LONG-TERM EVALUATION OF ANNUAL RYEGRASS CROPPING SYSTEMS FOR SEED PRODUCTION – YEAR 6

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A field trial was established to evaluate reduced tillage systems in annual ryegrass (*Lolium multiflorum*) seed production. This progress report summarizes the impact on seed yields and soil organic matter accumulation following 6 years of field testing at the OSU Hyslop Field Research Laboratory.

Introduction

Annual ryegrass seed production practices in Western Oregon have changed significantly from the time when open field burning and no-till planting was a common practice. Before 1990, more than 50% of the acreage was burned. Between 1990 and 2008, about 20% of the acreage was burned annually. Legislation in 2009 further restricted burning in Oregon and essentially eliminated open field burning for annual ryegrass seed production.

For the past 20 years, annual ryegrass seed production acreage was the most stable of Oregon's major grass seed crops with approximately 120,000 acres in production, primarily in the southern Willamette Valley. The stability of acreage is partially due to production on soils too poorly drained for small grains and vegetable crops, and on soils less productive than that required for higher value perennial grass and clover seed crops. This situation led to a system of continuous seed production of annual ryegrass. Some fields have been in continuous annual ryegrass seed production for over 40 years.

The majority of annual ryegrass seed production is managed with conventional tillage and planting systems. Although costs have increased, seed yields comparable to or greater than the traditional practice of open field burning have been achieved by the seed industry.

No-till and volunteer systems are being tested and used by farmers in an effort to reduce costs. In the volunteer system, a stand is established from seed shattered from the previous crop and no tillage or planting equipment is used. Grazing and row spraying with herbicides may be used to control stand density. When no-till planting is used, a sprout of volunteers and weed seeds are-sprayed with glyphosate herbicide before planting.

Both volunteer and no-till establishment systems offer reduced tillage and fuel expenses, as well as reduced concerns about dust and air quality. However, previous field work demonstrated that seed yields under volunteer and no-till systems decline significantly if these systems are used in consecutive years (Young et al., 1997). In the first year of production, no-till and volunteer methods have been comparable to conventional methods of planting, suggesting a system of alternate year tillage may be a feasible way to maintain seed yields. Some grass seed farmers report good results using a reduced tillage approach.

This study was designed to evaluate the multi-year economics of cropping systems in a continuous annual ryegrass monoculture. A secondary objective was to measure the impact on soil properties, especially soil organic matter and soil carbon levels in reduced tillage systems.

Material and Methods

The study was established at OSU's Hyslop Field Research Laboratory near Corvallis, Oregon in the fall of 2005. The diploid variety "Gulf" was used in the trial. The field had been planted to 'Gulf' annual ryegrass the previous two years under a conventional tillage system. Soil was a moderately well-drained silt loam with a pH of 5.4 and soil test levels of P, K, Ca, and Mg above those levels considered adequate for seed production. Six treatments were included in a Randomized Complete Block design, and replicated three times with plots 25 feet by 125 feet. The resulting treatments included:

1. Continuous conventional tillage and planting system
2. Continuous no-till planting system
3. No-till/conventional tillage rotation (alternate year tillage)
4. Volunteer/conventional tillage rotation (alternate year tillage)
5. Burn and no-till/conventional tillage rotation (alternate year tillage)
6. Volunteer/no-till/conventional tillage rotation (tillage every 3rd year)

In all except the burn treatment, residue from the previous year's crop was flail chopped and left on the field. Tillage included plowing to a depth of 8 to 10 inches, disking, and pulvi-mulching. A final seedbed was prepared by harrowing and rolling. All treatments except the volunteer included at least one preplant application of glyphosate to control volunteer seedlings. A preplant fertilizer of 200 lb/acre of 16-16-16 was applied to all treatments. A Great Plains no-till drill was used to seed all treatments except the volunteer at a planting rate of 12 lb/acre. The volunteer plots were established by allowing the seeds left on the surface the previous year to germinate and grow. Rows in the volunteer plots were established by spraying 7 inches out every 10 inches with glyphosate at 40 oz/acre. All herbicide use, pest control and spring fertilization (150 lb N/acre) were performed according to OSU recommendations and industry standards.

Plots were harvested by swathing in late June, using a modified John Deere 2280 swather. Yields were determined by cutting one 6-ft. swath lengthwise down the middle of each plot to assure a uniform harvest area. Plots were combined in mid-July with a Hege 180 plot harvester. Seed was cleaned using a Clipper M2B cleaner and clean seed yields, cleanout percentage and seed weight determined. Standard Central Analytical Laboratory procedures for soil carbon, organic matter and pH were used. Data were analyzed over the six years of the trial using a factorial design with years as an independent variable. The treatments in this study take more than one year's management into consideration; e.g., alternate year treatments were considered as two or three cycles of each rotation. Means were separated using on LSD (0.10).

Results and Discussion

Cropping systems produced significant differences in the six-year average clean seed yields (Table 1). No differences in percent clean-out or seed weight (g/1000 seeds) due to treatments were observed (data not shown). Among treatments, continuous no-till management had the lowest yield of the six different systems of stand establishment. The burn and no-till planting method alternated with conventional tillage had the greatest mean seed yield.

Table 1. Average seed yield of annual ryegrass and comparison of production costs after six years, 2006 - 2011.

Establishment system	Seed yield 6-year average		Total cost yearly average	Cost savings compared to con-ventional	Break-even price based on 2000 lb/acre and relative yields[2]	
	(lb/acre)	(% of con-ventional)	($/acre)	($/acre)	(lb/acre)	($/lb)
1. Continuous conventional tillage	1624 b[1]	100%	$612	$0	2000	$0.31
2. Continuous no-till	1423 c	88%	$517	$95	1760	$0.29
3. No-till/conventional tillage rotation	1570 b	97%	$565	$47	1940	$0.29
4. Volunteer/conventional tillage rotation	1549 b	95%	$526	$86	1900	$0.28
5. Burn and no-till/conventional tillage rotation	1760 a	108%	$561	$51	2160	$0.26
6. Volunteer/no-till/ conventional tillage rotation	1593 b	98%	$523	$89	1960	$0.27
LSD (0.10)	118					

[1]Means followed by the same letter do not differ significantly
[2]Yield expressed as a % of conventional x 2000 lb/acre

All systems of establishment that included alternate year tillage provided mean seed yields that were 95% to 98% of that achieved with the conventional annual tillage method of establishment. In year 6 (data not shown), the alternate year tillage treatments as a group out-yielded the no-till by 406 lb/acre and also out-yielded conventional tillage by 250 lb/acre. These results suggest that seed yields comparable to conventional tillage systems can be maintained with reduced tillage systems that include tillage once in every second or third year. Among the six systems of establishment, the continuous conventional tillage and planting approach had the highest cost of production, based on the Oregon State University enterprise budget for annual ryegrass (Eleveld et al., 2010). The conventional system was $51 to $89/acre more than methods of establishment that used tillage on an alternate year basis. Continuous no-till provided the lowest cost of production, but also experienced the most stand loss due to slugs. As a result no-till had the least uniform stand most years of the study, often with significant thin areas. Stand reduction due to slugs was probably a major reason for poorer yields in the continuous no-till treatment. Slug damage to seedling crops in the region is a common problem and a significant economic risk. Slug numbers in no-till annual ryegrass fields can be 14 to 29 times greater than in plowed and conventionally worked plots (Fisher et al., 1996). Systems that alternate no-till or volunteer methods with tillage have less risk of damage from this widespread and common pest. In addition, voles also seemed more of an issue in no-till plots, although there are no data to support this observation.

In this trial, the yearly mean seed yields when averaged across all treatments (the trial average for the year) ranged from a high of 2047 lb/acre in 2009 to a low of 1066 lb/acre in 2010. Seed yields in 2008 and 2010 were significantly affected by slug and vole damage. For this reason, composite yields for the treatments over years were below normal compared to commercial annual ryegrass seed fields in the Willamette Valley. While yields were low by industry standards, differences were statistically different. One way to compare treatments is to apply the relative yields (% of conventional) to the industry average seed yield of 2000 lb/acre. Based on this approach, and using the OSU enterprise budget for annual ryegrass, a break-even cost of production can be determined for each production system (Table 1). The break-even price for the conventional tillage method was $0.31/lb, and reduced tillage systems (excluding the open field burning method) had break-even prices that ranged from $0.27 to $0.29/lb of seed.

One of the reasons for using no-till or reduced tillage farming methods is to maintain soil organic matter levels and potentially increase carbon storage in the soil. Soil samples taken in this study showed that soil organic matter and soil carbon levels were similar under conventional or alternate year tillage systems in the 0-8 inch plow layer depth (Table 2). Soil organic matter and carbon were stratified under continuous no-till due to accumulation of soil organic matter in the surface 0-2 inch depth (Table 3). Below 2 inches (in the 2-8 inch samples) soil carbon in the continuous no-till was significantly less than that found in the soil samples taken from the other treatments, all of which included tillage during year 6 when samples were taken. Crop residues were incorporated by tillage to a greater depth than in no-till. And in spite of more tillage, which tends to promote the decomposition of soil organic matter through increased aeration and microbial activity, tillage in this trial has led to an increase in soil C deeper in the plow layer where it is slower to degrade. In contrast, crop residue in the no-till plots remained on the soil surface where it was subject to decomposition. Apparently the residue incorporation in this trial has been sufficient to balance that lost from tillage.

Table 2. The effect of planting methods and reduced tillage systems on chemical properties on soil collected from 0 to 8-inch depth. Year 6 of a long-term trial, Hyslop Experimental Farm, 2011.

Establishment System	Soil test			
	Carbon	Organic matter[1]	Total N	pH
	- - - - - - - - - - - - - (%) - - - - - - - - - - - -			
1. Continuous conventional tillage	1.64	3.98	0.123	6.03
2. Continuous no-till (6 years)	1.70	4.08	0.133	6.27
3. No-till/conventional tillage rotation	1.60	3.85	0.120	6.20
4. Volunteer/conventional rotation	1.63	3.90	0.133	6.13
5. Burn and no-till/conventional rotation	1.56	3.80	0.123	6.10
6. Volunteer/no-till/conventional rotation	1.57	3.78	0.120	6.17
LSD (0.05)	NS	NS	NS	0.137

[1] Determined by loss on ignition.

Table 3. The effect of no-till planting on the stratification of soil C, soil organic matter, and soil pH following six years of continuous no-till, Hyslop Experimental Farm, 2011.

Establishment System	Soil test (2011)				
	Soil depth	Carbon	Organic matter[2]	Total N	pH
	(inch)	- - - - - - - - - -	(%)	- - - - - - - - - - -	
Continuous no-till (6 years)[1]	0-2	2.05	4.04	0.147	6.07
	2-8	1.40	3.22	0.107	6.30
LSD (0.05)		0.06	NS	0.02	0.14

[1] All other treatments were tilled the year of sampling.
[2] Determined by loss on ignition.

Soil organic matter and nutrient stratification have been observed in previous no-till trials (Mellbye and Young, 1999). Despite differences in tillage and organic matter distribution, total accumulation of soil C among treatments was similar (assuming similar soil bulk density). Soil organic matter levels change slowly in a given cropping system in temperate climates (Johnston, 2011). The exception is when soil organic matter levels are low, and large additions of compost or manure are made, or when changes are made from annual to permanent grass cropping system. In a given climate and cropping system, soils tend to reach an equilibrium level of organic matter. Thus results from this trial may change over time, but the rate of C accumulation will probably be low compared to the total biomass of crop produced. A trend toward slightly higher soil organic matter and soil C levels can be observed in the continuous no-till treatments, but the changes are very small and not statistically different. More importantly, the results show that alternate year tillage or plowing in annual ryegrass cropping systems can maintain soil carbon at levels similar to those achieved with continuous no-till, at least over a short period of time.

Summary

To date, alternating conventional tillage with a no-till or volunteer method of establishment has provided seed yields close to conventional planting methods, but at a lower cost of production. Both alternate year and continuous tillage appear to maintain soil carbon levels comparable to continuous no-till for a period of up to 6 years. This trial is designed to last a minimum of 9 years, and a more thorough analysis of results will be presented in the future. The results to date demonstrate that alternatives to annual conventional tillage exist in annual ryegrass seed production that reduce costs while maintaining yields.

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