SUBTERRANEAN CLOVER LIVING MULCH: A SYSTEM APPROACH

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Modern crop production is a multi-task process and many factors must be integrated to achieve economically successful production. Simultaneously there are public demands that this process occur with minimal impact on the environment. Production costs and yields are primary concerns to producers. Movement of herbicides into surface and ground waters, movement of nitrogen into ground water and erosive soil losses are significant public concerns.

In an effort to address these concerns, several legume species have been evaluated in recent years as mulch or cover crops. The hope has been to provide weed suppression, nitrogen fixation and erosion control while maintaining high yields. To be adopted by producers such mulches must fit easily into on farm practices.

It was reasoned that on on subterranean clover (Trifolium subterranean L.) might be used as a living mulch to satisfy these requirements, because of its rather unusual life cycle. The plant initiates growth in late summer or early autumn and grows vegetatively until early winter. It becomes dormant in winter and resumes growth in the early spring. Later in the spring the plant flowers and seeds are matured in a burr at the soil surface. In early summer the plant senesces and dies. For the next two months, a dense mulch of dead clover remains on the soil surface. Beginning in late summer, the seeds produced in spring begin to germinate and a cover of living mulch is again produced.

A series of experiments has been performed at Rutgers University to examine the weed control potential of subterranean clover living mulches and the ability of these mulches to satisfy the nitrogen requirements of a main crop.

Materials and Methods

Weed Control on Maize (Zea mays Indentata L)

A factorial experiment with four replications was conducted using three tillage systems and three mulching practices. The tillage practices were conventional (CT), minimum (MT) and no (NT) tillage. The mulching practices were Subterranean clover living mulch (LM), rye (Secale cereale L.) dead mulch (DM) and no mulch (NM). Subclover cv. `Nangeela' was seeded in August 1985 and since subclover reseeds itself the same field was used in 1987 and 1988. No herbicides were used in the living mulch treatment. To create the dead mulch, winter rye was fall seeded and herbicidally killed the following spring prior to planting corn. No additional herbicides were used for the dead mulch treatments. A standard herbicide was used on all no-mulch treatments. Total weed biomass was recorded twice during the growing season. Silage and grain yields were also determined.

Weed Control in Soybeans (Glycine max L.)

A replicated split strip experiment was conducted with soybeans no-till planted in 38 cm rows in the spring of 1988. Subclover and no subclover were the strips. Subplots superimposed perpendicular to the strips included glyphosate for total vegetation control, winter barley (Hordeum vulgare L.) harvested prior to soybean planting, double disking prior to planting, and an untreated control. Weed biomass was measured periodically. Yields of soybean were recorded at season's end.

Nitrogen Fixation

A completely randomized block design with three treatments and four replications was used. The treatments were subclover inoculated with Rhizobium trifolii (I), non-inoculated subclover (NI) and bare soil check plots. Four soil samples were taken from each plot on September 3, 1986 to determine initial nitrogen levels. Subclover cv. "Nangeela" was planted the same day at 22 kg ha^{-1}. No fertilizer was used. Unplanted plots were utilized as checks. Soil and subclover plant tissue samples were taken at three week intervals during the growth period and analyzed for total nitrogen content.

Nitrogen Availability to a Main Crop

A subsequent study was initiated in 1989 and continued in 1990. The experimental design was a split strip plot with four replications. Conventional tillage without subclover and no tillage on established subclover were the main plots. Four fertilizer rates of 0, 112, 224 and 280 kg ha^{-1} were superimposed across the main plots. Eight rows of maize were planted in each plot. Soil samples were taken before planting to determine initial N level in the soil. At planting, 112 kg N ha^{-1} were broadcast on all treatments receiving N fertilizer. The remaining N fertilizer was broadcast when corn was at the 8 to 10 leaf stage. Soil samples and corn plant samples were taken at 3 week intervals for N analysis. Corn silage and grain yields were determined at harvest. Silage yields are expressed on a dry matter basis; grain yields are expressed on a 15.5% moisture control.

Results

Weed Control in Maize

The most prevalent weed species were fall panicum (Panicum dichotomiflorum Michx.) and ivyleaf morning glory (Ipomoea hederacea (1.) Jacq.) In 1986 control of fall panicum was poor in all treatments, but control was much better in the subclover plots the following two years. Ivyleaf morning glory control was excellent in all living mulch treatments in all three years. The weed biomass produced in the no tillage living mulch treatments was lower than that produced in the no tillage dead mulch and the conventional tillage no mulch treatments in all three years of the experiment.

The silage and grain yields of no till living mulch treatments were comparable to the conventional tillage no mulch plots in 1986 and 1987 and greater than them in 1988. The no tillage living mulch silage yields were comparable to the no tillage dead mulch treatments in 1986 and 1988 and greater than them in 1987; the grain yields were greater in all three years of the experiment.

Weed Control In Soybeans

In this experiment the lowest weed biomass production occurred in the subterranean clover check plots and barley plots. Weed biomass was significantly higher in all other plots.

With regard to yield, there was no difference between subclover and no subclover in the subplots which contained barley, were double disked or chemically treated. Yields were significantly higher in the living mulch check plots than they were in the no mulch check plots.

Nitrogen Fixation
Both inoculated and non-inoculated sub clover fixed large amounts of Nitrogen during the period from September 1986 to May 1987. Inoculated clover produced an increase of 585 kg N ha^{-1} when compared to the initial N levels at planting. Of this amount, 167 kg was in plant tops and 418 kg was in the soil.;

For non-inoculated sub clover there was a marked decrease in total N (soil and plant tissue) from zero to *n* days after planting. This decrease was reversed by season's end when there was a net increase of 323 kg N ha^{-1}. Of this increase, 117 kg was in plant tops and 206 kg was in the soil.

Total N in the check plots decreased by 168 kg N ha^{-1} by the end of the experiment. This decrease commenced in late winter to early spring and indicates that a large amount of N was lost to leaching and or denitrification.

Nitrogen Availability to a Main Crop
A comparison of subclover and conventional tillage plots for both zero and 280 kg N treatments shows that, overall, the N content of maize plants was higher in the subclover plots. Of even greater significance is the fact that the plant N content was higher in the subclover-zero N treatments than in the conventional tillage 280 N treatments throughout the growing season.

From 42 days after planting onward, the soil N content was higher in the subclover-zero N treatments than in conventional tillage plots at either zero or 280 kg N. However, there was no difference between zero and 280 kg N in the subclover plots. There was an increase in soil N in both the subclover zero N and the conventional tillage 280 kg N treatments but the subclover ended the season with 195 kg ha^{-1} more N than the conventional tilled plots.

Corn silage and grain yields reflect these differences in soil and plant N content. In 1989, silage yields in all subclover plots were higher than conventional tillage at zero and 112 kg N ha^{-1} and comparable to the 224 and 280 kg treatments. The grain yields for the season were high in all of the subclover plots, with the highest yield for the experiment occurring in the zero N subclover treatments.

In 1990, the highest yield levels for both silage and grain were obtained in the subclover plots with zero additional N.

Conclusions
This series of experiments demonstrated several important and positive attributes for subterranean clover living mulch systems. They can provide significant weed control in maize and in soybeans without the use of herbicides. Their use for weed control has either a positive or no effect on crop yield. In addition, these living mulches can increase the amount of available nitrogen in the cropping system and satisfy the N requirements of a main crop of maize. A final consideration is that use of this living mulch will reduce the risk of erosive soil loss dramatically.

Current and future research efforts will focus on incorporating the subterranean clover living mulches into a greater variety of crops, screening additional varieties for improved winter hardiness and comparing nitrogen leaching from this living mulch system with that from nitrogenous fertilizers. Further, it is our hope to participate in efforts to promote and extend this technology to producers in climates where it is appropriate.