

TITLE: Interrow cultivation and intercropping for organic transition in dryland crop production systems

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Abstract

Organic farming in the dryland agriculture region of eastern Washington is rare, and little information exists for growers to make a successful transition from conventional to organic production. Fertility and weed control pose the biggest challenges during the three-year transition period, and costs associated with this period often serve as a barrier for growers to transition to organic production. To address these challenges, an organic transition study was designed that examines wheat and triticale intercropped with peas, which are mowed down mid-season to serve as a green manure. This system enables growers to begin the soil-quality-building process essential to organic production without sacrificing a full year of crop production in exchange for growing a green manure. In year 1, monocropped spring wheat and grain triticale yielded 4650 kg ha⁻¹ and 4500 kg ha⁻¹, respectively, under certified organic production. While grains intercropped with peas were planted to 50% of the area of monocropped grains, intercropping only reduced spring wheat and triticale grain yields by 40%. Grain nitrogen content was greater in intercropped versus monocropped grain, especially in spring wheat. Intercropping also provided weed control benefits in spring wheat, reducing weed biomass by 55%; however, no differences in weed biomass were observed between treatments in either triticale variety. The technique of intercropping grains and green manure has the potential to reduce weed pressure during the transition period to organic, as well as provide some revenue to growers during a usually unprofitable period.

Project Description

Due to the prohibited use of synthetic nitrogen sources, organic cropping systems must rely on other inputs to satisfy nutrient requirements of grain crops. In large-scale systems, nitrogen (N) is most commonly obtained from animal manure or leguminous cover crops (green manure). Eastern Washington is an area characterized by large-scale small grain cash cropping systems with few livestock producers, making manure as a cost-effective fertilizer difficult to find.

Green manure is an important source of nitrogen for organic growers, who use it as a cover crop or as part of a cropping rotation to diversify the system and supplement nitrogen stocks in the soil. Lack of moisture in eastern Washington restricts the use of cover crops, which means that producers interested in growing a green manure crop must sacrifice a year of crop production to do so. For growers transitioning to organic production this can prove a particular burden, as the transition period from conventional to organic is often associated with increased costs and decreased revenues. However,

intercropping a green manure crop with a small grain crop can provide growers with moderate income, while at the same time contributing to soil N stocks and soil improvement.

To study the benefits of intercropping, three-year study was designed to examine the effects of intercropping during the three-year organic transition period. Spring wheat and two varieties of triticale (forage and grain) were intercropped with spring peas in years 1 and 2, and compared with monocropped grains and green manure, in a total of seven treatments. In year 3, a trap crop of winter wheat will be planted to measure the effects of intercropping versus monocropping on yield, grain quality, weed competition, and soil N going into the certified organic production phase.

Methods

The study was seeded in the spring in 10-inch rows with a Monosem planter in a randomized complete split-block design at a site just outside of Pullman, WA. Treatments 1 and 3 consisted of monocropped spring wheat and a grain variety of triticale, respectively. Treatment 2 was a green manure control, where only spring peas were planted, and treatment 4 was a monocropped forage variety of triticale. The remaining three treatments consisted of intercropped spring wheat + spring peas, forage triticale + spring peas, and grain triticale + spring peas (treatments 5, 6, and 7, respectively). All peas planted in the study were Aragorn field peas, and were cut down at pod set using sweeps placed on the pea rows in treatments 5 and 7. The green manure control was mowed down with a brush hog mower. Pea biomass was left on the surface in all treatments.

One of the two subplots in each block was fertilized each year with quail manure at a rate of 1900 kg ha⁻¹, in order to compare soil nitrogen with animal manure as a supplemental fertilizer versus only green manure as an N source. A weeding operation was performed on half of the plots in early June using a field cultivator, with the shanks positioned between rows. The forage triticale treatments (mono- and inter-cropped) were swathed when triticale reached the head emergence stage, and baled for hay. The peas were baled along with the triticale. Spring wheat and spring triticale grain was harvested in early September.

Assessment of intercropping as a strategy for the organic transition period, as compared to monocropping, will be based upon grain and hay yields and weed suppression. A net nitrogen balance will be constructed to track nitrogen in each system, to determine which systems built up the most soil N during the transition period. In year 3, winter wheat yields following each treatment will be used to assess residual effects of intercropping versus monocropping during the organic transition period.

Outputs

Work Completed

Intercropped treatments had significantly lower mean yields than mono-cropped treatments in both the grain and hay treatments. While spring triticale often yields higher than spring wheat in the region, the intercropped and the monocropped wheat and triticale yields were similar. Similarly, hay yield for mono-cropped triticale was significantly higher than the intercropped triticale + pea forage. While the

grain crops in the intercropped treatments were planted to only 50% of the area of grains in the monocropped treatments, intercropped grain yields were 60% of monocropped yields. The mixed forage planting of triticale + peas yielded 18% less dry matter per hectare than forage triticale planted alone. The quail manure fertilizer had no significant effect on grain or hay yields (p -value = 0.7018) in the first year of the study; however, this is likely due to slow mineralization during the summer season where low moisture limits soil microbial activity. Fertility effects on yield are expected to be observable in 2014 after mineralization of nitrogen occurs during the winter, after which soil nitrogen levels can be compared between green manure-only treatments and those receiving both green and animal manures.



Figure 1. Inter-row cultivation and pea mow-down operation performed on June 25, 2014.

The weeding operation performed by the inter-row cultivator had no effect on end-of-season weed biomass, and had a negative impact on yield. This was likely due to the difficulty of keeping the shanks positioned between the 10-inch rows, and deviations from the area between rows resulted in crop takeout. Improvements in GPS or driving technologies are necessary for this type of mechanical weeding to be successful. Takeout of the peas by positioning cultivator shanks between grain rows proved more successful, and doubled as a weed control measure. This system of intercropping peas with grains also affords growers with more flexibility with regards to tillage for weed control, as the extra room between grain rows enables in-season cultivation.

Soil moisture change from planting to pea mow-down in 2013 was significantly different at an alpha level of 0.10 between treatments (p -value = 0.0932). The intercropped wheat and grain triticale had less soil moisture loss than the mono-cropped treatments. Small grains have a stronger competitive ability for moisture compared to pea (Willey, 1979; Hauggaard-Nielsen, 2001), so intraspecific competition for soil moisture in mono-cropped treatments was likely greater than the interspecific competition in intercropped treatments, resulting in more total moisture uptake in mono-cropped wheat and triticale.. Intercropping resulted in higher soil moisture at harvest, relative to monocropping. This could have benefits for winter crops planted in the fall, following the harvest of the spring crops.

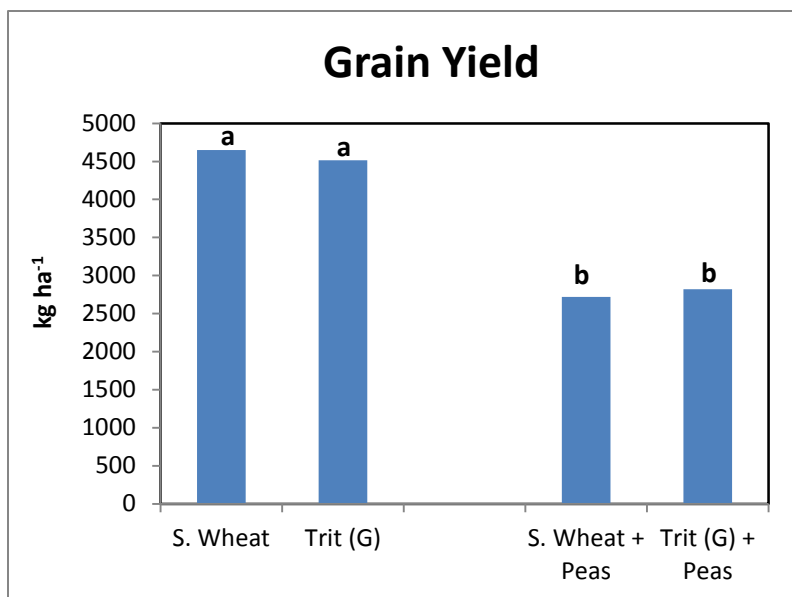


Figure 2. 2013 grain yield LSmeans. Means with the same letter are not significantly different at the $\alpha = 0.05$ level. G = grain triticales variety

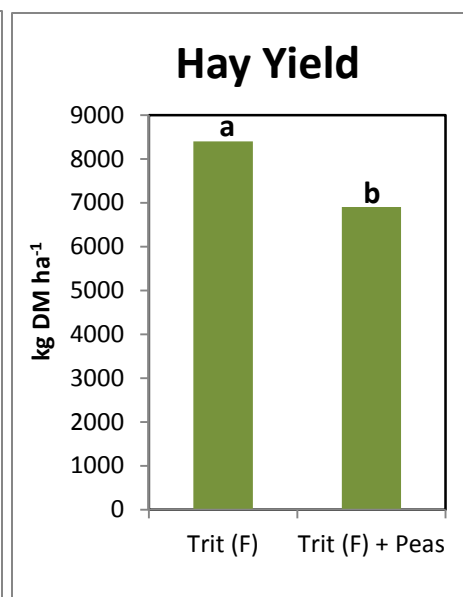


Figure 3. 2013 hay yield LSmeans. Means with the same letter are not significantly different at the $\alpha = 0.05$ level. F = forage triticales variety

Intercropping reduced weed biomass in spring wheat, relative to monocropping. In both the grain and forage varieties of triticales, intercropping had no effect on weed biomass relative to monocropping. However, all grain crops reduced weed biomass relative to the green manure check; intercropping green manure with grain crops could reduce weed pressure and seed set that would otherwise be an issue during a green manure crop year. Intercropping could reduce weed seed set and recruitment, a common issue experienced by growers with land in transition to organic production. Both treatments of forage triticales demonstrated strong competitive ability with weeds, indicating this crop as a potential weed suppressor in a rotation. The forage triticales especially suppressed Canada thistle growth, a common troublesome weed for organic growers.

Grain N content was 15% greater in intercropped spring wheat and triticales grain, compared to monocropped grain. It is possible that breakdown of the pea biomass in the intercropped treatments contributed to soil N stocks later in the season, which the grain crops could access during grain fill. Intercropping could be a technique used by organic growers having difficulty meeting grain protein standards. Additionally, while the effects of the quail manure were not evident in weed biomass or yield, addition of the quail manure resulted in greater grain N content, relative to non-fertilized grain. We expect to observe more effects of the quail manure as the study progresses. The construction of the net N balance will further illuminate the fertility status of each system, when field trials are completed.

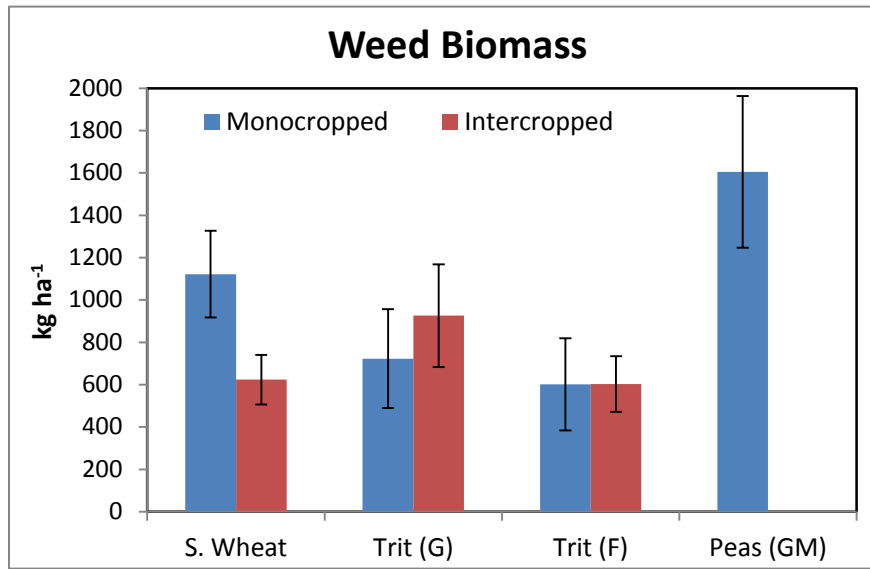


Figure 4. Weed biomass was measured by biomass clipping just prior to pea mow-down in early July, 2013.

Treatment	% N
Grain Triticale + Peas	2.29*
Spring Wheat + Peas	2.08*
Grain Triticale	2.03
Spring Wheat	1.81

Table 1. Grain N content measured by dry combustion analysis.
* significant at the $\alpha = 0.05$ level

Presentations and Outreach

Reports and photos have been posted on the recently-launched “Transitioning to Organic” page of the CAHNRS and WSU Extension “Wheat and Small Grains” webpage. We anticipate that this will be a valuable Extension tool with which to provide easy-to-access information to organic grains growers in Washington. The trial will be shown to organic researchers and growers as part of the Dryland Organic Farming Research Review and Farm Tour, to take place on July 9th, 2014. Demonstrations of inter-row cultivating operations will take place. Additionally, findings of the study through the 2014 season will be presented at the 2014 American Society of Agronomy meeting. Following the completion of the study in year 3, a manuscript will be published in a peer-reviewed journal.

Impacts

Short-term, modifications to equipment have impacted the possibility of intercropping being viable on a field scale. Though the inter-row weeding cultivation needs improvement, pea mow down using sweeps between the grain rows was very effective. Organic and conventional growers alike could benefit from the viability of this practice. A few organic small grains growers have already adopted inter-row weeding operations similar to this system and achieved good results. Intermediate and long-term impacts include advances in soil improvement and nitrogen delivery to organic systems. Outreach could result in increasing grower income through organic grains by providing information on an organic transition system that has a lower financial burden for the producer while providing the fertility for a productive system following the transition. Results of this study also indicate that the practices of intercropping and planting forage triticale can reduce weed pressure and contributions to the weed seed bank during a period when weed pressure is usually quite high.

Additional Funding

Funds to finish this study will be provided by Small Planet Foods.

Graduate Students Funded

Nicole Tautges

Recommendations for Future Research

The fertility effects of the green and quail manure occur over time as nitrogen is mineralized, and their respective effects on grain yield, quality, weed competition, and soil health can be measured in future years of the rotation. More agricultural engineering work should be done to improve technology enabling inter-row operations, specifically for weeding in narrow-row crops. Current GPS, RTK, and other precision agriculture technologies have the potential to be adopted for large-scale organic grain production. Further research and market development should be conducted to improve the viability of triticale as an organic and conventional grain crop in the Pacific Northwest, as its inherent competitive abilities could improve productivity and reduce the need for herbicide applications in conventional production systems. Organic growers have demonstrated an increased interest in incorporating intercropping techniques into rotations, and research using this technique is needed for other crops common to organic rotations.

Works Cited

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