Crop variety response in direct-seed (no-till) and conventional tillage

Stephen Guy and Ying Wu

Department of Plant, Soil and Entomological Sciences, P.O. Box 442339, University of Idaho, Moscow, Idaho, USA.
www.ag.uidaho.edu/cereals/ Email sguy@uidaho.edu, ywu@uidaho.edu

Abstract

Conservation tillage is needed in the Palouse region located in Idaho, Washington, and Oregon of the Pacific Northwest, USA. Crops of winter wheat need residue on the soil surface from previous crops to deter erosion. Previous studies evaluated wheat response to previous crops, crop residue levels over time, but have not addressed differences for variety response between tillage systems. A replicated tillage comparison trial was started in 2000 and is ongoing near Genesee, Idaho, USA with varieties of winter wheat, spring wheat, spring barley, and pea within tillage treatments. Other soil and biological differences between the tillage are also studied. Yields of cereals are generally similar between the tillage treatments, but when problems occur with weed control, rodent feeding, stand establishment, and other factors, the no-till (NT) treatment usually suffers more impact. Generally cereal test weight, seed size, and kernel plumpness are higher in NT, but crop biomass, yield, protein, and plant height are lower in NT. Most varieties and environments did not show an interaction with tillage, but in some cases certain varieties did perform better. The winter wheat variety ‘Rod’ was the highest yielding in NT both years, but not in conventional till. It appears that some varieties are not suited to NT and give consistently poor results. It may be easier to identify varieties that are not adapted to NT than to find varieties that are superior in NT.

Media summary

Selection of winter wheat, spring barley, spring wheat, and dry pea varieties in direct seed (no-till) systems can be an important management tool.

Key words

No-till, conventional-till, variety, wheat, pea, barley

Introduction

Conservation tillage acreage has increased in the past decade across the pea and lentil crop region of the Palouse region located in Idaho, Washington, and Oregon of the Pacific Northwest, USA (Schillinger et al. 2004). Palouse hills and loess soils create high erosion potential for the region and surface residue left by conservation tillage practices reduces soil erosion. Winter wheat (*Triticum aestivum* L.), spring small grains, and grain legumes are important crops grown in rotation in this area. Winter wheat, the most economically important crop in the region, averaged nearly 40% higher production following pea or lentil compared to wheat after wheat in six conventional tilled and direct seeded comparisons. When crops of mustard (*Sinapis alba* L.), pea (*Pium sativum* L.), and lentil (*Lens culinaris* Medik.) preceded winter wheat, wheat yield was highest following pea and lentil one year, but not in another year, and N fertilizer response was greatest following mustard (Guy and Gareau, 1998)

One problem with grain legumes is the limited amount of crop residue groundcover after harvest. Residue groundcover was increased after pea when previous crop residue was maintained through the pea crop by direct seeding. After pea seeding, previous cereal crop residue groundcover levels averaged 58% in direct seeding compared to 7% after fall plowing in on-farm comparisons (Guy and Cox 2002). Groundcover averaged 85% after direct seeding and 42% when fall chisel plowing preceded pea planting in seven on-farm comparisons. Pea yields were not different for direct seeding in most of these comparisons, but twice were higher when direct seeding was compared to fall plowing. Across comparisons, pea yield averaged 8% more in direct seeding compared to fall primary tillage.

Very little information is available about variety performance differences between conventional tillage and direct seeding conditions. Many dynamic processes are different between these tillage systems such as: available water, different insects and diseases, earthworms, and soil carbon. Studies were undertaken in 2000 to assess many of the biological processes, crop rotation, residue management, and variety choice that are critical elements for successful direct seeding production systems and represent new management technologies needed by growers.

Methods

The study is a replicated tillage comparison, four replicates of conventional tillage (CT) and direct seeding or no-till (NT). Each tillage main plot is about 20 m wide and 90 m long. The CT was chisel tilled in the fall to 0.25 m depth, followed by field cultivation and harrow (usually twice) for seedbed preparation just prior to planting. NT was not disturbed except for seeding. The trial was established in crop year 2000 on a hill-slope at the University of Idaho experimental farm near Genesee, Idaho, USA. All seeding was with a Great Plains-Turbo Colter NT drill with 0.23 m row spacing. Fertilizer was banded at seeding or broadcast at sowing for winter wheat. The study area was divided into three sections and planted to either: winter wheat, spring wheat and barley, or pea. Each year the sections are rotated to follow the wheat-spring grain-grain legume rotation. Within each crop section, varieties were planted on half of the area and the other half was planted uniformly to one variety. For the experimental design, varieties become sub-plots on the main plot tillage treatments. A variety sub-plot is about 2 by 6 m. This allows analysis of the interaction of tillage and varieties without confounding design factors. Each year, to remove small plot carryover effects, the varieties were planted on the half that was previously uniformly planted. There were 15 winter wheat, 9-15 spring wheat, 6-15 spring barley, and 15 pea varieties evaluated annually. The uniformly planted half in each crop was used for the sampling portion of the project for investigation of insect dynamics and soil properties.

Agronomic and quality data for each variety was determined. Plant stand counts determined establishment success. For each of the cereal varieties prior to harvest, plants were removed from two one metre sections of row within each plot to determine yield components, harvest index, and crop biomass. The number of tillers or stems, heads or pods, and seeds per head were determined. Plant height was measured and used as an indicator for growth along with total biomass. Lodging was visually assessed on a severity and area basis per plot. At maturity, each variety plot was combine harvested and seed yield determined. A sub-sample of seed from each plot was evaluated for quality factors: test weight, kernel hardness, protein content, and plumpness for barley. Results were analyzed using ANOVA and protected mean separation tests.

Results

Variety responses, Winter wheat. When grain yield was combined over varieties, CT produced 5,370 kg/ha and NT was slightly lower at 5,170 kg/ha in 2003 (Table 1). There were larger differences in 2002 because of rodent feeding in NT over winter. There was no interaction of tillage and variety and 9 of 15 varieties yielded less in NT than CT. ‘Rohde’, ‘Mohler’, and ‘Lambert’ were highest yielding in CT, while Rod, ‘Hubbard’, and ‘Temple’ were highest in NT. In 2002, Rod was also the highest yielding in NT, however, Lambert was second highest in NT in 2002, but was lowest yielding in 2003 indicating an interaction of variety response across tillage and environments. Grain test weight averaged 760 kg/m^3 in CT and was slightly higher in NT at 765 kg/m^3, with no differences between tillage or interaction of tillage and variety. Seed weight was also not different between CT, 32 g/1000 seed, and NT, 33 g/1000 seed.

Winter wheat establishment in the fall of 2002 was quicker and the early plant development was ahead in NT compared to CT. This is attributable to retention of moisture in NT during seeding that was lost from CT because of tillage and seeding. This was also reflected in the stand counts taken in the spring that showed 172 plants/m^2 in CT versus significantly more, 237 plants/m^2 in NT. As found for the cereals in previous trials, there were shorter plants, 76 cm, in NT than in CT, 79 cm. Growth analysis showed a significant difference for number of heads between NT, at 474 heads/m^2, and CT, at 410 heads/m^2. There was not an interaction of variety and tillage for number of heads. Crop biomass was only 370 kg/ha different between NT and CT and averaged about 13,100 kg/ha. Biomass samples tend to be variable due to their size, but there were significant differences among varieties. Harvest index was calculated based on sample grain weight divided by sample biomass weight. Harvest index was 0.43 for CT and 0.42 for NT, and that means about 42% of the biomass weight was grain. Differences among varieties show 'Finch' and 'Hubbard' low at about 0.38 and while 'Hiller' was 0.53 and 'Temple' was 0.54. More winter wheat performance results are needed to find consistent tillage responses.

Dry pea. The tillage comparison trial yielded 1,470 kg/ha in CT and 1,280 kg/ha in NT averaged across pea varieties in 2003. Although not statistically different, this was a 13% difference compared to 11% the previous year. 'Stratus' was the highest yielding green pea variety, 1,930 kg/ha, in CT and 1,640 kg/ha, in NT. 'Badminton' and 'Swing' were the highest yielding yellow varieties in both NT and CT and averaged about 1,570 kg/ha. There was no interaction of tillage and variety for any of the pea variables, but all variables had differences among varieties. Seed weights averaged 195 g/1000 seed in CT and 193 g/1000 seed in NT. The marrowfat variety 'Supra' had highest seed weights followed by Karita, 'Rex', and Stratus. Plant stands were not different between tillage treatments and were 87 plants/m^2 in CT and 92 plants/m^2 in NT, but did vary among varieties. Vine lengths were much shorter than in previous years due to the hot, dry growing conditions and averaged only 46 cm. Canopy heights were similar to vine lengths and only different for the long vine types 'Columbian', 'Joel', and 'Shawnee'.

Spring wheat. Spring wheat grain yield in 2003 was 2,820 kg/ha in CT, not different from NT at 2,690 kg/ha. There were variety differences with tillage treatments and 'Westbred 936' gave the highest yield in CT and 'Jefferson' was highest in NT, again, as in 2002. As in previous years, grain test weight was higher in NT, 752 kg/m^3, than in CT, 741 kg/m^3. All varieties had higher or equal test weights in NT than in CT with no interaction of variety and tillage. Seed weights were also higher in NT, 27.5 g/1000 seed, than in CT, 26.5 g/1000 seed, but not significantly different. The dry, short growing season limited grain filling. Plant height was equivalent in NT and CT. All stands were good. Head density was not different between tillage treatments, but was highest for 'Hank' and lowest for 'Westbred 926'. Biomass was slightly lower in NT, 7,820 kg/ha, than in CT, 8,530 kg/ha, as found in previous spring wheat comparisons. I believe this lower growth in NT is due to cooler, delayed conditions in the spring that carries through the growing season and often comes through with lower yield. Harvest index is lower in spring wheat than the winter wheat, because of the shorter growing season available to spring wheat, especially when planted in the middle of May as was dictated this year due to wet spring conditions. Among varieties, the lowest average harvest index was for 'Penawawa', at 0.36, and highest was Westbred 926, at 0.43.

Spring barley. Barley grain yield was 3,780 kg/ha in CT and 3,390 kg/ha in NT and 'Baronesse' was highest yielding in both NT and CT. No interactions of tillage and variety were found for any variables. Grain test weight, plumpness, and seed weight were slightly higher in NT than in CT, but lower than in previous years due to weather. Plant height, biomass, and heads were also lower in NT than in CT, but not significantly, while lodging and harvest index were slightly higher in NT than in CT. Harvest index averaged an impressive 0.48, a high value considering the growing conditions. This shows the resilience of barley under less than favorable spring growing conditions.

Table 1. Average performance of winter wheat, spring wheat, barley, and pea across varieties under replicated CT and NT management near Genesee, ID 2000-2003.

	Seed yield (kg/ha)		Test weight (kg/$m^{3)}$)		Plant height (cm)		Seed weight (g/1000)		Seed protein (%)	
Crop/Year	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT
Winter wheat										

2002	6,450	4,840	789	788	84	76	74	71	--	--
2003	5,380	5,170	759	764	79	79	64	66	10.4	9.8
Spring wheat										
2000	4,170	3,630	748	763	89	84	31	33	13.3	12.7
2001	4,900	4,900	789	797	84	79	37	39	13.6	13.0
2002	4,170	3,630	772	784	79	76	57	63	12.7	12.3
2003	2,820	2,690	741	752	66	66	53	55	13.0	12.6
Spring barley										
2000	5,430	4,410	660	667	91	89	68	74	11.4	11.1
2001	5,800	5,700	681	690	91	86	67	76	9.0	9.1
2002	3,120	3,010	651	659	64	61	70	73	--	--
2003	3,870	3,390	623	628	69	66	62	64	10.0	9.9
Spring pea										
2000	1,300	1,000	--	--	69	64	177	178	--	--
2001	3,070	2,750	--	--	71	69	249	236	--	--
2002	2,340	2,000	--	--	71	66	216	215	--	--
2003	1,550	1,280	--	--	51	43	195	193	--	--

Conclusion

Variety performance differences can be found when direct seeded (NT) and conventional seeded production systems are compared. Growers should be careful to select varieties that have general adaptability and consistent performance over years. Management practices may also have to be adjusted in NT to compensate for decreased soil temperatures in the spring, reduced spring growth, lower N uptake and protein. Growers can take a marketing advantage from NT conditions by selling crops with higher test weights, lower protein soft white wheats, and larger seed size. The environmental impacts were also monitored in this study and show NT benefits soil biological activity, beneficial insects, organic matter accumulation, and erosion control.

References

Guy SO and Wu Y (2003). No-till and conventional tillage comparisons of wheat, barley, and pea varieties. CD ROM. In 2002 Agronomy Abstracts, ASA, Madison, WI.

Guy SO and Cox DB (2002). Reduced tillage increases residue groundcover in subsequent dry pea and winter wheat crops in the Palouse region of Idaho. Soil and Tillage Res. 66:69-77.

Guy SO and Gareau RM (1998). Crop rotation, residue durability, and nitrogen fertilizer effects on winter wheat production. J. Production Agric. 11:457-461.

Schillinger WF Papendick RI, Guy SO, Rasmussen PE and van Kessel C (in press). Dryland cropping in the western United States. In G.A. Peterson, P.W. Unger, and W.A. Payne (ed.) Dryland Agriculture 2nd ed. Agron. Monogr. ASA, CSSA and SSSA, Madison, WI.