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FOR SUSTAINABLE AGRICULTURE

COMPETITIVE
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Spring-seeded smother plants for weed control in corn and soybeans

Abstract: *Smother plants are specialized cover crops developed for their ability to suppress weeds and may provide an alternative, non-chemical method of weed control. The goal of this project was to define the characteristics and mechanics of establishing a successful spring-seeded smother plant system and to study and exploit the competitive interactions among weeds, smother plants, and the crop.*

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Budget:
$31,000 for year one
$32,400 for year two
$34,000 for year three

Background

Weed management is a critical issue in sustainable agriculture because controlling weeds is intimately linked to two of the greatest sources of environmental pollution associated with crop production: soil erosion and herbicide contamination of water resources. More than 95 percent of the corn and soybeans in the north central United States is treated with one or more herbicides. Producers of major crops have few weed management options besides herbicides and tillage.

Smother plants are specialized cover crops being investigated for their ability to suppress weeds. Besides offering an alternative method to combat weeds, smother plants could reduce soil erosion and improve soil quality.

In the past, researchers have suggested that if annual weeds can be suppressed for four to six weeks by a smother plant, crop yields may not be reduced by weed infestations. Their proposed "ideal" qualities for spring-seeded smother plants are: a) rapid seedling emergence under cool soil conditions, b) horizontal leaf angle, c) mature leaf size of 0.8 by 1.2 in, d) rooting depth of 1 in, e) maximum height of 4 in, f) a life cycle of five weeks or less, g) nondormant seed, and h) seed production potential of at least 445 lb A^{-1}.

Objectives for this project were to:

- Define the characteristics of a spring-seeded smother plant system for corn and soybean,
- Examine the feasibility of using spring-seeded smother plants for weed control, and
- Understand and exploit the competitive interactions among weeds, smother plants, and the crop.

Approach and methods

Potential smother plants effects on corn and soybean Several experimental treatments were established at early and late planting times at three locations. Among them were:

- Weedy control
- Weed-free control
- Caliph medic
- Santiago medic
- Sava medic
- Berseem clover
- Brassica
- Buckwheat (1996 and 1997 at Ames)

Field experiments were conducted near Sioux Center and Ames in 1995, 1996, and 1997; and near Crawfordsville in 1997. Separate experiments for corn and soybeans occurred near Ames and Sioux Center. Soybean was not evaluated at Sioux Center in years 2 and 3 due to limitations of equipment and labor. All treatments were replicated four times. The corn or soybean plus smother plant combinations were each planted on two dates at each location. The first planting was early, relative to local conditions, and the second planting was done two weeks later.

Sava medic

The smother plants were seeded immediately following the planting of corn or soybean in a 10 in band centered over the crop row. Smother plant seeds were incorporated into the upper 0.4 in of soil with a garden rake. All plots received timely interrow cultivation to control weeds between crop rows. Weedy and weed-free control plots were included in all experiments.

Data collected included:

- Emergence times for smother plants, primary crop, and weeds
- Smother plant and primary crop density at 14, 28, and 72 days after planting (DAP)
- Visual estimation of weed suppression by species 14, 28, and 72 DAP
- Weed density and biomass by species 40 DAP
- Primary crop height and growth stage at 28 and 72 DAP and days to 50 percent silk (corn) and 50 percent flowering (soybean)
- Primary crop yield and grain moisture

Competitive interactions among weeds, smother plants, and corn A series of field experiments near Ames in 1995, 1996, and 1997 was designed to focus on potential management aspects such as the timing of smother plant establishment, spatial arrangement of smother plants, the length of the competitive period, and the interaction of cultivation and smother plants on weed suppression and corn growth. This research expanded on the basic idea of planting a band of smother plants over the row at corn planting time to exploring other spatial and temporal seeding options. In order to limit the work to a manageable level, only one smother plant, Sava medic, was chosen for use, based on previous results and seed availability.

Early spring smother plant establishment Shortening the smother plant/primary crop competitive period through the use of low rates of herbicides at different timings was investigated in experiments at Ames. Treatments included combinations of different herbicide timings (at crop planting and 30 DAP), different kill patterns (banded and broadcast), and allowing the smother plant to grow to maturity. Finding the appropriate way to manage the weed/crop/smother plant competitive periods appears to be one of the greatest challenges in the development of this system.

Spatial arrangement At the Ames location experiments, researchers also investigated spatial arrangements of smother plants and use of low rates of herbicides. Treatments included combinations of smother plant location (row band, interrow band, and broadcast), allowing the smother plant to grow to maturity, killing it at 30 DAP, and performing or not performing interrow cultivation.

Rotary hoe incorporation The timing for smother plant establishment will be a critical factor in developing successful management strategies. Experiments were designed to investigate seeding the smother plant prior to and after corn planting. Post-corn planting smother plant establishment (at 7 and 14 DAP) was achieved by using a broadcast drop-spreader and rotary hoe.

Planting depth Consistent and uniform smother plant emergence and establishment is essential to establishing the competitive relationships required for a successful smother plant weed management system. This experiment evaluated the effects of smother seed

planting depth on smother plant density in a greenhouse setting. Sava (large-seeded) and Santiago (small-seeded) medics were planted in a band over corn rows.

Results and discussion

Potential smother plant species effects on corn and soybean Timely establishment of an effective smother plant population presents a fundamental challenge if this system is to succeed. Additionally, the seasonal dynamics of smother plant densities must be such that they do not inhibit the primary crop from achieving its yield potential.

Differences in population dynamics existed among the species in 1995. Typically, the initial stand of Brassica was higher than the other species, and the higher seeding rate was the primary cause for the large difference seen at 14 DAP. However, as the growing season progressed, the short life of cycle of Brassica became apparent and few plants remained at 72 DAP.

In 1996, densities of the smother plant species ranged from 0 to near 40 plants per $0.1m^{-2}$ during the growing season, with the medics achieving stands that were generally lower than Brassica and Berseem clover. In 1997, smother plant densities in corn had trends similar to the two previous years.

Poor smother plant establishment was a major problem in soybeans, especially in late planted treatments. Based on the results of this research, surface spreading of seed followed by shallow incorporation at crop planting is not a viable method for establishing smother plants in soybeans. The major reason for differences between corn and soybean seemed to be related to planting dates and subsequent smother plant establishment and growth. The soybeans were planted 20 or more days later than corn, generally exposing the smother plants to warmer and drier conditions following planting. Poor seeding establishment and low levels of biomass production following soybean planting resulted in little weed suppression. All of the smother plant species evaluated were cool-season species that display slow growth and low plant vigor when exposed to high temperatures early in their growth cycle. This suggests that these cool-season varieties may not be good candidates for smother plants for crops planted in the region after early May.

Collecting weed biomass

Weed suppression in 1995 compared to the weedy check plot ranged from 19 to 90 percent across the smother plant species. Brassica, Sava medic, and Berseem clover generally suppressed weeds better than the other two medics.

In 1996, the smother plant species also demonstrated differences in weed suppression capabilities. At 40 DAP, giant foxtail and common lambsquarters suppression ranged from 20 to 94 percent. Minor treatment differences in giant foxtail control were observed, with Caliph medic providing the lowest control at 20

Manual seeding of smother plants

percent, while other treatments provided about 60 percent control. All four smother plant treatments suppressed common lambsquarters greater than 80 percent with no differences among species.

The lower weed suppression observed in soybeans at 40 DAP (relative to that in corn) was attributed to poor smother plant establishment. In soybean in 1997, no significant differences were observed in foxtail or lambsquarters suppression between smother plant species. In contrast to the results in corn, lambsquarters suppression ranged from 8 to 15 percent, nearly 70 percent less. Likewise, foxtail suppression was 20 to 40 percent less in soybeans than in corn.

Competitive interactions among weeds, smother plants, and corn Difficulties were encountered for the field experiment in early spring smother plant establishment in Ames. The 1995 protocol for establishing early (pre-corn planting) smother plants has evolved into a work in progress. Abnormally wet, cool spring conditions ruined the initial efforts in this area. There was poor smother plant establishment the next year (1996) due to extremely dry conditions and the experiments were discountinued in 1997.

Spatial arrangement Smother plants were grown in several different configurations: banded over the crop row, banded between the crop row, and broadcast seeded. Smother plants in these spatial arrangements were allowed to grow to maturity and then compared to the same arrangements killed at 30 DAP (to shorten the competitive period between the crop and smother plants).

The general efficacy of treatments was quite different for specific weed species. For example, control of foxtail was generally greater when the smother plants were grown to maturity than when they were killed at 30 DAP. When smother plants were placed in a band between the rows, control was about 75 percent, compared to less than 40 percent when plants were killed at 30 DAP.

Rotary hoe incorporation Delaying the seeding of the smother plant and allowing the primary crop to emerge and establish may be a method to reduce the negative effects of smother plant/primary crop competition. Sava medic was broadcast seeded one and two weeks after corn planting in an experiment where weed populations were below yield reduction levels. This resulted in reduced corn height at 72 DAP. Corn yield also was reduced in the smother plant plots established at 7 DAP. However, when smother plant establishment was delayed until 14 DAP, corn yield did not differ from the control plot with no smother plants.

In 1996, weed density also was affected by these seeding methods. Compared to the weedy check, the three seeding methods all had significantly lower giant foxtail and pigweed density. It appears, however, that the efficacy of these seeding method treatments was specific to the weed species.

Planting depth Consistent and uniform smother plant establishment is essential for a successful smother plant weed management system. The effect of seeding depth on smother plant establishment for two of the medics was evaluated in the greenhouse in 1996. Smother plant seed that was planted at 1.5 and 3 cm below the surface produced significantly higher plant

densities when compared with seed planted at 0.5 cm. Along with planting depth, smother plant seed size seemed to have an effect on smother plant density. Generally, the larger seeded (Sava medic) plant planted at 1.5 or 3 cm showed significantly greater densities than the smaller seeded Santiago variety.

Conclusions

Can mulched living plants or smother plants suppress weeds? Using living vegetation to smother weeds is not a new concept and has been used in crop rotations for many years. The research showed inconsistencies among locations, years, and crops, but some general trends emerged for the use of smother plants as an alternative weed control strategy.

Timely establishment of an effective smother plant population to gain a competitive edge over weeds is a big challenge to overcome. Several species showed potential to become established and suppress weeds in corn, but efforts with soybeans were less successful. Establishment with corn was more rapid, uniform, and consistent during the cooler, more moist conditions that followed corn planting. Brassica showed more desirable characteristics such as providing greater initial densities and reaching maturity sooner, therefore shortening the competitive period with the primary crop. Although Brassica was the most efficient at reducing weed populations, it also reduced corn yields; it may have competed for resources the corn needed. The medics and Berseem clover provided the greatest early season densities in soybean and these greater densities also offered the greatest weed suppression in both corn and soybean.

Spatial arrangements and length of competitive period also affected interactions between smother plants and corn. Allowing smother plants to grow to maturity resulted in significantly greater foxtail suppression regardless of the planting arrangement used. Banding smother plants over the row was consistently effective in suppressing weeds.

One management aspect we focused on to define competitive interactions was the timing of smother plant establishment. Establishment is a crucial period because the smother plant needs to emerge and grow before the weeds do. Abnormally wet and unusually dry spring conditions in successive years hindered initial attempts in this area.

A new Leopold Center-funded project (#99-3) currently underway, "Managing weeds by integrating smother plants, cover crops and alternative soil management," will attempt a more integrative approach to developing new weed management tactics.

Impact of results

Although this project did not generate management recommendations for farmers, significant progress was made. The research advanced the understanding of factors that regulate the efficacy of smother plant systems. The variability in results was frustrating from a scientific standpoint, but reinforced the concept of the biological complexity of the system.

Brassica *smother plants in corn*

Emerging smother plants

One of the major impacts of this project was the opportunities it provided to introduce the concepts of plant interference-based weed management systems to a broad audience. This included farmers, industry representatives, crop consultants, undergraduate and graduate students, and scientists.

The results generated a series of questions revolving around factors that determine the efficacy of smother plant systems. The success or failure of these treatments was closely tied to the nature and intensity of the weed population. Future research needs to focus on the development of practices that reduce weed densities before crop planting, thus improving the effectiveness and consistency of smother plant and other alternative weed control systems.

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Education and outreach

Articles about smother crops based on this research appeared in the *Journal of Soil and Water Conservation*, the North Central Weed Science Society proceedings, *National Conservation Tillage Digest*, and the proceedings of the Integrated Crop Management Conference. After reading about the research project in the *Leopold Letter*, the editor of the journal *Weed Science* invited the researchers to prepare a commentary on the subject, which appeared in the July-August 1998 issue.

The project investigators estimate that their research results were presented to more than 4000 people through oral presentations and field days over the three years of the project. Some presentations were made during field days at the research sites and others were made at classes, training sessions, and professional and scientific gatherings.

Informal meetings and discussions were held with scientists at the University of Minnesota who also are engaged in research on smother plants for weed and soil management. Cooperative efforts were made with Dordt College in Sioux Center, the ISU department of agricultural and biosystems engineering, the ISU Agronomy Research Farm in Crawfordsville, and Practical Farmers of Iowa.