PROJECT NO: BJKV30 , BJKV31

TITLE: Production Systems for Dryland Grain

PERSONNEL: Dr. Juliet Marshall, Ext. Crop Mgmt. Specialist (SC and E Idaho)
Paul Patterson, Ext. Ag Economist, Idaho Falls

ADDRESS: Dr. Juliet Marshall, 1776 Science Center Dr, Ste 205, Idaho Falls, ID, 83402; 208-529-8376; jmarshall@uidaho.edu

JUSTIFICATION: Direct seeding of wheat and barley is a standard production practice in many of the dryland grain areas of southeast Idaho. In some cases, the lack of market and production options have lead to over twenty years of continuous wheat in no-till systems. Continuous wheat production has resulted in yield declines from a buildup of disease and insect pests. These declines have been exacerbated by below average summer rains. Input costs have soared, and some growers have reduced fertilizer inputs, potentially resulting in reduced yield, protein and end-use quality. Growers are seeking options to improve the economics of dryland production, including taking ground out of no-till systems. However, this risks losing the benefits of improved soil moisture, soil structure, organic matter, and erosion control. The next several years will be critical in the development and maintenance of sustainable cropping systems from agronomic, environmental, and economic perspectives.

While both 2009 and 2010 were exceptionally wet years, precipitation in the last ten years has declined below the 30-year average, raising the possibility of returning to a summer fallow production system. Indeed, precipitation during the 2012 season was very low and subsoil moisture (up to three feet deep) was extremely low. Other production options include the use of composted manures and leguminous cover crops that provide multiple benefits of disease suppression and nitrogen fixation. We propose to look at some of these production alternatives, assess the economics and determine variety performance under four different production schemes.

HYPOTHESIS & OBJECTIVES: The maintenance of no-till production is critical for the success of dryland production systems. Plowing, while reducing disease, will result in excess soil moisture loss and yield reduction. Manures have the potential to improve soil microbial activity, reduce disease pressure and improve economics. The specific objectives include:

1. Evaluate the agronomic performance and economics of wheat under four different production
   systems: 1) chem fallow, 2) continuous conventional no-till, 3) composted manure application, and 4) plowing. These are detailed below:

   a) Chem fallow treatment will have the weeds controlled the first summer with Roundup, and the second year will be planted into spring wheat.
   b) The continuous conventional no-till treatment will be under the standard production system that the producer (Gordon Gallup) utilizes.
   c) Composted cow manure will be applied to improve tilth and fertility. The compost will be applied yearly prior to planting. Green manure crops will be planted every fourth or third year.
   d) Plowing to bury residue and reduce disease and insect pressure in the spring. Wheat will be planted every year.

2. Develop and compare detailed cost of production estimates for each of the four production systems, looking at cost per acre and per bushel for operating, ownership and total costs.

3. Monitor soil moisture, pH, organic matter, nutrients, nematode populations, and disease.

4. Improve recommendations for production practices under dryland grain production systems.

PROCEDURES: Thirty acres under no-till dryland grain production is available for large plot (production equipment size) trials in the Swan Valley area above Ririe, ID. This ground has been in no-till wheat production for more than twenty years. Six replications of main plot (production system) have been established in 45-foot wide strips in a randomized complete block design. The grower (Gordon Gallup) will be responsible for plowing, fallowing, applying herbicides, and planting. Measurements will be taken on agronomic characteristics (yield, test weight, protein and plump) and soil characteristics (soil moisture, pH, organic matter, nutrients, nematode populations, and disease). Records will be kept for economic assessment (Patterson). The study must be for at least four years in order to correctly assess the impact of a two-year treatment.

DURATION: Multiple. This would be the second set of four years, the first of four years.

COOPERATION: County Extension Educators, and grower cooperators (Gordon Gallup, Clark Hamilton)

ANTICIPATED BENEFITS/EXPECTED OUTCOMES/INFORMATION TRANSFER: Idaho grain producers will receive the most recent information on effectiveness of no-till production systems to improve production efficiency, increase economic returns, and maintain competitiveness. Results from the trial will be communicated to growers in cereal schools as well as news releases, progress reports, bulletins, newsletters, internet websites, and mass media. At this location, we hold the annual direct seed field day, which has given the IWC and UI an excellent format to discuss direct seeding practices, successes, and issues.

LITERATURE REVIEW:

DeVayast, Eric A. and Ardell D. Halvorson. Economics of annual cropping versus crop-fallow in the northern great plains as influenced by tillage and nitrogen. Agron. J. 96:148-153 (204).

Janosky, Jeffrey S., Douglas L. Young and William F. Schillinger. Economics of conservation tillage in a wheat-fallow rotation. Agron. J. 94:527-531 (202).

Triplet, Jr., G.B. and Dick, W.A. 2008. No-Tillage Crop Production: A Revolution in Agriculture. *In* Celebrate the Centennial. Agron. J. 100:S-153 - S-165.

Schillinger, W.F. and Papendick, R.I. 2008. Then and Now: 125 Years of Dryland Wheat Farming in the Inland Pacific Northwest. *In* Celebrate the Centennial. Agron. J. 100:S-166 - S-182.

COMMODITY COMMISSION BUDGET FORM

Allocated by	Idaho Wheat Commission	during FY 2013	$	9,746
Allocated by	Idaho Wheat Commission	during FY 2014	$	9,746

REQUESTED FY 2015 SUPPORT:

	Salary	Temporary Help	Fringe	Travel	OE	CO	Grad Fees	TOTALS
Idaho Wheat Commission	$ -	$ 4,927	$ 2,435	$ 769	$ 1,650	$ -	$ -	$ 9,781

OTHER RESOURCES (not considered cost sharing or match):

a) Industry	$ 1,500
b) UI (salaries, operating)	$ 10,000
c) Other (local, state)	$ 3,500
d)	$ -
e)	$ -
TOTAL OTHER RESOURCES	$ 15,000

TOTAL PROJECT ESTIMATE FOR FY 2015:	$ 9,781 *(Requested)*	$ 15,000 *(Other)*	$ 24,781 *(Total)*

BREAKDOWN FOR MULTIPLE SUB-BUDGETS:

	Marshall	*Patterson*	*Parma*	*(PI name)*
Salary	$ -	$ -	$ -	$ -
Temporary Help	$ 4,327	$ 600	$ -	$ -
Fringe Benefits	$ 2,250	$ 185	$ -	$ -
Travel	$ 769	$ -	$ -	$ -
Operating Expenses	$ 1,400	$ 250	$ -	$ -
Capital Outlay	$ -	$ -	$ -	$ -
Graduate Student Fees	$ -	$ -	$ -	$ -
TOTALS	$ 8,746	$ 1,035	$ -	$ -

Total Sub-budgets $ 9,781

10.29.2013 - Version

CURRENT AND PENDING SUPPORT Form:

Name: Juliet Marshall

NAME (List PI/PD #1 first)	SUPPORTING AGENCY AND AGENCY NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITT-ED	TITLE OF PROJECT
	Current:				
Marshall, J.M., and Johnson (Schroeder)	Idaho Wheat Commission	$29,090	7/1/13 - 6/30/14	10	Extension Wheat Nurseries
Marshall, J.M. and Johnson (Scroeder)	Idaho Barley Commission	$13,000	7/1/13 - 6/30/14	8	Education for Barley Production / Extension Nurseries
Marshall, J.M. and Patterson, P.	Idaho Wheat Commission	$9,746	7/1/13 - 6/30/14	7	Production Systems and Wheat Varieties for Dryland Grain
Marshall, J.M.	USDA-ARS SCA	$9,000	10/1/13 - 9/31/14	10	Management of Wheat and Barley Root Pathogens in Idaho
Marshall, J.M.	Monsanto, Syngenta, Limagrain, etc	$28,250	7/1/13 - 6/30/14	2	Private breeding company entries into the Extension Variety Trials
Marshall, J.M.	Bayer Crop Sciences, BASF, Syngenta, etc	$53,092	8/1/13- 7/31/14	8	Seed Treatment / Specialty Trials / Product Evaluation
Marshall, J.M.	Federal 047	$1800		1	South Idaho Crop Management
Marshall, J.M.	Idaho State Funding	$17,847	7/1/13 – 6/30/14	10	Barley Enhancement
Marshall, J.M.	Hatch Funding	$1118	10/1/13 - 9/31/14	10	Foot Rot
Rashed, A. and Marshall, J.M.	Idaho Wheat Commission	$7,800	7/1/13 – 6/30/14	2	Variety Screening for BYDV Resistance in Idaho

Marshall, J.M. and Schroeder, K.	Idaho Wheat Commission	$9,000	7/1/13 – 6/30/14	5	Collaborative Nitrogen by Variety Interaction Study with LCS
Marshall, J.M. and Schroeder, J.	Idaho Wheat Commission	$14,000	7/1/13 – 6/30/14	5	Biostimulant Efficacy Field Trial
Moore, A., and Marshall, J.M.	Idaho Barley Commission	$16,000 (SA $547)	2013-2014	1	Long-Term Impacts of Manure Application on Production of Barley and Other Crops
Moore, A. and Marshall, J.M.	Idaho Wheat Commission	$18,210 (SA $547)	2013-2014	1	Long-Term Impacts of Manure Application on Production of Wheat and Other Crops
Chen J., Wang, Y., and Marshall, J.M.	Idaho Wheat Commission	$44,973 (SA $7462.35)	7/1/13 – 6/30/14	2	Digging the genetic factors underlying LMA in wheat
Murray, T., Carter, A., and Marshall, J.M.	Idaho Wheat Commission	$52,980 (SA $4000)	7/1/13 – 6/30/14	1	Enhancing Resistance to Snow Mold Diseases in Winter Wheat
Marshall, J.M.	Idaho Wheat Commission	$12,888	7/1/13-6/30/15	1	Endowment funding
	Pending:				
Marshall, J.M., and Schroeder, K,	Idaho Wheat Commission	$31,437	7/1/14 - 6/30/15	10	Extension Wheat Nurseries
Marshall, J.M. and Scroeder, K.	Idaho Barley Commission	$14,672	7/1/14 - 6/30/15	8	Education for Barley Production / Extension Nurseries
Marshall, J.M. and Patterson, P.	Idaho Wheat Commission	$9,746	7/1/14 - 6/30/15	7	Production Systems and Wheat Varieties for Dryland Grain

Marshall, J.M.	USDA-ARS SCA	$6,042	10/1/14 - 9/31/15	10	Management of Wheat and Barley Root Pathogens in Idaho
Rashed, Marshall, Bosque-Perez, Pappu, Wallis, Eigenbrode	Idaho Wheat Commission	$19,069	7/1/14 - 6/30/15	2	Wheat variety response to BYDV infection at different developmental stages
Rashed, A and Marshall, J.M.	Idaho Wheat Commission	$36,400	7/1/14 - 6/30/15	2	A survey of central and eastern Idaho wireworm species and evaluating ecological and chemical approaches to maximize cereal production
Rashed, A and Marshall, J.M.	Idaho Barley Commission	$15,540	7/1/14 - 6/30/15	2	A survey of central and eastern Idaho wireworm species and evaluating combinations of ecological and chemical approaches to limit damage to barley crops
Marshall, J.M. and Schroeder, K.	Idaho Wheat Commission	$9,000	7/1/14 – 6/30/15	5	Collaborative Nitrgen by Variety Interaction Study with LCS
Marshall, J.M. and Schroeder, K.	Idaho Wheat Commission	$14,000	7/1/43 – 6/30/15	5	Biostimulant Efficacy Field Trial
Moore, A. and Marshall, J.M.	Idaho Wheat Commission	$19,110 (SA $547)	2014-2015	5	Long-Term Impacts of Manure Application on Production of Wheat and Other Crops
Moore, A. and Marshall, J.M.	Idaho Barley Commission	$16,000 (SA $547)	2014-2015	5	Long-Term Impacts of Manure Application on Production of Barley and Other Crops

Rashed, Marshall, Bosque-Perez, Pappu, Wallis, Eigenbrode	Idaho Wheat Commission	$19,069	2014-2016	3	Wheat variety response to BYDV infection at different developmental stages
Strawn, D., Chen, J., McDaniel, P., and Marshall, J.M.	Idaho Wheat Commission	$73,907	7/1/14-6/30/15	2	Field-based study of factors affecting cadmium uptake by wheat from Idaho Soils
Chen, J., Wang, Y., and Marshall, J.M.	Idaho Wheat Commission	$64,205	7/1/14 – 6/30/15	2	Digging the genetic factors underlying LMA in wheat

CURRENT AND PENDING SUPPORT Form:

Name: Paul Patterson

NAME (List PI/PD #1 first)	SUPPORTING AGENCY AND AGENCY NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITT-ED	TITLE OF PROJECT
	Current:				
Patterson, P.E.	Idaho Potato Commission	$7,670	7/1/12 – 6/30/13	10%	Cost of Potato Production in Idaho
Marshall, J.M. and P.E. Patterson	Idaho Wheat Commission	$9,781 ($1,035)	7/1/12 – 6/30/13	2%	Production Systems & Wheat Varieties for Dryland Grain
Dandurand, Knudsen, Caplan, Hutchinson and Patterson	USDA-NIFA	$436,529 ($15,945)	9/1/13 - 8/16/16	2%	Sustainable Production of New Varieties from the PNW Potato Variety Development Program
	Pending:				
Patterson, P.E.	Idaho Potato Commission	$7,025	7/1/14 – 6/30/15	10%	Cost of Potato Production in Idaho

Tarkalson, Bjorneberg, Koehn and Patterson	Foundation for Agronomic Research – IPNI	$12,000	2/1/14 – 12/31/14	1%	Nutrient Management in North America Sugar Beet Production: Historical Knowledge & Future Directions
Marshall, Patterson	Idaho Wheat Commission	$9,746	7/1/13 - 6/30/14	2%	Production Systems for Dryland Grain

INTERNAL PEER REVIEW VERIFICATION

Commodity commissions/organizations require internal peer review by colleagues familiar with the subject matter. This proposal has been peer reviewed by the following individuals:

Reviewer 1:	Phil Nolte (Type/Print name)	(Signature)	1/3/14 (Date)
Reviewer 2:	Phillip Wharton (Type/Print name)	P Wharton (Signature)	1/2/14 (Date)
Dept. Head/ Unit Administrator	Paul McDaniel (Type/Print name)	(Signature)	1/6/14 (Date)

PROGRESS REPORT

PROJECT NO: BJKV30, BJKV31

TITLE: Production Systems and Wheat Varieties for Dryland Grain

PERSONNEL: Dr. Juliet Marshall, Ext. Crop Mgmt. Specialist (SC and E Idaho)
Paul Patterson, Ext. Ag Economist, Idaho Falls

ADDRESS: Dr. Juliet M. Marshall, 1776 Science Center Drive, Suite 205, Idaho Falls, ID 83210, 208-397-4181; jmarshall@uidaho.edu

ACCOMPLISHMENTS: Direct seeding of wheat and barley is a standard production practice in many of the dryland grain areas of southeast Idaho. In some cases, the lack of market and production options have led to over twenty years of continuous wheat in no-till systems. Yield declines have resulted from a buildup of disease and insect pests, and those declines have been exacerbated by reduced summer rains. Input costs have soared, and some growers have reduced fertilizer inputs, potentially resulting in reduced yield, protein and end-use quality. Growers are seeking options to improve the economics of dryland production, including taking ground out of no-till systems. However, this risks impacting the benefits of improved soil moisture, structure, organic matter, and erosion control gained under no-till. The next several years will be critical in the development and maintenance of sustainable cropping systems from agronomic, environmental, and economic perspectives.

Precipitation in the last ten years has declined below the 30-year average (with the exception of 2009 and 2010), raising the possible necessity of returning to a summer fallow production system. Additional cropping options include crop rotations and the topdressing of compost that provide multiple benefits of disease suppression and improved beneficial soil microbial growth.

The objectives of this study were to explore the production options for dryland producers to maintain profitability, reduce disease, and examine alternative crops and cropping systems. This demonstration study also provided a forum for dryland producers to share and debate successful business and production strategies.

Replicated plots were established in a 30-acre field with production-equipment size trials in the Swan Valley area above Ririe, ID. This ground has been in no-till wheat production for twenty years. Six replications of main plot (production systems) have been established in 45-foot wide strips in a randomized complete block design. The grower (Gordon Gallup) was responsible for plowing, fallowing, applying herbicides, and planting. Measurements were taken on agronomic characteristics (yield, test weight, protein and plump) and soil characteristics (soil moisture, pH, organic matter, nutrients, nematode populations, and disease). Records are being kept for economic assessment (Patterson). Objectives and treatments included the following:

1. Evaluate the agronomic performance and economics of wheat under four different production systems: a) Chem fallow, b) continuous conventional no-till, c) composted manure and green manure crops, and d) plowing. These are detailed below:

    a) The chemical fallow treatment:
    Year 1: weeds controlled with Roundup
    Year 2: planted into spring wheat
    Year 3: weeds controlled with Roundup
    Year 4: planted into spring wheat

    b) The continuous conventional no-till will be under the standard production system that the producer (Gordon Gallup) normally utilizes.

c) Topdress composted cow manure / green manure treatment:
Year 1: No-till wheat
Year 2: fallow
Year 3: Composted manure applied
Year 4: Green manure crop planted

d) Plowing to bury residue and reduce disease and insect pressure. Spring wheat will be planted every year.
Year 1: No-till wheat, fall plowing
Year 2: Spring discing, planting, fall plowing
Year 3: Spring discing, planting, fall plowing
Year 4: Spring discing, planting, fall plowing

2. Evaluate the agronomic performance of crop rotation (wheat, barley, oats) under the four systems (long term).

3. Monitor soil moisture, pH, organic matter, nutrients, nematode populations, and disease.

4. Improve ability to recommend production practices under dryland grain production systems (long term).

In the first year of the study, we began to look at some of these production alternatives, assess the economics and determine crop performance under four different production schemes. Unfortunately, abundant spring moisture promoted crop growth in excess of expectations and in excess of area growers' ability to meet nitrogen requirements of spring grain crops. In the first year, yields averaged across the plots from 70 bu/A to 81 bu/A with 63 lb test weight but with less than the optimal 12.5% protein. Soil moisture in 2009 was calculated from 24 samples, taken from eight sites across the field prior to planting. Soil moisture varied in the 0 - 12" depth from 15.4 - 20%, averaging 17.8%. In the 12 - 24" depth, soil moisture varied from 15.2 – 21.7%, averaging 18.2%. In the 24 - 36" range, the soil moisture varied from 13.9 – 20%, averaging 16.8%. Soil was sent to Servitech for nutrient analysis.

Composite samples from eight sites were sent to the Nematode Diagnostic Laboratory at the University of Idaho in Parma. Nematode species identified included root-lesion nematodes (*Pratylenchus* species) and stunt nematodes (*Tylenchorhynchus* species), and combined are at damaging levels for grain production.

In the second year (2010), we took soil moisture samples, nematode samples, and yield data from each plot. Soil samples were taken from each treatment block, and half sent to Servitech for nutrient analysis, and half to Western Laboratories for nematode analysis. Yield, test weight, soil moisture and nematode data are reported in Table 1. The highest yielding treatment in 2010 was grain following the chemical fallow treatment. There were no significant differences in test weight, percent soil moisture, or number of nematodes.

In the third year, 2011, yield again varied significantly with treatment (Table 2). There were significant differences in yield, with the plots receiving manure out-yielding the continuous production plots by four bushels per acre. The lowest yielding plots were the plowed plots (independent of the chemical fallow plots which were not planted in 2011).

The fourth year, summer of 2012, all plots were planted to grain except the manure / green manure plots, in which were planted a mix of different plant species. Subsoil and soil moisture was extremely low just prior to planting (see Table 3), but was not significantly different between treatments. Prior to planting, soil moisture varied in the 0 - 12" depth from 4.5 to 6.5%, averaging 5.5%. In the 12 - 24" depth, soil moisture varied from 4.1 to 4.9%, averaging 4.5%. In the 24 - 36" range, the soil moisture varied from 2.8 to 5.4%, averaging 3.7%. The spring and summer of 2012 were very dry (see Figure 1).

We will develop and compare detailed cost of production estimates for each of the four production systems, looking at cost per acre and per bushel for operating, ownership and total costs. Yields were very poor, averaging 9-12 bu/A, with the highest yields following chem. fallow. However, the season started with little residual moisture at the 24-36" depth due to excessive run off of what little moisture was received during the 2011-2012 season, and no real opportunities throughout the season for soil moisture replenishment. It will be very interesting to measure the soil moisture of these plots in the spring 2013 prior to planting, to assess infiltration of snow melt.

The current year (2013) was also dry, with spring and summer precipitation below average. Total soil moisture was low at planting. The lowest yielding plots were those that were plowed, and the highest yielding plots were those that were treated with manures and cover crops. Nematodes were highest in the continuous grain plots (Table 4 and Figure 2).

Over the course of the experiment, lesion and stunt nematode populations increased, but were lower in March 2012, probably due to excessively dry conditions. Nematodes can enter a state of suspended animation (diapause) under extremely dry conditions and may not have been active when soils were tested. The method for testing levels of stunt and lesion nematodes measures active nematodes, and will not measure those in state of diapause. When appropriate moisture levels are regained, nematode activity will resume and the ability of the testing to detect population levels will be improved. In 2013, the lesion nematode population was significantly higher than the previous year's measurements

PROJECTIONS: Idaho grain producers will receive the most recent information on effectiveness of no-till production systems to improve production efficiency, increase economic returns, and maintain competitiveness. Results from the trial will be communicated to growers in cereal schools as well as news releases, progress reports, bulletins, newsletters, internet websites, and mass media.

PUBLICATIONS:
Smiley, R. W., **Marshall, J. M.**, Gourlie, J. A., Paulitz, T. C., Kandel, S. L., Pumphrey, M. O., Garland-Campbell, K., Yan, G. P., Anderson, M. D., Flowers, M. D., and Jackson, C. A. 2013. Spring wheat tolerance and resistance to *Heterodera avenae* in the Pacific Northwest. Plant Disease 97: 590-600.

Figure 1: 2011-2013 growing year precipitation versus 10-year and 93-year averages recorded at Aberdeen, ID.

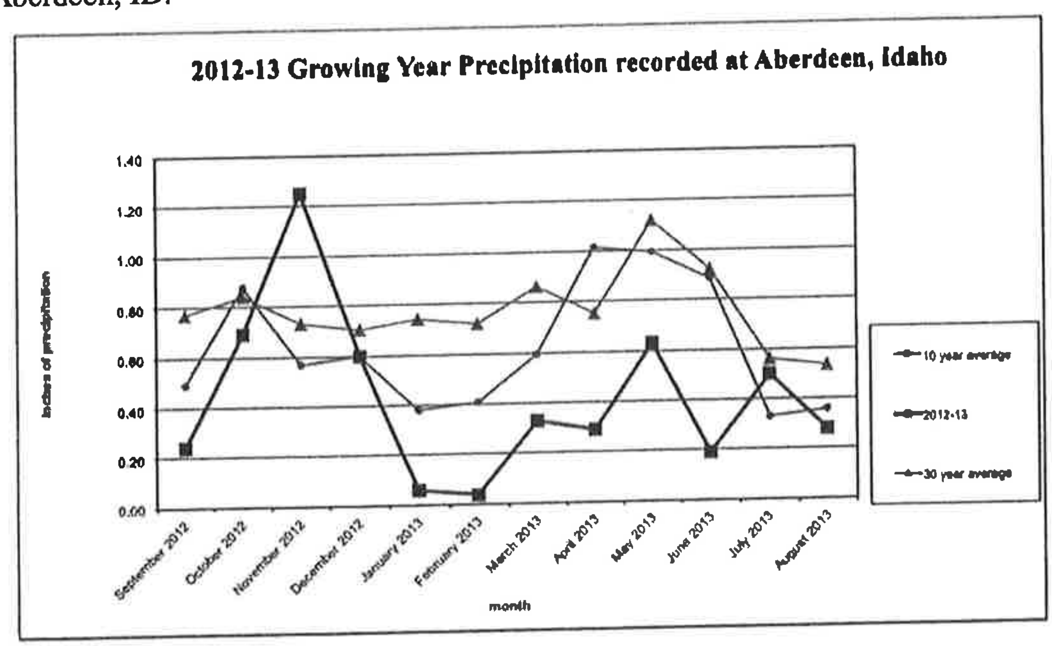

Table 1. Results from 2010 trial, including yield, test weight, percent soil moisture at three depths (0-12", 12-24", 24-36") and the number of nematodes from 0-36" in depth from each treatment. Treatments with a different letter are significantly different.

Treatment	Test Weight lbs/bu	Yield bu/A		Percent Soil Moisture 0-12"	12-24"	24-36"	Number of Nematodes/500 cc of soil Lesion	Stubby	Stunt
Chem Fallow	57.6	70.117	A	14.52%	12.72%	13.78%	225	0	75
Continuous	**56.3**	**49.917**	**C**	**14.99%**	**11.62%**	**14.14%**	**1470**	**15**	**150**
GM	57.8	0	D	15.78%	14.93%	11.50%	825	10	365
Plowing	56.8	57.24	B	15.57%	14.91%	9.69%	780	5	165
LSD (0.05)	2.05	5.46		2.63%	8.00%	5.34%	1039	22	355
CV	2.7	9.13		10.82	36.9	27.2	78.74	183	118
mean	57.1	45.75		15.22%	13.54%	12.28%	825	8	189
Pr>F	0.4048	**<0.0001**		0.7011	0.7324	0.2657	0.1295	0.4861	0.3488

Table 2. Results from the 2011 trial, including yield, percent soil moisture at three depths (0-12", 12-24", 24-36") and the number of nematodes from 0-36" in depth from each treatment.

Treatment	2011 Yield bu/A		Percent Soil Moisture 0-12"	12-24"	24-36"	Number of Nematodes/500 cc of soil Lesion	Cereal Cyst	Stunt
Chem Fallow	0	C	17.03	14.744	15.986	482	10	140
Continuous	**56.6**	**B**	17.697	13.373	16.479	**1695**	**0**	**350**
Manure	60.4	A	18.745	17.549	13.111	723	0	255
Plowing	55.0	B	18.447	18.196	11.017	822	70	370
LSD (0.05)	3.6		3.59%	10.90%	6.45%	1571	-	405
CV	6.8		12.47	42.64	28.5	105.5	-	90.9
mean	43		17.98%	15.96%	14.15%	931	-	279
Pr>F	**<0.001**		0.7084	0.7224	0.2536	0.3767	-	0.5806

Table 3. Results from the 2012 trial, including yield, percent soil moisture at three depths (0-12", 12-24", 24-36") and the number of nematodes from 0-36" in depth from each treatment.

Treatment	2012 Yield bu/A		Percent Soil Moisture 0-12"	12-24"	24-36"	Number of Nematodes/500 cc of soil Lesion	Cereal Cyst	Stunt
Green Manure	-		6.4%	4.1%	5.4%	110	0	180
Chem Fallow	12.04	a	4.6%	4.1%	3.1%	920	0	100
Plowing	9.78	b	6.5%	4.8%	3.4%	575	0	40
Continuous	9.36	b	4.5%	4.9%	2.8%	**1065**	**0**	**150**
LSD (0.05)	1.39		4.20%	3.34%	3.80%	1020	-	226
CV	10.42		47.8	46.7	64.19	95.5	-	85
mean	10.4		5.50%	4.47%	3.70%	668	-	118
Pr>F	**0.033**		0.5478	0.8976	0.4248	0.2219	-	0.5482

Table 4. Results from the 2013 trial, including yield, percent soil moisture at three depths (0-12", 12-24", 24-36") and the number of nematodes from 0-36" in depth from each treatment.

Treatment	2012 Yield bu/A	Percent Soil Moisture			Number of Nematodes/500 cc of soil		
		0-12"	12-24"	24-36"	Lesion	Cereal Cyst	Stunt
Chem Fallow	0	4.6%	4.1%	3.1%	920	0	100
Continuous	**45**	4.5%	4.9%	2.8%	**1065**	**0**	**150**
Manure	51.6	6.4%	4.1%	5.5%	110	0	180
Plowing	39.4	6.5%	4.8%	3.4%	575	0	40
LSD (0.05)		4.20%	3.34%	3.80%	1020	-	226
CV		47.8	46.7	65.2	95.5	-	85
mean		5.50%	4.47%	3.70%	668	-	118
Pr>F		0.5478	0.8976	0.4248	0.2219	-	0.5482

Figure 2. Population of lesion nematodes in the various treatments from 2009 to 2012. Measurements from 2009 were derived from an average across the field.

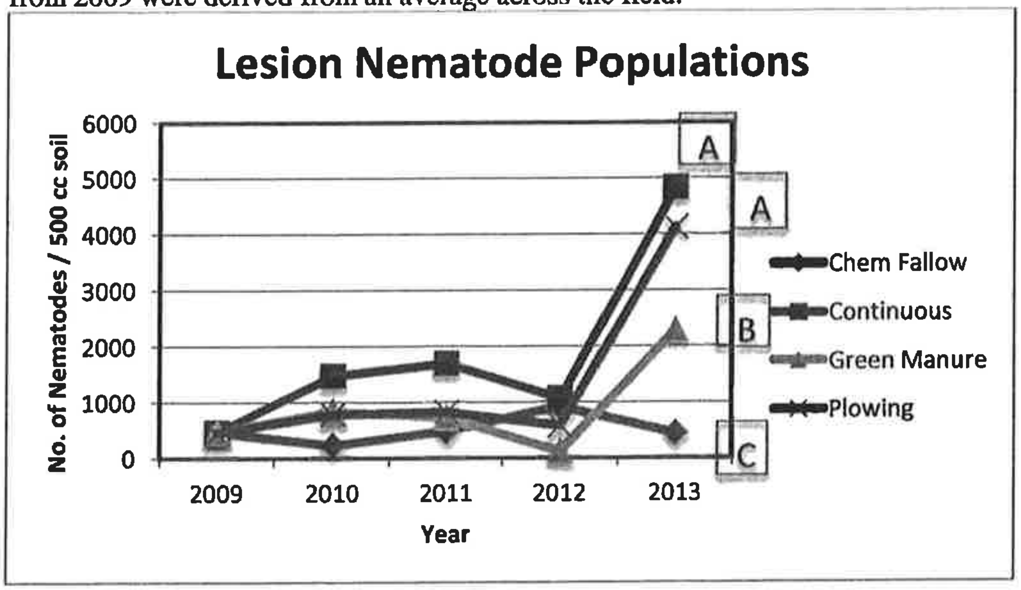

Figure 3. Population of stunt nematodes in the various treatments from 2009 to 2012. Measurements from 2009 were derived from an average across the field.