



SARE Farmer/Rancher Grant Final Report for Project No. FNC08-742

Project Title: Comparing Prairie Grass & Small Grains Straw for mulching Vegetable Crops

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Field Trial Summary

In a 2010 field trial with high and low foot traffic vegetable crops, switch grass straw mulch compared well with oat and wheat straw, deterring weeds with similar effectiveness. This prairie grass straw in the study, however, showed two important advantages over small grains straw: roughly double the tissue nitrogen content and a much lower carbon to nitrogen ratio. These differences should affect the rate of material decomposition since the C:N ratio is closer to the 30 to 1 ratio required for microbial breakdown.

Background and Need: Economics, Ecology, Sustainability

Intensive, diverse organic vegetable crop production relies heavily on manual labor, especially for controlling weeds. As scale increases, hand labor can easily dominate production expenses. Some Community Supported Agriculture growers in the Upper Midwest, for instance, spend one-third of their gross receipts on labor.

Community Supported Agriculture (CSA), which brings consumers as subscribers or “shareholders” into direct market relationship with growers, spawned from a pair of such operations on the East Coast in the 1980s. It now numbers more than 4,000 largely vegetable crop initiatives of widely varying sizes in the United States on the Local Harvest web site. CSA is helping revive local, direct market fresh vegetable production in many urban and suburban areas nationwide.



To individual CSA growers, controlling labor costs through reliable, cost-effective methods of weed suppression has become vitally important. An advanced CSA grower must typically budget or provide for one adult worker full time per one acre to one acre-and-one-half of vegetable crop production.

Rolled plastic mulch from polyethylene film has increasingly helped vegetable crop farmers control weeds since the 1950s. By 1999, the practice had spread globally to more than 30 million acres, with some more recent estimates of such plastic

mulch use estimated to cover more than 2,500 miles of crop production around the world. Tracking plastic mulch use has proven difficult, but much of these mulches do end up in landfills at season’s end. This adds disposal fees to production costs and raises environmental concerns.

Mulches conserve soil moisture, prevent erosion, cut soil compaction and eliminate root damage, which deep cultivation or hoeing may cause. Their weed suppression cuts labor expenses, too, though removing plastic mulches at season’s end requires at least 8 hours of manual labor per acre (McCraw, D. Motes, J.E. 2007, Oklahoma University Cooperative Extension).

Extracting and disposing of plastic mulch after the growing season poses challenges for most growers. Photodegradable and biodegradable plastic mulches, made from such alternatives as cornstarch or coated paper, have been and are being developed and studied. Washington State University researchers at Vancouver evaluated 10 alternative mulches in a field study in 2006 and 8 in 2007, comparing all alternative mulch products to black plastic mulch.

A trans-disciplinary research and extension project on Biodegradable Mulches for Specialty Crops Produced Under Protective Covers (Reference No: 2009-02484; funded by NIFA's SCRI program) is determining whether experimental spun-bond non-woven mulch and leading commercially-available biodegradable mulches are of similar quality to conventional black plastic in both high tunnel and open field specialty crop production. It is also examining whether they can safely biodegrade in the soil. In this 3-year study, a team of 17 scientists is evaluating biodegradable mulches in tomato production in three U.S. regions (<http://mtvernon.wsu.edu/hightunnels/mulch.html>)

The Plant Polymer Research Unit of the USDA National Center for Agricultural Utilization Research in Peoria, Ill., has also been investigating utility of bio-plastic mulch films for biodegradability and functionality. Its lead scientist anticipates a field trial with orchards and strawberries in 2012. The unit indicated **products** already on the market from manufacturers can be found at:

- <http://www.biobagusa.com/Content/MulchReport.pdf>
 - <http://www.ferro.com/Our+Products/Specialty+Plastics/Plastic+Colorants/Markets/Agriculture/Mulching+Films.htm> <http://www.suntexcp.com/Imaflex-Brochure.pdf>
 - <http://ir.metabolix.com/releasedetail.cfm?releaseid=334775> (Mirel bioplastic)
 - <http://www.omnexus.com/lod.aspx?preview=157> (presentation online for PHBs)
 - <http://perfectbioplast.com/technology.htm>
 - http://www.google.com/patents/about/5866269_Agricultural_mulch_with_extended.html?id=BhYXAAA
- AEBAJ**

Concerns noted in and from some of these studies relate to: the ability of the biodegradable mulch alternatives to meet national organic standards; residues the mulches may leave behind after degrading or inability of some mulches to completely degrade; and the effectiveness of some alternative mulches for longer-season vegetable crops, which broke down before season's end.

On-Farm Research Objective of this SARE Study

Scotch Hill Farm has operated as a Community Supported Agriculture vegetable crop and small-scale livestock farm in southern Wisconsin since 1994. Starting with just 5 subscribers and growing gradually to serve more than 200 households by its 15th year, Scotch Hill now depends for 90 percent of its farm income on production of more than 100 varieties of fresh vegetables.



The farm has employed a variety of mulching methods to control weeds and keep down labor expenses. Black plastic was a primary means of mulching vegetable crops for 11 years and is still used. Straw mulch has been used increasingly for 4 years. The farm has always relied on organic methods of production, but became certified organic only 2 years ago.

Black plastic mulch cost Scotch Hill Farm \$155 for a 4-foot-by-2,400-foot roll in 2008 before this study. A single worker at the farm (on a tractor with a secondhand mulch layer purchased for \$450) has been able to apply black plastic to an entire field of 100- and 200-foot beds

for vegetable transplants. This mechanical application can be completed in half a day, leaving driving paths of perennial grasses between 4- or 6-row sections, which we then mow during the growing season.

While this has been the most cost-effective means of weed control for Scotch Hill, organic certification standards require plastic mulch to be completely removed annually from fields. Removal can become a long, labor-intensive process that runs into cold weather, or even the following spring.

Black plastic mulch also does not always allow rain to penetrate to vegetable crop roots. It is petroleum dependent for its manufacture and has raised consumer concerns about leaching of toxic substances into soil. Plastic mulch cannot be recycled, leaving millions of tons from commercial vegetable grower use destined to landfills annually.

In this SARE study, Scotch Hill growers Dela and Tony Ends compared performance of prairie grass straw to oat and wheat straw as organic mulch alternatives to black plastic for fresh market production of a variety of vegetable crops. We also compared our own experience establishing 3-to-5-acre fields of oats, wheat and prairie grass and their integration into our primary production and rotation of vegetable crops. Mulch comparisons for this study were made in the 2009 and 2010 growing seasons.

2010 Project Field Trial Approach

A field trial was conducted on Scotch Hill Farm near Brodhead Wis., in 2010, with UW Rock County Extension Agent Jim Stute. Three mulch materials (oat and wheat straw and prairie grass straw) were compared in two systems: high traffic (tomato) and low traffic (Cole crops).

Individual rows were mulched on both sides with a specific straw type at a rate of approximately 1 bale per 40 feet of linear row on June 2. Tomatoes were trellised on 3-foot centers, Cole crops grown in rows on 1-foot centers. Other than mulch type, normal cultural practices were used in both systems.

2010 Field Trial Measurements included:

- 1 Straw composition
2. Weed density 40 days after mulching. Weed measurements were taken within three random 2.5 square foot areas within each mulch type. Measurements included weed number, average height, species present and an estimation of predominant species. Beds were hand-weeded following rating.
3. Visual assessments of mulch performance (as a weed barrier, persistence) throughout the growing season.

2010 Field Trial Results:

I. Straw composition

Results from pre-placement material sampling are shown in table 1. Prairie grass is noticeably different from the straw in 2 measurements: 1) roughly double the tissue nitrogen content and; 2) a

much lower C:N ratio. These differences should affect the rate of material decomposition because the C:N is closer to the 30:1 required for microbial breakdown.

Table 1. Chemical composition of mulch materials.

Material	N	P	K	C	C:N
	%	%	%	%	Ratio
Prairie grass	1.06	0.09	0.58	46.7	44:1
Oat straw	0.58	0.22	2.30	45.8	79:1
Wheat straw	0.52	0.11	0.61	45.7	88:1

II. Weed density

Weed density was only measured in the Cole crop trial because the trellised tomato trial had developed complete canopy over the row when the measurement were take. Weed density data is shown in table 2. Weed species penetrating the mulch in 2010 included foxtail, small flower galinsoga, Venice mallow and lady’s thumb smartweed. These common broadleaves should be considered more of an issue than foxtail because of their potential size and ability to compete for resources. Smartweed is also an attractant for Japanese beetles, a particularly problematic insect pest for horticultural production in southern Wisconsin.

Table 2. Weed density 40 days after application

Material	Weed		Volunteer	Dominant species
	Density (p/ 2.5 ft ²)	Height in	Density (p/ 2.5 ft ²)	
Prairie grass	10.6	var		Foxtail Smallflower galinsoga
Oat straw	7.3	var	7.3	Volunteer oat Smallflower galinsoga
Wheat straw	6.3	var	min	Foxtail Smallflower galinsoga

Var, variable. Different species present in differing densities made calculating an average height meaningless.

Min, minimal. Less than one plant per sample

Prairie grass had a greater weed density than the straw materials, approximately 4 plants per 3 ft², which consisted of foxtail. In general, the type of mulch did not impact the predominant weed species or individual weed species height, indicating that all 3 were equally effective in delaying the emergence of weeds.

When volunteers are included, oat straw had the greatest total weed density, and volunteer plants equaled the native weed populations. This volunteer potential is undesirable. Although relatively easy to remove, the volunteers are robust, competing for resources. They also may harbor a variety of rusts, which may serve as a late-season disease reservoir for other crops.



Figure 1. Mulch materials at application, June 2, 2010.

Top: Wheat straw

Middle: Oat straw

Bottom: Prairie grass





Figure 2. Prairie grass mulch, 40 days after application.

Visual assessment of mulch performance

The 2010 growing season represented one of optimal conditions for weed growth and competition due to the combination of ample rainfall and high temperatures. Observations of the field trial with specific varieties mirrored grower observations across a wider variety of vegetable varieties in the growers' broader comparison over the 2009 and 2010 growing seasons.

During this time, Scotch Hill used straw to mulch garlic, broccoli, snow peas, cauliflower, tomatoes, cabbage, melons, cucumbers, squash, sweet potatoes and three varieties of beans. For all varieties of straw mulch employed, their ability to suppress weeds seemed largely a function of how quickly we applied the mulch after seeding or transplanting, and how thick and thorough was the mulch application.

Our farm acquired a two-row mechanical transplanting implement, three-row Planet Junior seeding equipment for 40 varieties of seed and a slower-g geared diesel tractor for vegetable crop production in 2010. We had previously done all transplanting of vegetable starts and most direct seeding of vegetables by hand or with walk-behind equipment.

The newer equipment has meant that bed preparation, scale planting and transplanting and mulching can all take place in the same day, which has greatly improved performance of all three types of straw. Previously, when the growers used straw mulch instead of black plastic, application came later when time permitted and labor was available. All three types of straw effectively deterred a

wide range of weed types, excepting Canadian thistle, in each of these vegetable varieties in the two growing seasons of this study.



Beds for our various varieties of vegetables mulched with the three straw varieties ranged from 40 feet to 300 feet in length, in double rows of plants about 3 feet wide. The snow peas and tomatoes were trellised in single and double-rows respectively. We have also begun trellising cucumbers, planted in early spring in high tunnel greenhouses. In the 2009 season, squash was planted in hills, “three sisters” style around pole beans trellising on sunflowers or sweet corn.

In 2010, squash was planted with the mechanical seeder in double rows and cultivated mechanically.

Walking paths between double rows of vegetables were either mulched with straw or sometimes mowed with a push mower. Straw mulch was also used in walking paths between black plastic beds of transplants. Prairie grass straw seems to hold up better under high foot traffic, where harvests are repeated every few days or daily (such as tomatoes or beans) than do oat and wheat straw mulches.

Scotch Hill has also used straw mulch in two high tunnel greenhouses, built in 2008 and 2010, where the straw is put down in some paths to deter weeds and stored along east and west walls as an extra barrier against cold. The bales are then close to surrounding vegetable crop beds at the next season’s planting.

Straw Mulch Lessons and Tips

The longer term the vegetable crop plant variety, the more likely all types of straw mulch will eventually succumb to weather, deteriorate and allow some weeds to compete with the vegetables. If applied immediately after planting or transplanting, though, each type of mulch seems to last long enough for the vegetables to establish and develop a canopy.

Wheat straw seems to hold up best over winter as a mulch for garlic, planted in fall and harvested the following July. Prairie grass straw mulch seems to last the longest during the regular growing season. No straw works very well in delicate, dense leafy crops, such as leaf lettuce mix or spicy greens mix. The straw catches up in the growing greens and makes a clean harvest difficult and time-consuming in post-harvest handling.