RESEARCH PROJECT TITLES: Assessing the Impact of Direct Seeding (No-Till) and Conventional-Till on Crop, Variety, Soil, and Insect Responses in Years 4-6 *and* Assessing the Impact of Direct Seeding (No-Till) and Conventional-Till on Nitrogen Fertility, Soil, and Insect Responses

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INTERIM REPORT COMBINED: for one year funding FY05 (continuation of FY02-04 project) and for the project funded FY06-08.

PROJECT OBJECTIVES: FY05 project -

1. Evaluate crop and variety performance differences between NT and CT production systems in a replicated tillage trial for winter wheat, spring barley, spring wheat, and dry pea during year four to six of the 'transition period'
2. Determine the impact of CT and NT on soil microclimate and fauna and document changes in key soil hydraulic and chemical properties
3. Monitor pea leaf weevil abundance, activity and damage in CT and NT pea
4. Conduct controlled experiments in the laboratory and field trials to assess predation by specific ground-dwelling predators on pea leaf weevil.
5. FY06-08 project -
6. Compare hard red winter and spring wheat nitrogen fertilization responses from rates and timing of N application in a replicated NT and CT comparison.
7. Determine the impact of CT and NT on soil microclimate and fauna and document changes in key soil hydraulic and chemical properties.
8. Monitor pea leaf weevil abundance and damage in CT and NT pea.
9. Conduct controlled experiments in the laboratory and field trials to assess predation by specific ground-dwelling predators on pea leaf weevil.
10. Compare immigration of pea leaf weevil into NT and CT pea and test the effects of specific factors on immigration of pea leaf weevil into NT and CT pea.

KEY WORDS: Tillage, Varieties, Nitrogen Fertility, Soil Dynamics, Insects

STATEMENT OF PROBLEM: Information and new technologies about crop, variety, soil, insect and disease will help solve problems inherent in conservation practices, particularly NT, in the high rainfall areas of the Pacific Northwest. Past results show that varieties can respond differently to tillage and when evaluated in a replicated trial, those variety differences can be compared and quantified. Understanding the influence of topography on C sequestration and nutrient distribution is necessary to achieve the most efficient application of nutrients to agricultural fields, especially in areas such as the Palouse that are characterized by rolling topography. The relation between macrofauna, porosity, and pore-size distribution in the early stages of NT operations are not known. Differences in population dynamics, crop losses, and variety specific response have not been characterized for Pea Leaf Weevil and other crop pests in replicated comparisons between CT and NT cereal production systems in the PNW. The importance and dynamics of the natural enemies of insects have also not been fully quantified in replicated NT comparisons in the PNW.

ZONE OF INTEREST: Higher precipitation Palouse region of ID and WA.

ABSTRACT OF RESEARCH FINDINGS: Experimental investigations were carried out according to the proposals. For crop year 2005, winter wheat, pea, and lentil varieties; and soil and insect studies were evaluated in the No-Till (NT) versus Conventional-Till (CT) comparison located at the Kambitsch research farm near Genesee, Idaho. All crops were established well in both tillage systems, with higher winter wheat plant counts in NT than CT as in previous years. The NT winter wheat yield was 2 bu/acre greater, at 109 bu/acre, than the CT. 'Lambert' again was the highest yielding variety in NT and was at the top in CT too. Test weights and plant heights were similar between NT and CT. Many of the varieties appear to be adapted to NT and CT, but 'Madsen' was the lowest soft white for both, although 'Boundary' hard red was lower still. All parameters were different among varieties and did not show a significant interaction with tillage. Pea yield, seed weight, plant stand, vine length, and canopy height were not different between NT and CT. 'Stratus', 'Monarch', and 'Joel' were high yielding in NT, but 'Bluebird' and Stratus were high in CT. Over three years, Stratus and Bluebird were highest yielding in CT and NT. Average yields over three years were 1820 lb/acre for CT and 1770 lb/acre for NT. Seed weights for both pea and lentil averaged higher in NT than CT and could be related to moisture availability differences between tillage systems during grain fill. Lentil performance was not different between tillage treatments and 'Merrit' and 'Pardina' produced the highest yields in NT and Pardina and 'Brewer' were highest in CT. Preliminary assessment of spring wheat response to N fertilization was started, but no results are available yet. Soil sampling before planting spring wheat showed 61 lb/acre of available N in NT and 69 lb/acre N in CT. As in previous years, earthworm densities were higher in NT (90/m^2) than CT (20/m^2). Differences in earthworm population density between CT and NT plots were seen as early as 2001 and have been consistent. Annual variation in population density suggests that macroclimate has a large impact on earthworm numbers and that population density values within soils should not be based on only one year of data. The relationship between years is similar to data from nearby prairie and CRP earthworm collection sites, and values were higher in NT than in those nearby sites, suggesting that NT will support high populations of earthworms. Soil moisture was consistently higher in adjacent NT than CT plots, even when NT

was higher in slope position that CT. Soil temperature varied by no more than 1ºC across all treatments, but appears to be mediated by slope position and was lower in NT than CT. Samplings conducted before 2005 revealed weevils were significantly more abundant in CT plots compared to NT, with a mean of 0.42 weevils per sample in CT vs. 0.18 weevils per sample in NT ($P = 0.03$). Our results also show that the pitfall trap sampling method is not biased by differential pea leaf weevil (PLW) activity. In a related study, significantly more PLW were captured on the first compared to a later pea planting date. Initial analysis does not show any significant differences in weevil emergence between CT and NT. Additional results from these studies will be forthcoming as investigation and analysis in the non-field season continue. Besides many presentations, one refereed journal article was published, many other publications were finished, and several journal articles are being prepared from these studies.

RESULTS AND INTERPRETATION: Previous results from the first part of this study can be found in 2001, 2002, and 2003 STEEP annual reports. Results are also available on line at: http://www.ag.uidaho.edu/cereals

Experimental Site Management. At the Kambitsch farm north of Genesee, Idaho a tillage comparison trial included 15 varieties of winter wheat, 12 varieties of spring dry pea, 6 varieties of lentil, an a preliminary evaluation of N fertilizer amount and timing on spring wheat. They were evaluated in a replicated no-till (NT) versus conventional till (CT) comparison in 2005. Each crop was raised on the previous crop residue as part of the rotation winter wheat-spring wheat-pea from the previous year (2004). This three-year rotation and tillage treatments have been in place since the winter of 2000. Winter wheat was seeded on October 6, 2004 using a Flexi-coil Stealth opener, five row plot drill. A burn-down herbicide was applied 4 weeks prior to seeding and dry fertilizer was banded with the seed drill to give a 91-29-0-20 lb/a application. Winter wheat was top-dressed with 40-0-0-6 lb/a dry fertilizer broadcast applied in the spring after green-up. Spring crops were seeded 3 weeks after a burn-down application using a small plot drill with Flexi-coil shank openers. Spring wheat was seeded on April 27, 2005 with 93-33-0-18 lb/a of fertilizer banded below the seed on the bulk area and treatment application on the fertilizer assessment area, but no fertilizer was applied to the pea and lentil area seeded the same day. The tillage treatment included a fall chisel plow about 8 inches deep on September 29, 2004 and two cultivations with a field cultivator/harrow prior to seeding. The no-till treatment was not disturbed except for seeding. In the bulk areas, 'Brundage 96' winter wheat, 'Monarch' pea, and 'Hank' spring wheat were seeded. Weed control included a 2.5 oz/acre rate of Pursuit in the pea area, and Rhino and Harmony Extra at standard rates in the cereals. A few weed escapes were hand weeded. Overall, weed control was good and should not have had any impact on crop yields. Pea leaf weevil levels were high and were controlled by an application of Capture and pea seed weevil and aphids were controlled by an application of Capture at bloom.

Over winter there was limited vole feeding in the winter wheat area and Zink Phosphide bait stations were in place to control winter wheat crop loss. The winter wheat established well and survived the winter well. The spring crops had a normal seeding date and crop establishment was uniform and typical. However, due to drill problems at seeding of the spring wheat, some planned treatments and plots had to be repositioned onto fully seeded plots. This problem limited the N fertilizer treatments and evaluation on spring wheat. Soil moisture was good for most of the first portion of the crop season, but became limited for spring crops during reproductive stages Lack of later moisture gave below average yields and seed quality in the spring crops.

<u>Variety responses:</u> Stephen O. Guy, Mary Lauver, Ying Wu

Winter wheat. When grain yield was combined over varieties, CT produced 113 bu/a and NT was higher at 115 bu/a although not significantly (Table 1). These values do not include 'Moreland' that was devastated by Stripe Rust. There was no significant interaction of tillage and variety and 7 of the 9 soft white varieties yielded more in NT than CT. 'Hubbard' was significantly higher yielding (more than 10 bu/a different) in NT than CT. 'Lambert', 'Rod', and 'Stephens' were highest yielding in CT, while Lambert, 'Brundage 96', 'Mohler', and Stephens were highest in NT. In 2002 to 2004, Rod yielded very well in NT, but this year was below average in yield in NT. As a group, the soft white common varieties yielded more than the club varieties. Grain test weight averaged 62.2 lb/bu in CT and in NT, 62.4 lb/bu.; also without Moreland. Between CT and NT, test weights were very close for all varieties. In past years and with spring cereals, test weights are often higher in NT than CT. Seed weight, seed protein, seed hardness, number of spikes, crop biomass, and harvest index data are not available at the time of reporting due to the early reporting date. In past years with later reporting, the growth analysis samples had been completed.

Winter wheat establishment started after planting in the fall and there was some growth before winter. An open winter and warm temperatures during January and February gave plants an early start in the spring. Cooler temperatures during the beginning of spring and through anthesis gave high amounts of vegetative growth and yield potential than was obtained. The stand counts, taken in the spring, show an average of 22 plants/ft^2 in CT versus 27 plants /ft^2 in NT (Table 2) with all varieties except 'Rohde' having more plants in NT than CT. Mature plant height was tall, 40 inches in NT and 41 inches in CT. These tall plants reflect the favorable vegetative growth conditions.

Average yields across the four years of winter wheat variety testing are shown in Table 3 for varieties that were common across those four years. In 2002 vole damage to NT plots limited yields and made the yields higher in CT. However, in the other years, NT averaged three bu/a higher yields than CT. When averaged across 2002-2005, all varieties were equal or higher in NT than CT except for 'Hiller'. Brundage 96 and Hubbard averaged 8 bu/a more yield in NT than CT and were the only two varieties that yielded more in NT than CT all years 2002-2005; but there were no varieties that always yielded less in NT than CT. However, Lambert and 'Rohde' averaged the same in NT and CT and were the highest yielding varieties averaged across the trial. Finding consistent variety differences is difficult, and three site/years of information to compare variety performance between NT and CT conditions only provides a glimpse into the possible responses. Based on these results, there are many varieties that should be adapted to NT, and we are growing them now. However, it is interesting to note that 'Madsen' did not do better overall, but was below average in both NT and CT. Disease resistance is a notable attribute to Madsen, and if that were a problem in our NT site, it should have done very much better in NT, and this speculation carries through that there may not have been much disease and disease loss differences between the tillage treatments.

Table 1. Winter Wheat Variety Performance Under Replicated Conventional-Tillage and No-Till Management near Genesee, ID, 2005.

Variety	Seed Yield		Test Weight		Seed Protein[1]		Seed Hardness[1]		Seed Weight[1]	
	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till
White Wheat	---bu/acre---		-----lb/bu-----		----- % -----		----0-100----		----g/200----	
Brundage 96	116	125	61.7	62.4						
Cashup	109	113	61.5	62.1						
Finch	112	119	62.6	61.9						
Hubbard	102	112	61.5	61.4						
Lambert	124	128	62.3	62.2						
Madsen	110	113	61.5	61.1						
Mohler	113	122	62.0	62.4						
Rod	124	114	61.9	61.6						
Stephen	123	120	62.5	62.3						
Red Wheat										
Boundary	88	88	61.9	61.8						
Moreland	32	24	55.4	53.8						
Club Wheat										
Coda	116	112	63.8	63.7						
Hiller	112	109	59.9	59.1						
Rohde	113	117	63.8	63.6						
Temple	114	112	62.9	62.7						
Average[2]	107	109	61.7	61.5						
LSD (0.05)	10	10	0.9	0.9						
CV	8	8	1.3	1.3						

[1] Values for 2005 are not analyzed at the time of reporting.
[2] Average values do not include Moreland.

Table 2. Winter Wheat Variety Performance Under Replicated Conventional-Tillage and No-Till Management near Genesee, ID, 2005.

Variety	Stand Count		Plant Height		Spikes[1]		Biomass[1]		Harvest Index[1]	
	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till
White Wheat	--no./sq. ft.-		---inches---		no./sq. ft.		1000 lb/acre		----0.0-1.0----	
Brundage 96	23	34	39	40						
Cashup	22	26	37	39						
Finch	23	24	40	42						

Hubbard	24	28	45	49
Lambert	24	26	42	45
Madsen	20	26	39	41

Table 2, continued

Mohler	22	30	39	41
Rod	21	25	38	39
Stephens	25	29	38	39
Red Wheat				
Boundary	22	26	40	40
Moreland	22	25	36	37
Club Wheat				
Coda	20	27	43	44
Hiller	21	25	38	40
Rohde	24	23	41	43
Temple	22	27	42	43
Average	22	27	40	41
LSD (0.05)	5	5	2	2
CV	17	17	3	3

[1] Values for 2005 are not analyzed at the time of reporting.

Table 3. Four Year Yield Averages for Winter Wheat Varieties tested Under Replicated Conventional-Tillage and No-Till Management near Genesee, ID, 2002-2005.

	2002*		2003		2004		2005		2003-05 Avg.	
Variety	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till
White Wheat	bu/acre									
Brundage 96	99	74	72	75	95	104	116	125	94	101
Cashup	87	59	67	74	112	106	109	113	96	98
Finch	97	79	76	78	110	109	112	119	99	102
Hubbard	109	68	74	82	102	109	102	112	93	101
Lambert	91	80	84	65	100	115	124	128	103	103
Madsen	98	73	79	75	92	105	110	113	94	98
Rod	100	88	83	86	100	109	124	114	102	103
Stephens	94	69	82	77	99	111	123	120	101	103
Red Wheat										
Boundary	84	60	78	75	109	104	88	88	92	89
Club Wheat										
Coda	97	69	74	71	99	109	116	112	96	97
Hiller	92	70	80	77	102	104	112	109	99	97
Rohde	94	73	90	80	110	114	113	117	104	104
Temple	94	72	77	82	101	110	114	112	97	101

Average	95	72	78	77	102	108	112	115	97	100
LSD (0.05)	15	15	11	11	11	11	10	10		

*2002 yields were lower in no-till due to vole damage over winter and were not included in the study average.

Dry pea. The tillage comparison trial yielded 1320 lb/acre in CT and 1470 lb/acre in NT averaged across pea varieties (Table 4). Although not statistically different, this 10% increase is the first year that NT has out yielded CT for dry pea. Nine of the twelve varieties had higher yields in NT than CT. The weather conditions could have contributed to the higher yields in NT with greater available soil moisture under that management (see soil section below). 'Stratus' and 'Bluebird' were the highest yielding green pea varieties in CT and 'Monarch', Stratus, and 'Joel' were highest in NT. 'Rex' and 'Fallon' were the highest yielding yellow varieties in CT, but 'Shawnee', Rex, and Badminton' were highest in NT. There was no interaction of tillage and variety for any of the pea variables, but all variables had differences among varieties except plant stand that was higher in NT than CT. Seed weights averaged 17.7 g/100 seeds in CT and 18.3 g/100 seed in NT a significant difference, and about 20% lighter than last year, again probably due to moisture pattern. Karita, Stratus, and Rex had the highest seed weights. Plant stands were different between tillage treatments and averaged 7.9 plants/ft^2 in CT and 8.3 plants/ft^2 in NT. These plant stands are less than most previous years, but still adequate especially for a low yield potential, dry year. Vine lengths were typical and averaged 27 inches in both CT and NT, shorter than measured in the previous year. Canopy heights were similar to vine lengths and only different for the long vine types 'Columbian', 'Joel', and 'Shawnee'.

Average yields across the past three years of testing are presented in Table 5 for varieties that are common across those years. Average yields for the previous two years were lower in NT than CT and a three year average shows 1810 lb/acre in CT and 1760 lb/acre in NT. Across years, the highest yielding variety was Stratus in both CT and NT and Bluebird was second in both. The largest difference between NT and CT performance was for Columbian at 250 lb/acre lower in NT and by far the lowest yielding variety in that system. Karita was 110 lb/acre higher in NT than CT, the biggest difference favoring NT. Yellow varieties Badminton and Rex did well in both NT and CT. There is a relationship between variety performance in NT and CT, but CT performance does not always seem to predict NT performance.

Table 4. Pea Variety Performance Under Replicated Conventional-Tillage and No-Till Management near Genesee, ID, 2005.

	Seed Yield		Seed Weight		Plant Stand		Vine Length		Canopy Ht.	
Variety	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till
<u>Green Pea</u>	----lbs/acre----		-----g/100-----		Plants/sq.ft.		---inches---		---inches---	
Columbian	1330	1100	17.3	16.5	8.7	8.0	35	40*	20	20
Bluebird	1730	1580	17.9	18.7	8.5	8.0	23	23	23	23
Joel	1470	1690	17.9	18.8	6.2	8.8	43	40	20	21
Karita	1180	1460	20.3	21.2	7.9	8.5	24	26	24	26
Monarch	1430	1810*	15.5	15.9	7.6	8.5	19	24	19	23

Stirling	1140	1270	15.2	16.5*	8.6	9.4	20	22	20	22
Stratus	<u>1570</u>	<u>1760</u>	<u>18.6</u>	<u>19.9*</u>	<u>7.7</u>	<u>7.8</u>	<u>22</u>	<u>21</u>	<u>22</u>	<u>21</u>
Average	1410	1540	17.5	18.2	7.9	8.4	27	27	21	22
<u>Yellow Pea</u>										
Badminton	1240	1500	17.5	19.5*	8.2	7.8	22	21	22	21
Fallon	1330	1150	18.4	18.0	8.2	7.4	24	23	21	23
Rex	1430	1490	19.7	19.8	7.7	8.9	26	28	23	26*
Shawnee	1210	1510	17.0	17.5	7.8	8.3	42	42	19	18
				<u>Table 4, continued</u>						
Swing	<u>810</u>	<u>1310*</u>	<u>16.6</u>	<u>17.3</u>	<u>7.3</u>	<u>7.9</u>	<u>26</u>	<u>27</u>	<u>26</u>	<u>27</u>
Average	1200	1370	17.8	18.4	7.8	8.1	28	28	22	23
Average	1320	1470	17.7	18.3*	7.9	8.3*	27	28	21	22
LSD (0.05)	290	290	0.9	0.9	NS	NS	3	3	2	2
CV	21	21	5	5	21	21	12	12	9	9

*No-Till values followed by an asterisk are significantly different than Conventional till.

Table 5. Three Year Pea Yield Under Replicated Conventional-Tillage and No-Till Management near Genesee, ID, for 2002-2005.

	2003		2004		2005		2003-2005	
Variety	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till
<u>Green Pea</u>	------------------------------------ lb/acre ------------------------------------							
Bluebird	1420	1110*	3040	2940	1730	1580	2060	1880
Columbian	1110	950	2620	2240*	1330	1100	1690	1440
Joel	1440	1260*	2540	2450	1470	1690	1820	1800
Karita	1330	1180	2780	2980	1180	1460	1760	1870
Stirling	890	780	2730	2780	1140	1270	1590	1610
Stratus	<u>1720</u>	<u>1460*</u>	<u>3060</u>	<u>2810</u>	<u>1570</u>	<u>1760</u>	<u>2120</u>	<u>2010</u>
Average	1320	1120	2800	2700	1400	1490	1840	1770
<u>Yellow Pea</u>								
Badminton	1530	1250*	3080	2840	1240	1500	1950	1860
Fallon	1210	1200	2970	2510*	1330	1150	1840	1620
Rex	1300	1140	2890	3000	1430	1490	1870	1880
Shawnee	1360	1220	2530	2300	1210	1510	1700	1680
Swing	<u>1510</u>	<u>1270*</u>	<u>2600</u>	<u>2860</u>	<u>810</u>	<u>1310*</u>	<u>1640</u>	<u>1810</u>
Average	1380	1220	2810	2700	1200	1370	1800	1770
Average	1360	1180*	2780	2680	1320	1470	1820	1770
LSD (0.05)	160	160	320	320	290	290		

* No-Till values followed by an asterisk are significantly different the Conventional till.

Lentil. Lentil yields averaged across varieties were 1310 lb/acre in CT and 1330 lb/acre in NT, a non-significant difference and compares to nearly 2000 lb/acre yields last year (Table 6). ‘Merrit’ and ‘Pardina’ were highest yielding in CT, but ‘Brewer’ and Pardina were highest in

NT. Brewer was significantly higher in NT than CT in 2005, but was significantly lower in NT than CT in 2004. Seed weights averaged 4.6 g/100 in CT and 4.7 g/100 in NT and 'Pennell' and Merrit had the largest seed. Lentil plant stands were similar between tillage treatments and adequate across the trial for yield. Plant heights averaged the same between tillage treatments with little variability. Lentil performance in drought and heat conditions, that greatly lowered pea yield, is far better than pea. Lentil yields were close to regional historical averages, while pea yields were well below.

Table 6. Lentil Variety Performance Under Replicated Conventional-Tillage and No-Till Management near Genesee, ID, 2005.

	Seed Yield		Seed Weight		Plant Stand		Plant Height	
Variety	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till
	----lbs/acre----		----g/100----		--Plants/sq.ft.--		---inches---	
Brewer	1370	1630*	5.5	5.6	9.3	11.9*	17	18
Eston	1090	1140	3.0	2.9	12.7	10.7	17	17
Merrit	1440	1330	5.6	5.8	11.2	9.9*	17	17
Pardina	1450	1460	3.5	3.6	12.5	12.4	16	17
Pennell	1210	1210	5.6	5.8	11.8	14.4*	17	17
Richlea	1310	1200	4.4	4.6	10.0	10.4	17	18
Average	1310	1330	4.6	4.7	11.3	11.6	17	17
LSD (0.05)	150	150	0.2	0.2	1.8	1.8	NS	NS
CV	11	11	3.8	3.8	16	16	4.0	4.0

* No-Till values followed by an asterisk are significantly different the Conventional till.

Spring Wheat. A preliminary study was started to transition from variety evaluation comparison of cereal grains between tillage treatments to evaluating nitrogen fertilizer responses for wheat between tillage treatments. Before spring seeding, a set of soil samples were collected for this trial to assess soil N levels. Each tillage treatment was soil sampled in each replication in the top 1 foot and second foot depth. Nitrate nitrogen was slightly higher in CT than NT and NH_4^+ nitrogen was slightly higher in NT than CT. The total available N in the two foot depths was 61 lb/acre in NT and 69 lb/acre in CT; not a statistical difference. Plots were seeded with starter N and P delivered through the drill offset and below the seed, but planting problems caused much of the plot area to be improperly seeded. Nitrogen timing and rate treatments were applied to available plot areas and results are pending analysis. Fall treatments will be applied to winter wheat seeded in October to start the current study investigations.

Soil Properties: Jodi Johnson-Maynard, Karl Umiker, Yaniria Sanchez-de Leon
Methods: Earthworm density was measured during the spring of 2004 and 2005. Two 50-cm-deep pits (average volume of 0.02 m^3) were hand-dug in three NT and three CT plots within each crop for a total of 18 pits per year. For each date, earthworms were sampled over a period of no longer than four days to minimize the possible impact of changing climatic conditions on earthworm density. A combination of sieving and hand-sorting was used to separate earthworms from the soil. Soil temperature and moisture were continuously monitored (30-minute intervals) over the two growing seasons by EchoTemp and Ech2o soil moisture probes (Decagon Devices,

Inc., Pullman, WA) in combination with an Em5 data logger. Two temperature probes and three soil moisture probes were placed in each plot. Earthworm and soil environmental data from 2005 are currently being analyzed and will be presented in next year's STEEP report.

Results and Discussion: Similar to results presented for phase I of this project (2001-2003), earthworm density was higher in NT plots as compared to CT (Figure 1). As part of another study, earthworm density was also measured in Palouse Prairie and adjacent conservation reserve program (CRP) sites in 2003 and 2004. Data indicate that earthworm population densities in NT plots were similar to those measured in nearby undisturbed ecosystems (Figure 1).

The hillslope monitored in this study presents an opportunity to determine how NT practices impact soil environmental conditions on different slope positions. Figure 2 shows soil moisture (average for the 0 to 20 cm depth) on four different landscape positions under winter wheat in 2004. Position 1 is the lowest lying landscape position while position 4 corresponds to the highest position on the hillslope. Under similar management toeslope positions are generally wetter than upper landscape positions on Palouse hillslopes (Pierson and Mulla, 1990). In general we would expect soil moisture to decrease from position 1 to position 4. Position 3 (upper position in CT), however, was consistently drier than the upper most landscape position 4 which is a NT plot (Figure 2). Likewise, although position 2 (NT) is above position 1 (T), it is wetter in the spring and dries at a slower rate compared to position 1. The data demonstrate that although the entire range of soil moisture data is fairly narrow, tillage does appear to influence the retention of moisture across the hillslope. The relatively low soil moisture levels in the spring of 2004 are likely due to a combination of environmental conditions and soil moisture depletion by the actively growing winter wheat crop. The influence of tillage on soil temperature is not clear and appears to be mediated by slope position (Figure 3). While the NT plots tend to be cooler in early spring, temperature varies by no more than 1˚C across all treatments. Near harvest, the driest position (3, CT) was the warmest and reached temperatures known to limit earthworm activity (Lee, 1985). The lowest soil temperatures tended to be in the lowest landscape position which was conventionally tilled. Soil moisture and temperature for all crops will be further analyzed and related to earthworm population density and reproduction in following reports.

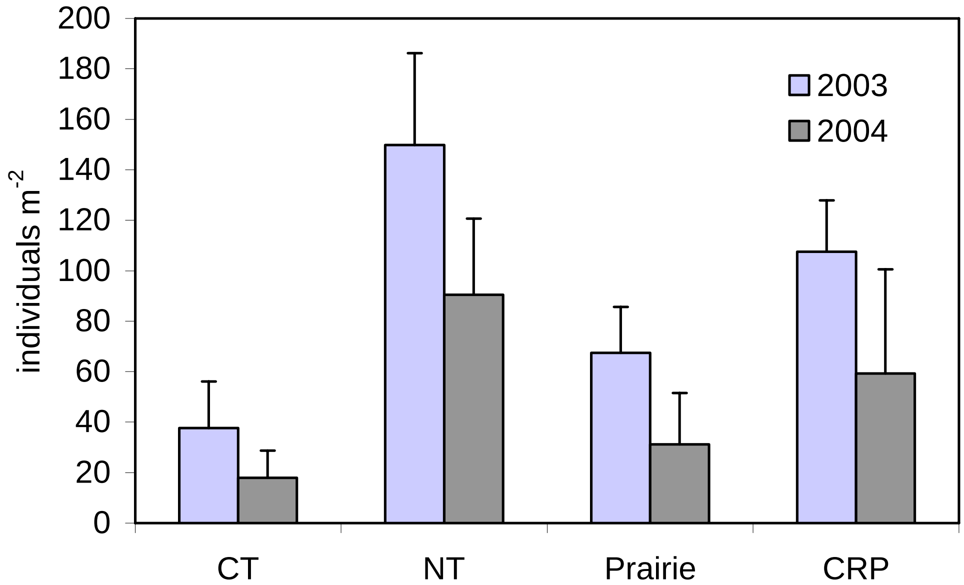

Figure 1. Earthworm density (earthworms m^{-2}) in plots sampled in 2003 and 2004. Conventionally tilled (CT) and no-till (NT) plots were sampled at the UI Kambitsch research farm. Three replicate Palouse prairie and adjacent conservation reserve program (CRP) sites were sampled in 2003 and four replicates were sampled in 2004.

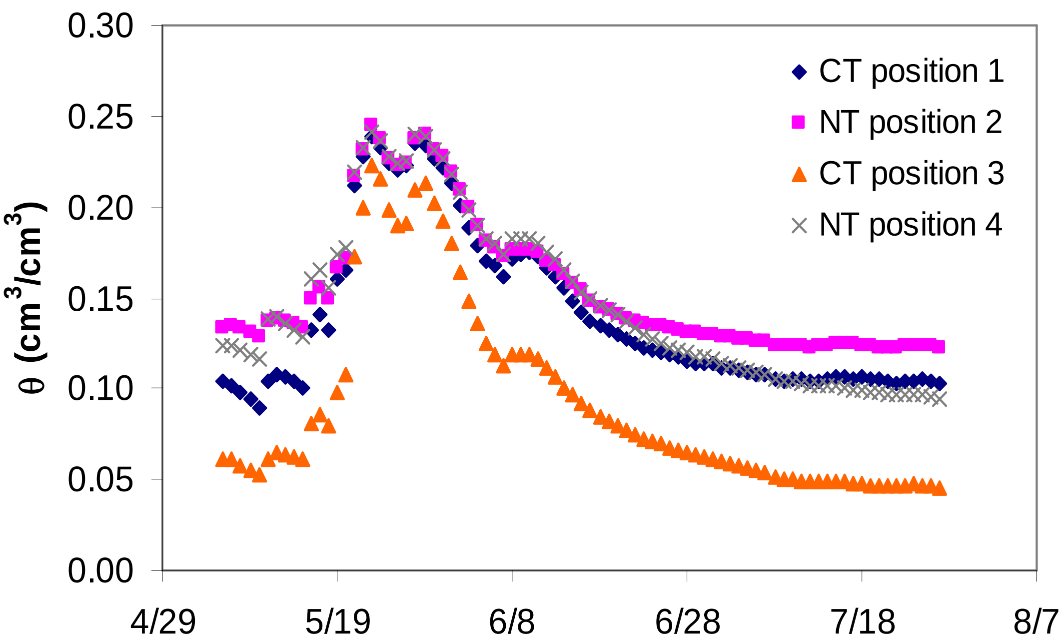

Figure 2. Average daily soil moisture in the 0 to 20 cm depth in conventionally tilled (CT) and no-till (NT) plots at the Kambitsch research farm during the 2004 growing season. Position 1 refers to the lowest landscape position sampled (footslope) while position 4 is on the midslope position. All measurements were taken under winter wheat.

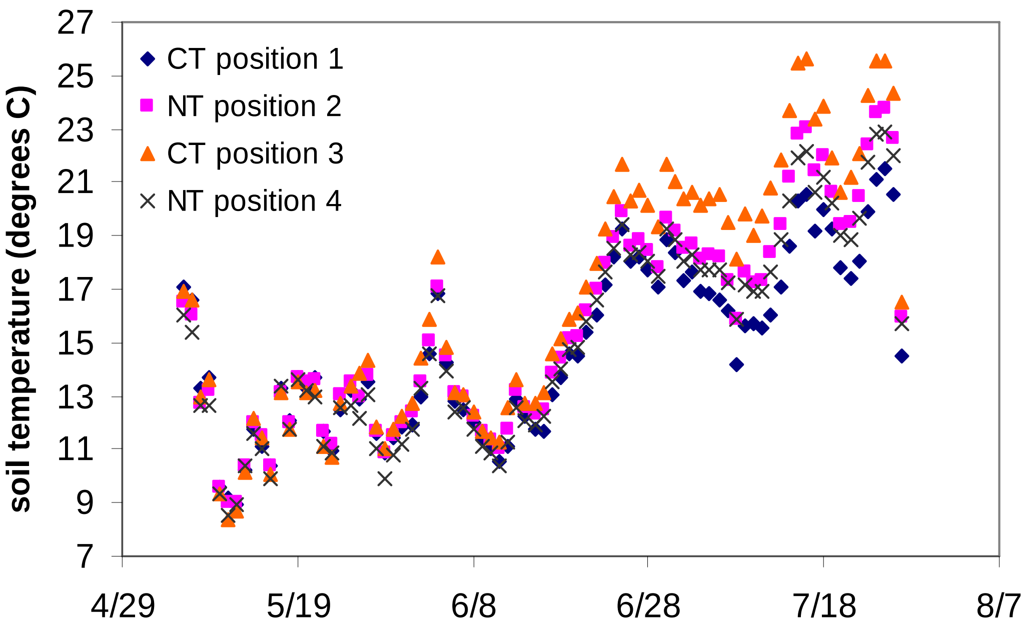

Figure 3. Average daily soil temperature at the 5-cm-depth in conventionally tilled (CT) and no-till (NT) plots at the Kambitsch research farm under winter wheat. Position 1 refers to the lowest landscape position sampled (footslope) while position 4 is on the midslope position.

Conclusions:

-Earthworm density is higher under NT than under CT and NT appears to support similar numbers of earthworms compared to relatively undisturbed Palouse prairie.

-Tillage management alters soil moisture content from what is generally expected across Palouse hillslopes that are uniformly managed.

-Soil temperatures appear to be less impacted by tillage over the short part of the growing season monitored.

Entomology. Nilsa Bosque-Pérez, Sanford Eigenbrode, Ryan Hanavan, Tim Hatten, Ruth Dahlquist, Dennis Schotzko

The combined objectives of the entomology research for the projects "Assessing the Impact of Direct Seeding (No-Till) and Conventional-Till on Crop, Variety, Soil, and Insect Responses in Years 4-6" and "Assessing the Impact of Direct Seeding (No-Till) and Conventional-Till on Nitrogen Fertility, Soil, and Insect Responses" were to:

1. Monitor pea leaf weevil activity, abundance, and damage in CT and NT pea.
2. Conduct controlled experiments in the laboratory and field trials to assess predation by specific ground-dwelling predators on pea leaf weevil.
3. Compare immigration of pea leaf weevil into NT and CT pea and test the effects of specific factors on immigration of pea leaf weevil into NT and CT pea.

Methods: The observed reduction in pea leaf weevil (PLW) abundance in NT fields could be due to preferential colonization of CT fields after seedlings emerge, reduced activity due to residue in

NT fields, or increased mortality from predation in NT fields. To evaluate colonization, linear foot soil samples for absolute abundance of weevils (Schotzko and Quisenberry 1999) and damage on seedlings were taken in plots of both tillage types at the University of Idaho Kambitsch Farm, north of Genesee, Idaho , as soon as damage was observed in the spring (prior to 2005). Samples were taken from four replications each of CT and NT (15x19 m plots), with ten samples per replication. To evaluate activity, two mark-recapture experiments were conducted. Marked weevils were released into 0.17 m^3 cages and collected in pitfall traps in both tillage types, with three replications of NT and CT (Southwood and Henderson 2000). The first experiment used dry pitfall traps with a petroleum jelly barrier to keep the weevils in, and the second experiment used pitfall traps with antifreeze.

Initial immigration and colonization of the PLW were studied at the Kambitsch experimental farm, in the spring and summer of 2005. Bi-directional aerial flight interception traps (Chapman and Kinghorn 1958) and pitfall traps (Greenslade 1964) were used to test the immigration and emigration of adult PLW in NT and CT plots (two treatments, four replications per treatment, for a total of eight plots). Tillage trials have been in place since 2000 and the NT fields have had several years to accumulate a suitable residue layer. The bulk pea section planted with the dry pea variety Monarch, was used for this study. Flight and pitfall traps were in place before PLW peak flight time (Mid-May).

Bi-directional flight interception traps were placed around all sides of each plot. Two flight traps were placed on each side and spaced apart one quarter of the distance from the center of each side, to create equal distance between every trap. The tillage treatments were arranged adjacent to one another with a buffer separating each plot. Only two flight traps were placed in this buffer for a total of 50 traps for the entire experiment. The traps' frame was constructed out of wood (2.4m tall x 0.6m wide) with a fiberglass screen (18 x 16 mesh) fastened to the upper 0.9m of the frame (0.9m tall x 0.6m wide). The trap was inserted 0.6m into the soil. This created an optimal capture height (61cm – 183cm above the ground) for PLW as determined by previous research (Fisher 1977). Two, 0.6m x 15cm fiberglass gutters with sealed caps were anchored directly below the screen. The separation of materials into either gutter allowed us to determine directionality of flight. The fiberglass gutters were filled with 600ml of propylene glycol (antifreeze) and 400ml of soapy water. Traps were collected once per week from the first week of May until early July.

Bi-directional pitfall traps were placed 0.5m off of the left post of each flight trap (N=50). Direction was distinguished by a piece of metal flashing (Southwood and Henderson 2000). Two pieces of metal flashing were bent at 45° angles and positioned so that one faced directly out and the other faced directly into the plot. The flashing was 0.6m long x 15cm tall and anchored 2.5cm into the ground and secured with wooden sticks. Regular (non-directional) pitfall traps were established in each plot in addition to the bi-directional perimeter traps in order to identify insect activity within the plots (2 pitfall traps per plot, N=16). The pitfall trap consisted of one 11oz cup anchored into the soil (flush with the surface) and one 10oz cup holding 5oz of propylene glycol. All traps were emptied weekly.

Absolute larval and adult PLW population estimates were taken using a previously developed linear foot plant and soil sample protocol (Schotzko and Quisenberry 1999). Samples were taken over the course of the growing season (10 samples per plot, N=80) in order to compare actual PLW population estimates to the bi-directional trap catches. Adult samples were collected in a linear foot of soil, taken randomly from the plot at ground surface and shaken through a series of sieves (large pore space to a finer pore space). The soil that did not fall through the finest sieve was bagged and taken back to the lab for further processing. Soil samples were then poured into a tub of water. This allowed the PLW to float to the surface and be collected. Larval samples were taken with a coring device that drilled directly into the soil. These samples were also taken back to the lab and "floated". This method of sampling allowed us to detect any differences in epigeal (surface-dwelling) PLW (adults) and those found in the rhizosphere (environment on and around the root of the plant) (larval and pupal PLW). Random collections of reproductive female PLW were taken throughout the plots and dissected to assess egg development following the adult population sample.

Stand development (emergence dates and plant density) and plant data (height and PLW notching) were evaluated for the first six weeks following planting. Emergence date was recorded once the cotyledon became visible above the surface of the soil. Stand density was assessed by measuring the number of stems per linear foot (20 samples per plot, N=160). Plant height and notching (the characteristic feeding scar caused by PLW and other *Sitona* spp.), were measured on all the plants sampled with the linear foot technique. Notching was assessed for the first three nodes of each leaflet using a 1-5 rating scale, where 1= least and 5 = the most severe level of notching.

A potential mechanism used by immigrating PLW to locate pea fields is "albedo" or the reflectivity of a surface. Albedo levels are raised in NT fields when cereal residue is left uncultivated. The potential influence of increased cereal residue in NT fields (increased albedo) on colonization by the PLW was evaluated at the Plant Science Farm near Moscow, Idaho. Three planting treatments (planting first week of May, last week of May 2005, and no planting or control plot) were tested with two different residue treatments (with cereal residue and without) as a three by two factorial experiment. The plots were 6.1m^2 and were replicated four times. Cereal residue was acquired in rolled mat form from SI in Genesee, Idaho, and placed over the plots receiving the residue treatment. To monitor PLW densities, 24 pitfall traps as described above (1 per plot) were established into the center of each plot and emptied weekly. Plant data (emergence, height, and notching) was collected weekly as described above. The experiment was run from May until early July.

We also assessed potential differences in adult PLW emergence from CT or NT pea fields. Differences could be directly due to increased predation in one system or indirectly a result of abiotic factors. The same bulk pea sections used in the immigration study at the Kambitsch experimental farm was used for this experiment. Emergence traps were used to collect adults as they emerged from the soil and began migration to overwintering sites. Three emergence traps were placed in each plot (N=24) and collected every other day from July 14th – September 5th, 2005. This period allowed pre and post-harvest collections to be made. The emergence traps were constructed out of steel cylinders (30.5cm x 30.5cm) and aluminum screen (16 x 18 mesh). The aluminum screen was cut into half circles with a 60cm radius. Once the half circle was rolled into a cone it was fastened on top of the steel cylinders giving a trap height of 0.9m. An 8oz collection jar was fastened to the top of the cone with hot glue. The screw top was glued to the cone, allowing the jar to be removed and emerging insects collected. Trap efficiency for PLW collection was tested in a series of lab trials where a fixed number of insects were released in 10 cages and allowed to sit for 24 hours. No escapes were detected, and increased sunlight caused greater upward migration of PLW. Thus it was determined that the best collection time was between 12-3pm (the hotter period of the day).

Results: Samplings conducted before 2005 revealed weevils were significantly more abundant in CT plots compared to NT, with a mean of 0.42 weevils per sample in CT vs. 0.18 weevils per sample in NT ($P = 0.03$). Weevil damage was significantly greater in CT plots, with a mean of 1.38 notches per node vs. 0.53 notches per node in NT. Two mark recapture experiments were conducted to evaluate weevil activity patterns. Weevil activity was not significantly different between tillage treatments. In the first mark-recapture experiment, 0.36 weevils per day were collected on average in CT vs. 0.27 in NT. This indicates that 3.2 % of the weevils were collected per day in CT vs. 2.2 % in NT ($P = 0.89$). In the second mark-recapture test, over the course of the experiment, a mean of 10.3 weevils was captured in CT, compared to 12 in NT. That is, the percent of weevils captured per day was 7.0 % in CT, compared to 7.8 % in NT, a non-significant difference. These results show that our pitfall trap sampling method is not biased by differential weevil activity and that abundance of pea leaf weevil is greater in CT than in NT pea fields in early stages of pea growth.

The beginning of the PLW migration was consistent with past estimates (late April-early May) and preliminary data from 2005 suggests a higher initial colonization in CT fields, and higher subsequent plant and stand damage. Some trap collections remain to be processed. A choice test will be conducted next year comparing pea grown in CT and NT to determine if there are any relationships between plant food quality and initial colonization of pea fields by the PLW. Absolute larval and adult density measurements were consistent with previous data (Fisher 1977, Schotzko and Quisenberry 1999). More complete results will be available next year. Results from the dissection of reproductive females suggest egg development happens slightly faster in CT fields. There was a significant difference in notching with greater damage detected in the earlier nodes of CT pea compared to NT pea. These data will be further tested against trap results for a more detailed analysis and explanation.

Cultivated soil has a lower albedo value than a field with cereal residue left as a cover. Significantly more PLW were captured on the first compared to the later planting date. Samples are being processed and more complete results will be available next year.

Emergence traps were placed out several weeks before harvest and then immediately following harvest. Initial analysis does not show any significant differences in emergence between CT and NT treatments but this could be partially due to one NT trap yielding a large number of adult PLW. The data will be further examined with a non-parametric approach. A large parasitic wasp in the family Ichneumonidae was collected immediately after the crash in adult PLW emergence. Identification of this wasp might be considered if any association to the PLW and/or potential predators of the PLW can be detected. Soil cores were taken and are currently being processed for insect cadavers with parasite emergence holes or any other evidence that might assist in identification of the wasp.

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