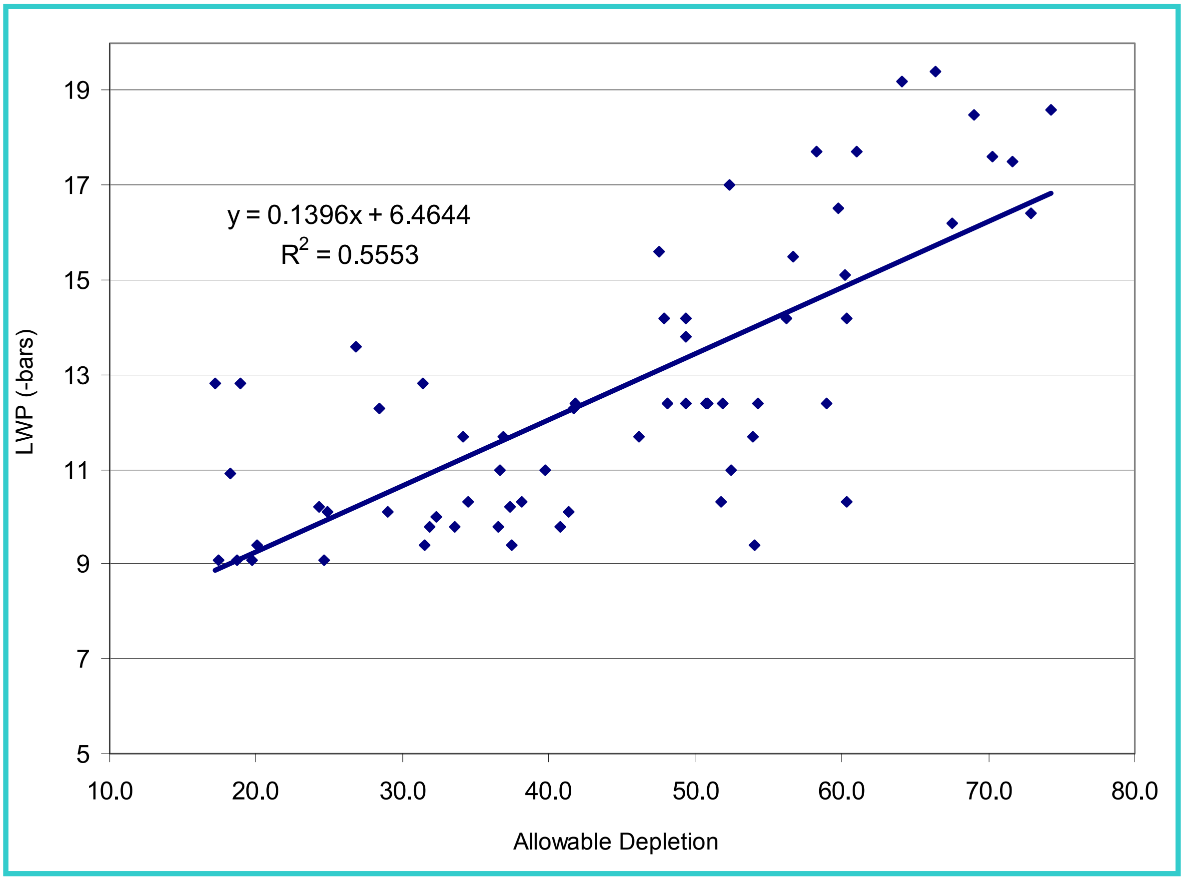


Figure 4. Percent allowable depletion and leaf water potential throughout the growing season. Data from three trial locations in western Fresno county with varying soil textures.



y = 0.1396x + 6.4644
R2 = 0.5553
LWP (-bars)
19
17
15
13
11
9
7
5
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
Allowable Depletion

Figure 5.