Cover Crops and Nitrogen Fertilization Effects on Nitrogen Conservation in Tilled and Non-tilled Soils

Upendra M. Sainju, USDA-ARS-NPARL, Sidney, MT and Bharat P. Singh, Fort Valley State Univ. Fort Valley, GA

U.S. Department of Agriculture

Agricultural Research Service

Introduction

Nitrogen conservation is needed to reduce the cost and rate of nitrogen fertilization, N leaching, and N_2O emission, a devastating greenhouse gas responsible for global warming. Cover cropping can increase N storage and reduce the potential for N leaching compared with noncover cropping by using residual soil N after crop harvest in the fall (Meisinger et al., 1990; McCracken et al., 1994). Legume cover crops can fix N from the atmosphere and supply N for succeeding crops (Kuo et al., 1997; Sainju et al., 2000). As a result, N fertilization to succeeding crops can be reduced (Sainju et al., 2000; Boquet et al., 2004). Nitrogen fertilization can also increase soil organic N (Kuo et al., 1997; Omay et al., 1997). Cover cropping and N fertilization can have variable effects on N storage in tilled and non-tilled soils due to differences in mineralization of crop residue and soil organic matter (Sainju et al., 2002).

Objective

Determine the influence of cover crops and N fertilization rates on total crop above- and belowground residue N supplied by cover crops, cotton, and sorghum and soil total N storage at the 0- to 120-cm depth in tilled and non-tilled soils from 2000 to 2002 in the subtropical humid region of the southeastern USA.

Treatments

Cover crops:

Hairy vetch, rye, hairy vetch + rye, and winter weeds (or no cover crop).

N fertilization rates:

0, 60-65, and 120-130 kg N ha^{-1} (0, 60, and 120 kg N ha^{-1} applied to cotton and 0, 65, and 130 kg N ha^{-1} applied to sorghum).

Experiment was conducted in a split-plot arrangement with cover crop as the main plot factor and N rate as split plot factor in randomized block with three replications in no-tilled, strip-tilled, and chisel-tilled soils from 1999 to 2002 in Fort Valley, GA.

Plant biomass and soil samples were collected in April and November of each year and plant and soil total N content analyzed.

Fig. 1. Winter cover crops grown in Fort Valley, GA.

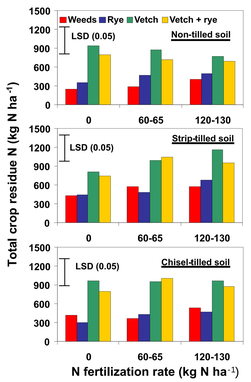

Fig. 2. Total above- and belowground residue N of cover crops, cotton, and sorghum returned to the soil from 2000 to 2004 in tilled and non-tilled soils as influenced by cover crops and N fertilization

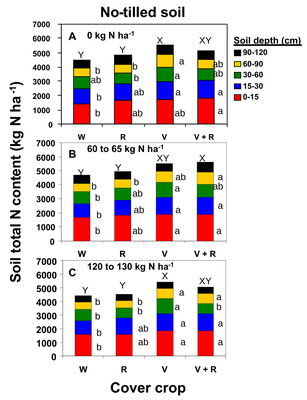

Fig. 3. Effects of cover crops and N fertilization rates on soil total N content at the 0- to 120-cm depth in no-tilled soil. W = winter weeds, R = rye, V = hairy vetch, and V + R = hairy vetch + rye.

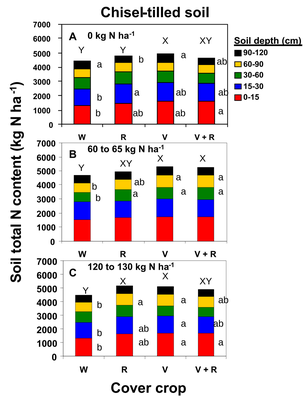

Fig. 4. Effects of cover crops and N fertilization rates on soil total N content at the 0- to 120-cm depth in chisel-tilled soil. W = winter weeds, R = rye, V = hairy vetch, and V + R = hairy vetch + rye.

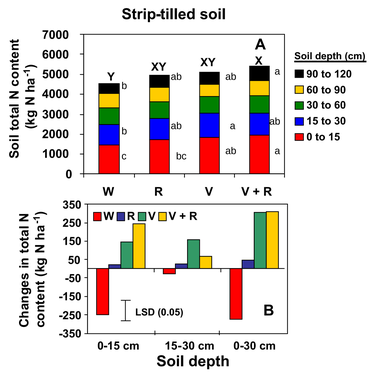

Fig. 5. Effect of cover crops on (A) soil total N content at the 0- to 120-cm depth and (B) changes in soil total N content from Oct. 1999 to Nov. 2002 in strip-tilled soil. W = winter weeds, R = rye, V = hairy vetch, and V + R = hairy vetch + rye.

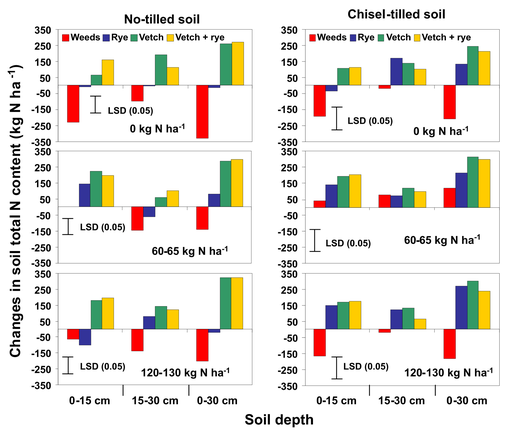

Fig. 6. Changes in soil total N content in no-tilled and chisel-tilled soils from October 1999 to November 2000 as influenced by cover crops and N fertilization

Results

- Total amount of crop residue N returned to the soil from 1999 to 2002 was greater with vetch and vetch + rye with N fertilization than with rye and weeds without N fertilization, regardless of tillage. Residue N was similar between vetch and vetch + rye (Fig. 2).
- Soil total N content at the 0- to 120-cm depth was greater in vetch and vetch + rye with 60 to 65 kg N ha^{-1} than in rye and weeds with 0 kg N ha^{-1} in no-tilled soil (Fig. 3). In chisel-tilled soil, total N was greater with vetch, rye, and vetch + rye than with weeds in 0 and 60 to 65 kg N ha^{-1} (Fig. 4). In strip-tilled soil, total N was greater in vetch + rye than with weeds (Fig. 5).
- From Oct. 1999 to Nov. 2002, N was lost in weeds but was gained in vetch and vetch + rye (Fig. 5 and 6). Nitrogen gain was greater in vetch and vetch + rye with 60 to 65 kg N ha-1 than in other treatments. Nitrogen gain was similar between vetch and vetch + rye in tilled and non-tilled soils.

Discussion & Conclusions

- Higher N content in vetch and vetch + rye residue with 60 to 65 kg N ha^{-1} increased the total amount of crop residue N returned to the soil than in other treatments. Increase in N fertilization rate did not increase residue N.
- As a result, soil total N content was also higher with vetch and vetch + rye than with rye and winter weeds with or without fertilizer N.
- Nitrogen can be conserved at 80 to 108 kg N ha^{-1} yr^{-1} at the 0- to 120-cm depth in vetch and vetch + rye compared with a loss of 40 to 110 kg N ha^{-1} yr^{-1} with weeds. Vetch and vetch + rye conserved similar rates of N.
- Because of greater N leaching potential with vetch but similar N conservation with vetch and vetch + rye, vetch can be replaced by vetch + rye to conserve soil N and reduce the potential for N leaching in tilled and non-tilled soils.

References

Boquet, D.J., R.L. Hutchinson, and G.A. Breitenbeck. 2004. Long-term tillage, cover crop, and nitrogen rate effects on cotton: Yield and fiber properties. Agron. J. 96:1436-1442.

Kuo, S., U.M. Sainju, and E.J. Jellum. 1997. Winter cover cropping influence on nitrogen in soil. Soil Sci. Soc. Am. J. 61:1392-1399.

McCracken, D.V., M.S. Smith, J.H. Grove, C.T. Mackown, and R.L. Blevins. 1994.Nitrate leaching as influenced by cover cropping and nitrogen source. Soil Sci. Soc. Am. J. 58:1476-1483.

Meisinger, J.J., P.R. Shipley, and A.M. Decker. 1990. Using winter cover crops to recycle nitrogen and reduce leaching. In J.P. Mueller and M.G. Wagger (eds.) Conservation Tillage for Agriculture in the 1990's. North Carolina State Univ. Spec. Bull. 90-1.

Omay, A.B., C.W. Rice, L.D. Maddux, and W.B. Gordon. 1997. Changes in soil microbial and chemical properties under long-term crop rotation and fertilization. Soil Sci. Soc. Am. J. 61:1672-1678.

Sainju, U.M., B.P. Singh, and W.F. Whitehead. 2000. Cover crops and nitrogen fertilization effects on soil carbon and nitrogen and tomato yield. Can. J. Soil Sci. 80:523-532.

Sainju, U.M., B.P. Singh, and W.F. Whitehead. 2002. Long-term effects of tillage, cover crops, and nitrogen fertilization on organic carbon and nitrogen concentrations in sandy loam soils in Georgia, USA. Soil Tillage Res. 63:167-179.