MAXIMIZING COTTON PRODUCTION AND RYE COVER CROP BIOMASS THROUGH TIMELY IN-ROW SUBSOILING

R.L. Raper[1], E.B. Schwab[1], J.S. Bergtold[1], A.J. Price[1], K.S. Balkcom[1], F.J. Arriaga[1], and T.S. Kornecki[1]

[1]USDA-ARS National Soil Dynamics Laboratory, Conservation Systems Research, 411 South Donahue Drive, Auburn, AL 36832. Corresponding author email address: randy.raper@ars.usda.gov

ABSTRACT

Most tillage and fertilizer practices attempt to maximize cash crop yields and do not focus on increasing cover crop yields. This project was conducted to determine the optimum time to perform in-row subsoiling in order to maximize cash crop and cover crop production. Two implements (Paratill or a KMC Rip/Strip) were used to perform in-row subsoiling at 6-week intervals beginning in the late fall in actively growing cover crops. Results indicated that maximum yields occurred for the cash crop and the cover crop by performing in-row subsoiling late in the spring after the cover crop had been terminated. All in-row subsoiling treatments were found to be superior to no-tillage which exhibited reduced plant growth, infiltration, and increased soil compaction.

Keywords. Tillage, In-Row Subsoiling, Soil compaction, Cover Crops, Biomass

INTRODUCTION

Soil compaction has been shown to reduce cotton (*Gossypium hirsutum* L.) yields in the Southeastern U.S. (Camp and Lund, 1964; Schwab et al., 2002; Raper, 2005c). In-row subsoiling is one of the most common methods used to remove compacted soil conditions (Box and Langdale, 1984; Busscher and Sojka, 1987; Raper, 2005b). Subsoiling disrupts compacted soil profiles, improves infiltration, increases soil moisture storage, and allows roots to proliferate downward to obtain adequate soil moisture and potentially improve crop yield (Raper and Bergtold, 2007). However, the shape of the subsoiler shank can have a large effect on the amount of soil disturbed both aboveground and belowground (Raper, 2005a). Increased belowground soil disruption coupled with reduced aboveground disruption have caused many producers to consider bentleg shanks as the preferred method of in-row subsoiling while maintaining conservation compliance.

Mostly ignored in the quest to improve crop production has been the impact and timing of tillage practices on cover crop production. In-row subsoiling is often recommended to be performed when timing is most plentiful, in the spring prior to planting or in the fall after harvest. The impacts of in-row subsoiling on cash crop and cover crop production is not often considered. However, maximum environmental and productivity benefits have been associated with large amounts of cover crop biomass (Reeves, 1994). Improved weed control, increased infiltration, decreased evaporation, increased water storage, improved soil quality, and reduced soil compaction have all been found as benefits of cover crops. During periods of extreme drought, many producers have even allowed their cattle to graze cover crops as a food source.

The ability to quickly produce a biomass crop may even have future implications for bioenergy. As the U.S. develops the capability to develop fuel from cellulose, one source of biomass that should not be overlooked is cover crops. Many producers in the Southeastern U.S. should be able to grow large biomass cover crops that could exceed yields of 4-5 t/ac with the plentiful rainfall that is mostly available during winter months. However, adequate research must be conducted to ensure that soil quality does not degrade as a result of this potential bioenergy crop. Therefore, an experiment was planned to determine if benefits in cash crop yields, cover crop yields, or soil properties could be improved through proper timing of in-row subsoiling.

Specifically, the objectives of this study were to:

• compare two different in-row subsoiling implements (Paratill and KMC Rip/Strip in-row subsoilers), and

• determine the optimum time of the year to conduct in-row subsoiling operations in order to maximize cash crop yield, cover crop yield, and soil properties.

MATERIALS AND METHODS

This experiment was begun in the fall of 2004 at the E.V. Smith Research Center in Shorter, Ala. (South-central Alabama) on a Compass loamy sand soil (coarse-loamy, siliceous, subactive, thermic Plintic Paleudults) which is a Coastal Plain soil commonly found in the southeastern U.S. and along the Atlantic Coast of the US. These soils are typically prone to subsoil compaction and usually require annual in-row subsoiling. This experiment focused on a continuous cotton production system which produced crops during 2005, 2006, and 2007.

Two implements were evaluated for this experiment. A Paratill, which is a bentleg subsoiler, (Bigham Brothers, Lubbock, TX) was compared against a Rip/Strip in-row subsoiler (Kelley Manufacturing Company, Tifton, GA) with a straight standard angled with the horizontal at 45°. Tillage depth for the experiment was maintained at 41 cm for both implements.

The timing of in-row subsoiling was the major subject of the experiment and was varied from late fall until spring prior to planting. Four times were selected beginning in mid-December and then spaced approximately 6 weeks apart. These times were mid-December, late-January, early-March, and late-April.

The experimental design was a randomized complete block with a 2x4 factorial arrangement of treatments augmented with an additional control treatment of no-deep tillage. The two factors investigated were: 1) in-row subsoiling implement (Paratill or Rip/Strip) and 2) timing of in-row subsoiling (four times). Treatments were replicated four times (36 plots) with each 4-row plot being 100 cm rows wide (4 m) by 15 m long.

After the cotton was harvested in the fall, a rye (*Secale cereale* L.) cover crop was planted and grown throughout the winter months. During the cover crop growing period, the in-row subsoiling was conducted until the following spring when the cover crop was terminated using glyphosate and rolling. Auburn University Extension recommendations were used to apply all fertilizers, herbicides, insecticides, and defoliants. The center two rows were harvested and weighted to obtain seed cotton yield. Rye was sampled by taking two 0.25 m square frames and oven-drying at 55° C until constant weight to remove moisture.

Soil strength was determined by use of cone index measurements (ASAE Standards, 2004b; ASAE Standards, 2004a) which were obtained with the Multiple-Probe Soil Measurement System (Raper et al., 1999). These measurements were taken with all five-cone index measurements being equally spaced at a 0.25-m distance across the soil with the middle measurement being directly in the path of the shank.

Data was subjected to ANOVA using the Statistical Analysis System (Littell et al., 1996). Preplanned single degree of freedom contrast and Fisher's protected LSD were used for mean comparisons. A significance level of $P<0.1$ was established a priori.

RESULTS AND DISCUSSION

COVER CROP BIOMASS

The amount of rye cover crop produced in spring of 2005 did not vary significantly ($p \leq 0.12$) based on the implement used or the timing of in-row subsoiling conducted during the preceding winter months (fig. 1; left). The only significant contrast that was noted was that December in-row subsoiling was more advantageous than March in-row subsoiling ($p \leq 0.07$; 2109 kg/ha vs. 3138 kg/ha, respectively). A trend was also noted that smaller amounts of cover crop biomass were produced by the no-till system as compared to a majority of the in-row subsoiling treatments.

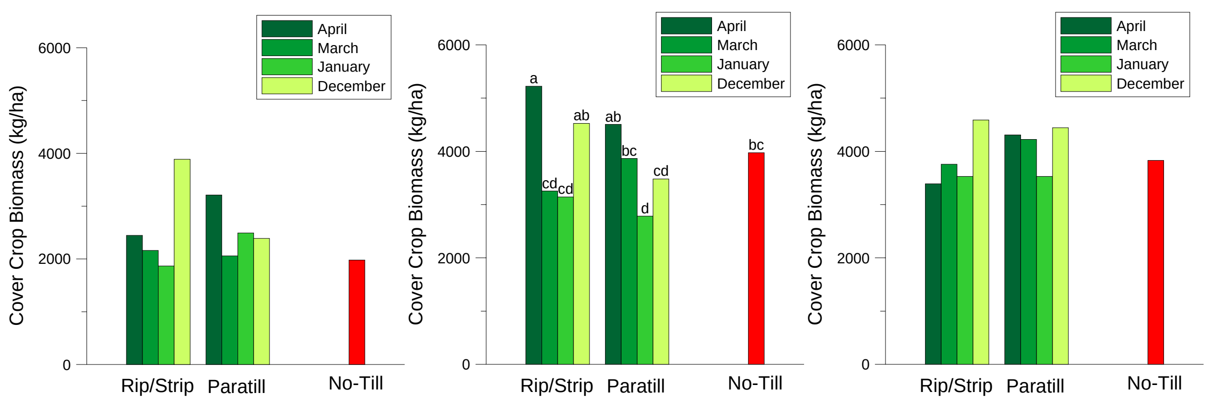

Figure 1. Rye cover crop biomass produced in 2004-2005 (left), 2005-2006 (center), and 2006-2007 (right). When present, letters indicate statistical significance ($LSD_{0.1}$).

Cover crop biomass results from spring of 2006 gave a greater amount of statistical differences (fig. 1; center). The implements were again found to not be significantly different ($p \leq 0.16$). The cover crop yield (4865 kg/ha) resulting from the last date of in-row subsoiling (April) was found to be statistically greater than March in-row subsoiling ($p \leq 0.01$), January in-row subsoiling ($p \leq 0.01$), or December in-row subsoiling ($p \leq 0.03$). December in-row subsoiling was also found to be greater statistically than January in-row subsoiling ($p \leq 0.01$).

Measurements of rye cover crop biomass taken in spring of 2007 again found no differences based on in-row subsoiling implement ($p \leq 0.50$). The only statistically significant contrast that was identified was that December in-row subsoiling was found to be superior to January in-row subsoiling ($p \leq 0.02$; 4518 kg/ha and 3530 kg/ha, respectively).

Two points are noted when these data are examined. The first point was that decreased cover crop yields result when in-row subsoiling was not applied. Rye roots suffered from similar rooting restrictions as cash crop plants even though they grew during winter months when rainfall was more plentiful. The second point was that in-row subsoiling provided during the middle growth stages of rye (January and March) was detrimental to maximum cover crop production. In-row subsoiling provided nearest the planting of the rye cover crop maximized production and was found to be superior to in-row subsoiling performed in January in 2 of the 3 years. Once the roots started to grow and proliferate, significant damage was done to the plants by performing in-row subsoiling. Waiting until the cover crop has been terminated (April in-row subsoiling) was also noted to produce good cover crop yields. It was interesting to note that this timing of in-row subsoiling was actually the closest tillage operation prior to planting of the rye cover crop which occurred less than 6 months later.

CASH CROP YIELD

Seed cotton yield from 2005 was not found to be affected by any treatments ($p \leq 0.50$), including in-row subsoiling implements (fig. 2, left; $p \leq 0.70$). In 2006, seed cotton yield was reduced by lack of timely rainfall and was again not affected by any treatments (fig. 2, center; $p \leq 0.16$), although all tillage treatments did have yields greater than the no-till treatment (1152 kg/ha). In 2007, seed cotton yield was found to be affected by tillage treatments (fig. 2, right; $p \leq 0.06$). Seed cotton yields from April in-row subsoiling (3758 kg/ha) was found to be greater than either January in-row subsoiling ($p \leq 0.02$; 3280 kg/ha), December in-row subsoiling ($p \leq 0.03$; 3280 kg/ha), or no-till ($p \leq 0.02$; 3242 kg/ha). March in-row subsoiling (3670 kg/ha) was also found to be greater than no-till ($p \leq 0.10$; 3242 kg/ha).

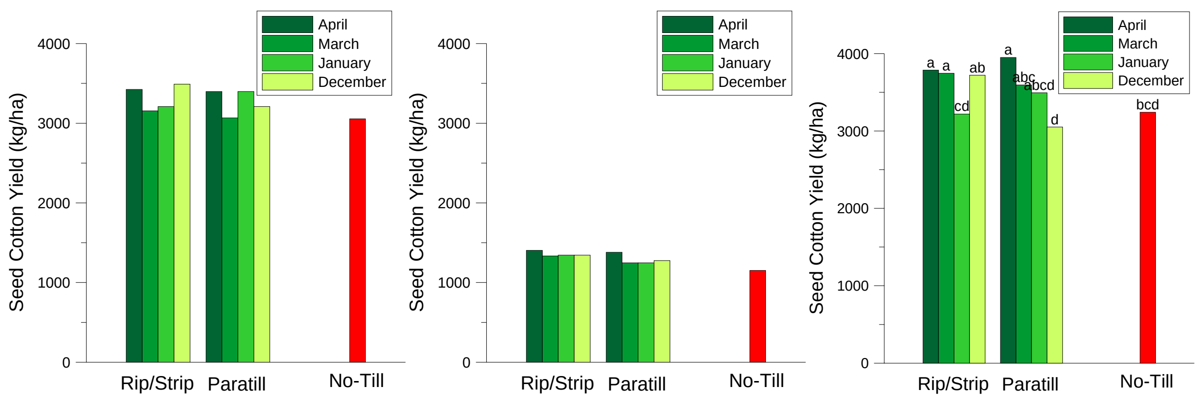

Figure 2. Seed cotton yield produced in 2005 (left), 2006 (center), and 2007 (right). When present, letters indicate statistical significance ($LSD_{0.1}$).

The greatest seed cotton yields occurred with the timing of in-row subsoiling as close as possible to planting. In most years, longer periods of elapsed time between in-row subsoiling and planting caused seed cotton yields to be reduced. Also, the smallest seed cotton yields were found with no tillage which indicated that significant soil compaction existed that must be removed prior to planting.

CONCLUSIONS

- Cover crop production was maximized by performing an in-row subsoiling operation either near the time of planting or after termination of the previous cover crop.
- Cash crop production was maximized by performing in-row subsoiling as close to planting as possible.
- No differences were noted between in-row subsoiling implements.
- The best time to perform in-row subsoiling should be based on maximum production of both the cash and cover crops. For our soils and climate, similar maximum production levels of cover crops were found with either early winter in-row subsoiling or post cover crop termination in-row subsoiling. Maximum growth of the cash crop was mostly found with post cover crop termination timing. Our recommendation would therefore be to perform in-row subsoiling late

in spring after cover crop termination in order to maximize performance of the cash crop without sacrificing cover crop yields.

DISCLAIMER

The use of trade names or company names does not imply endorsement by USDA-ARS.

REFERENCES

ASAE Standards, 50th Edition. 2004a. EP542: Procedures for obtaining and reporting data with the soil cone penetrometer. St. Joseph, Mich.: ASAE.

ASAE Standards, 50th Edition. 2004b. S313.3: Soil cone penetrometer. St. Joseph, Mich.: ASAE.

Box, J., and G.W. Langdale. 1984. The effects of in-row subsoil tillage and soil water on corn yields in the Southeastern coastal plain of the United States. *Soil Till. Res.* 4(1):67-78.

Busscher, W.J., and R.E. Sojka. 1987. Enhancement of subsoiling effect on soil strength by conservation tillage. *Trans. ASAE* 30(4):888-892.

Camp, C.R., and Z.F. Lund. 1964. Effect of soil compaction on cotton roots. *Crops and Soils Magazine* (November).

Littell,R.C., G.Milliken, W.W.Stroup, and R.D.Wolfinger. 1996. *SAS system for mixed models*. Cary, NC.: SAS Institute, Inc.

Raper, R.L. 2005a. Force requirements and soil disruption of straight and bentleg subsoilers for conservation tillage systems. *Applied Eng. Agric.* 21(5):787-794.

Raper, R.L. 2005b. Subsoiling. In *Encyclopedia of Soils in the Environment,* pp. 69-75. D. Hillel, D. Rosenzweig, K. Powlson, M. Scow, M. Singer, and D. Sparks, ed. Oxford, U.K.: Elsevier Ltd.

Raper, R.L. 2005c. Vehicle traffic effects on soil. *J. Terramechanics* 42(3-4):259-280.

Raper, R.L., and J.S. Bergtold. 2007. In-row subsoiling: a review and suggestions for reducing cost of this conservation tillage operation. *Applied Eng. Agric.* 23(4):463-471.

Raper, R.L., B.H. Washington, and J.D. Jarrell. 1999. A tractor-mounted multiple-probe soil cone penetrometer. *Applied Eng. Agric.* 15(4):287-290.

Reeves, D.W. 1994. Cover crops and rotations. In *Advances in Soil Science: Crops Residue Management,* pp. 125-172. J. L. Hatfield, and B.A. Stewart, ed. Boca Raton, FL.: Lewis Publishers.

Schwab, E.B., D.W. Reeves, C.H. Burmester, and R.L. Raper. 2002. Conservation tillage systems for cotton grown on a silt loam soil in the Tennessee Valley. *Soil Sci. Soc. Am. J.* 66(2):569-577.