Better Soil Management Practices for Sustaining Cotton Production in SE USA

Reddy, K. C. and Reddy, S. S.

Department of Natural Resources and Environmental Sciences, Alabama A&M University, Normal, AL 35762, Tel#: 256-372-8170; E-mail: Reddykcs@gmail.com

Abstract

Upland cotton is an important crop in the Southeastern United States. Due to traditional cultivation practices, cotton lands are losing top soil at alarming rates. Also, the excessive use of pesticides and fertilizers in cotton production systems are blamed for non-point source pollution. The development of conservation tillage systems capable of reducing soil erosion and improving soil quality, while increasing cotton yields and profits, remain a challenge. Also, the burgeoning poultry industry in the region is producing millions of tons of litter annually and its safe disposal is becoming a major problem for the industry. Two long-term field experiments were conducted at the Alabama Agricultural Experiment Station, Belle Mina, AL since 1994 with the objective of finding sustainable cotton production systems for the region. The first experiment dealt with the suitability of poultry waste as a nitrogen source to cotton over a five-year period and the second one is dealing with the development of appropriate tillage, cropping system, and nitrogen sources for cotton production for the last 10 years. The results from these studies indicate that fresh poultry litter is a comparable source of nitrogen and conserves soil when applied in combination with no-till system and a winter rye cover crop and improves cotton growth and lint yield. Further, rotation of cotton every third year with corn has been reducing the surface accumulation of P and leaching of nitrates thus making it feasible to apply poultry litter over a longer period of time.

Media summary

Locally and freely available poultry litter application in conjunction with no-till system and winter rye cover cropping helps sustain soil quality and cotton production in the southern USA.

Key Words

Cover cropping, cotton, crop rotation, no-tillage, poultry litter, soil quality

Introduction

Traditional intensive agricultural practices deteorate soil health. A wide range of sustainable agricultural practices improve soil quality. For example reducing tillage; increasing organic content in the soil by adding local available organic wastes and crop residues; crop rotations; ensuring sufficient ground cover to protect soil from erosion during off season etc. In United States over 10 billion kg of broiler litter is produced annually (Reddy et al., 2007). An economical and environmentally beneficial way to dispose of this poultry litter would be to apply it as a nutrient source in crop production. Many investigations proved that poultry litter has salutary effects on crop production (Reddy et al, 2007). But continuous application of poultry litter under mono cropping for many years may lead to nitrates leaching into ground water and build up of phosphorus and other elements in the soil (Reddy et al., 2008b).

Cover crops can provide crop residues which helps in improving soil water retention, increasing soil organic matter, and reducing soil erosion (Nyakatawa et al., 2001a). Winter cover crops may also reduce nitrate leaching to the groundwater by picking up excess nutrients from the previous

crop (Logsdon et al., 2002). Rotating deep rooted crops with shallow root crops compliment each other in nutrient uptake thereby making them more efficient in using soil nutrients. Further it helps in breaking the life cycles of major insect pests and diseases.

The objective of this study was to evaluate the performance of cotton rotated with corn in tilled and non-tilled system along with long term application of poultry litter and rye as winter cover crop.

Material and methods

Experimental Site and Treatments

Field experiments were conducted at the Alabama Agricultural Experiment Station, Belle Mina, Alabama, situated at 34^{o} 41' latitude and 86^{o} 52' longitude on a Decatur silt loam (clayey, kaolinitic thermic, Typic Paleudult).

Experiment I

It was conducted from 1994 through 1998. Treatments consisted of a factorial combination of three N sources: urea, fresh poultry litter (FPL), and composted poultry litter (CPL) applied at three N rates, 40, 80, and 120 kg N ha^{-1} all with and without the nitrification inhibitor; carboxymethyl pyrazole, and (CP) thus forming 18 treatments. In addition, two control plots: 0 N and 0 CP (control) and 0 N but with CP soil application (CP control) were included. Full details of the experimentation were published elsewhere (Reddy et al., 2007).

Experiment II

This experiment has been conducted since 1996 on the same plots. Treatments included three tillage systems: conventional tillage (CT), mulch tillage (MT), and no tillage (NT); two cropping systems: cotton in the summer and fallow in the winter (CF) and cotton in the summer and cereal rye cover crop in winter (CR); two sources of nitrogen: ammonium nitrate @ 100 kg N ha^{-1} and poultry litter @ 100 and 200 kg N ha^{-1}, a control treatment with no N application was also included. A bare fallow treatment was also maintained without any crop, tillage and fertilizer application. Full details of the experimentation are available elsewhere (Reddy et al., 2008a).

Results and Discussion

Experiment I

Increased rates of N application significantly increased lint yield compared to the control in all years. Among three N sources, FPL produced the highest mean lint yield over the five-year period (1492 kg ha^{-1}) compared to CPL (1392kg ha^{-1}) and urea (1391 kg ha^{-1}). The results from this five-year study indicate that the fresh and composted forms of poultry litter were as effective as urea in improving lint yield. But chemical analysis of soils showed that a linear increase in soil P occurred with increased application rates of composted litter (Reddy et al., 2008b). Fresh poultry litter did not increase P concentration even at higher rates of application. Both forms of poultry litter increased soil K and Mg concentrations in the top soil. Nitrate concentration levels of plots that

received fresh poultry litter and composted poultry litter were similar to that of urea (Reddy et al., 2008b).

Experiment II

Out of total 11 years of experimentation cotton was planted in 8 years in cotton-cotton-corn rotation. Interaction effects of tillage x cropping system and tillage x N source were found significant on cotton lint yields (Fig 1).

Tillage x cropping system:
There were no significant differences in lint yields between cotton-rye and cotton-fallow cropping systems under conventional tillage (Fig. 1A). Under no-tillage, cotton-rye cropping system gave on average 30% significantly higher lint yields compared to cotton-fallow cropping system. While comparing CT and NT, both recorded similar yields under cotton-rye cropping system. But under cotton-fallow cropping system CT recorded significantly higher yields than that of NT.

Tillage x N source:
There were no significant differences in cotton lint yields between 100 kg N ha^{-1} ammonium nitrate and 100 kg N ha^{-1} poultry litter treatments in plots under CT system (Fig. 1B). But under NT system, plots that received 100 kg N ha^{-1} ammonium nitrate on average recorded 15% significantly higher lint yield compared to those in plots received 100 kg N ha^{-1} poultry litter. All tillage systems gave similar lint yields when received 100 kg N ha^{-1} in the form of ammonium nitrate. However, CT plots which received 100 kg N ha^{-1} in the form of poultry litter, gave similar yields compared to MT and similar or higher lint yields compared to NT system (Fig. 1B). These results can be attributed to the fact that soil incorporation of poultry litter under conventional tillage speeds up mineralization whereas in mulch tillage and no-tillage systems, poultry litter mineralization is slowed down.

Available phosphorus concentration of top soil (0-15cm) was significantly influenced by tillage and nitrogen source interactions. No-till plots receiving poultry litter @ 100 kg N ha^{-1} recorded significantly lower available P at 0-5 cm (43 mg/kg) and 5-15 cm (27 mg/kg) depths compared to conventional till plots receiving poultry litter at the same rate (75 and 36 mg/kg, respectively). Higher concentrations of P in conventional till plots could be attributed to faster mineralization of P due to higher soil disturbance compared to no-till plots.

From these two long term studies it can be concluded that poultry litter can be utilized as N source for crop production. It solves the problem of safe disposal of this byproduct from burgeoning poultry industry in SE USA. Application of poultry litter under no-till system along with winter cover cropping further keeps the environmental quality as our soil erosion estimates, reported elsewhere, have indicated (Nyakatawa et al., 2001b).

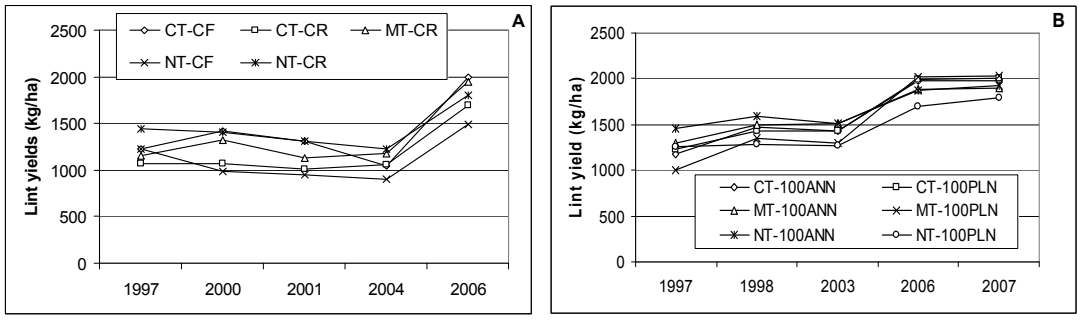

Fig. 1 Lint yields as influenced by tillage x cropping system and tillage x N source, Belle Mina, AL (vertical bars= S. E.).

References

Logsdon, S.D., T.C. Kaspar, D.W. Meek, and J.H. Prueger. 2002. Nitrate leaching as influenced by cover crops in large soil monoliths. Agron. J. 94:807-814.

Nyakatawa, E.Z., and K.C. Reddy. 2000. Tillage, cover cropping, and poultry litter effects on cotton. I. Germination and seedling growth. Agron. J. 92, 992-999.

Nyakatawa, E.Z., K.C., Reddy, and K.R. Sistani. 2001a. Tillage, cover cropping, and poultry litter effects on selected soil chemical properties. Soil Tillage Res. 58:69-79.

Nyakatawa E.Z., K.C. Reddy and J.L. Lemunyon. 2001b. Predicting Soil Erosion in conservation tillage cotton production systems using the revised universal soil loss equation (RUSLE). Soil Tillage Res. 57: 213-224

Reddy, K. C., S. S. Reddy, R. K. Malik, J. L. Lemunyon, and D. W. Reeves, 2008b. Nitrate movement and P, K, Ca and Mg accumulation in Soil as a result of 5-yr Continuous Poultry Litter Application for cotton. *Agron. J.* (In Press)

Reddy, K. C., T. Roberson, S. S. Reddy, E. Z. Nyakatawa, R. L. Raper, D. W. Reeves and J. Lemunyon. 2008a. Carbon Dioxide Efflux from Soil with Poultry Litter Applications in Conventional and Conservation Tillage Systems in North Alabama. J. of Environ. Qual. 37:535–541.

Reddy, K.C., R. Malik, S. S. Reddy and E. Z. Nyakatawa. 2007. Cotton Growth and Yield Response to Nitrogen Applied through Fresh and Composted Poultry Litter [online]. J. Cotton Sci. 11:26-34. Available at http://www.cotton.org/journal /2007-11/1/upload/jcs11-26.pdf.