Report Type: Progress

Title: Water, Land, and Nutrient Use Efficiency for Intercropping Systems in the Dryland Pacific Northwest

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Abstract:

In order to feed 9 billion people by the year 2050 current agricultural systems will need major increases in water, nutrient, and land use efficiencies. The monoculture production systems currently prevalent in developed countries will no longer be able to adequately support the population. Intensified agriculture will be required to replace and augment current production system. Intercropping has frequently been identified as a means of improving land use efficiency. To date most intercropping research has focused on grain-legume intercrops in organic systems. However, recent work in Canada and Australia has demonstrated massive potential for spring pea-canola intercrops. The current proposal seeks to intensify current dryland cropping systems through winter pea and winter canola intercrops. We will examine the potential of winter pea-canola intercrops to increase water use efficiency, nutrient use efficiency, and land equivalence ratio. In addition to calculating the resource use efficiencies we will estimate the economic benefits to growers and potential for increases in gross regional production.

Project Description:

Conventional agriculture lacks the requisite resource use efficiencies to sustainably produce adequate food, fiber, and feed to support a growing global population. Improved resource efficiency may be achieved through increased crop diversity and intensity. In many regions the integration of cover crops serves to increase crop diversity and intensity. However, due to regional rainfall patterns, cover cropping has met with limited success in the inland Pacific Northwest (iPNW). An alternative method for increased diversity and intensity is through intercropping. Intercropping of peas and canola (peaola) is of special interest in the iPNW. Research in both Australia and Canada have previously demonstrated the agronomic feasibility of legume-oilseed intercropping. Additionally, these practices have been adopted by a few large-scale conventional farming operations in Canada. In order to assess the feasibility of these practices in the iPNW a two-year plot study was planned at two locations in Washington. The two locations (Ralston, WA and Davenport, WA) were chosen to represent the low (<12”) and intermediate (12-18”) precipitation zones of dryland crop production in the region.

The plot studies were designed to compare canola and pea monocrops with full nitrogen (N) and phosphorous (P) inputs to peaola under full and reduced N and P inputs. The plot studies at Ralston, WA and Davenport, WA had six identical treatments. The treatments were canola 100% N and 100% P, peas 0% N and 100% P, and peaola at four different levels of N and P inputs. The

peaola intercrop treatments were three N fertilizer rates of 0%, 50%, 100% of the recommended canola N rate at 100% P, and one 0% P treatment at 100%. The treatments were designed to assess the response of N and P to peaola in the iPNW. Of the six treatments, only the two monocrop treatments and the peaola at 0% and 100% N will be utilized for constructing nitrogen balances and calculating N and P use efficiencies (Table 1). Each treatment was replicated four times in a randomized complete block design.

Table 1: Experimental Treatments for Plot Studies

Crop	*N rate*	*P rate*	*N and P Efficiencies Analyzed*
Pea	0%	100%	Yes
Canola	100%	100%	Yes
Peaola	0%	100%	Yes
Peaola	50%	100%	No
Peaola	100%	100%	Yes
Peaola	100%	0%	No

Project Objectives:

- Establish yield potential for winter peaola in the dryland cropping systems of the iPNW.
- Compare winter peaola resource (land, N, P, and water) use efficiencies with monocrop winter pea and winter canola resource use efficiencies.
- Develop N and P recommendations for winter peaola in the iPNW.
- Initiate extension activities focused on receiving input and communicating pertinent research data to 'early adopters' of sustainable agricultural systems across the iPNW.

Outputs

Overview of Work Completed and in Progress:

2019-2020 Field season:

Plot studies were established in Ralston, WA and Davenport, WA. Soil samples were taken to establish baseline moisture, N, and P at both locations. The plot trials were planted in early August at Ralston and early September at Davenport. At both locations as Fabro double disk drill was used to establish the plots. The peas were sown to a depth of 6" at Ralston and 4" at Davenport. At both locations canola was sown to a depth of 1". At Davenport both the peas and the canola successfully emerged. At Ralston only the peas emerged. The peas were overseeded with spring canola in the spring of 2020. However, the spring canola also failed to establish successfully. Yield data was collected at the Davenport location and the land equivalence ratio (LER) was analyzed (Table 2). The LER of canola was found to be significantly higher in the peaola than in the monoculture plots. While fertility was found to have a slight negative effect on canola

yield there was no effect on pea yield or LER from the addition of N to the system. In addition to analyzing the LER we assessed the relative yield of peas and canola from data collected at the Davenport location and data collected from an auxiliary study near Colfax, WA (figure 1).

Table 2: Yield and Land Equivalence Ratio of Canola, Peas, and Peaola at Davenport, WA					
Location	Crop System	N Rate (lbs/A)	Canola	Peas	LER
Davenport	Canola	60	1960	0	1.00
Davenport	Pea	0	0	2455	1.00
Davenport	Peaola	0	1810	1794	1.65
Davenport	Peaola	30	1520	1487	1.38
Davenport	Peaola	60	1259	1938	1.43
Significance					
Cropping System			***	***	*
N Rate			.	ns	ns

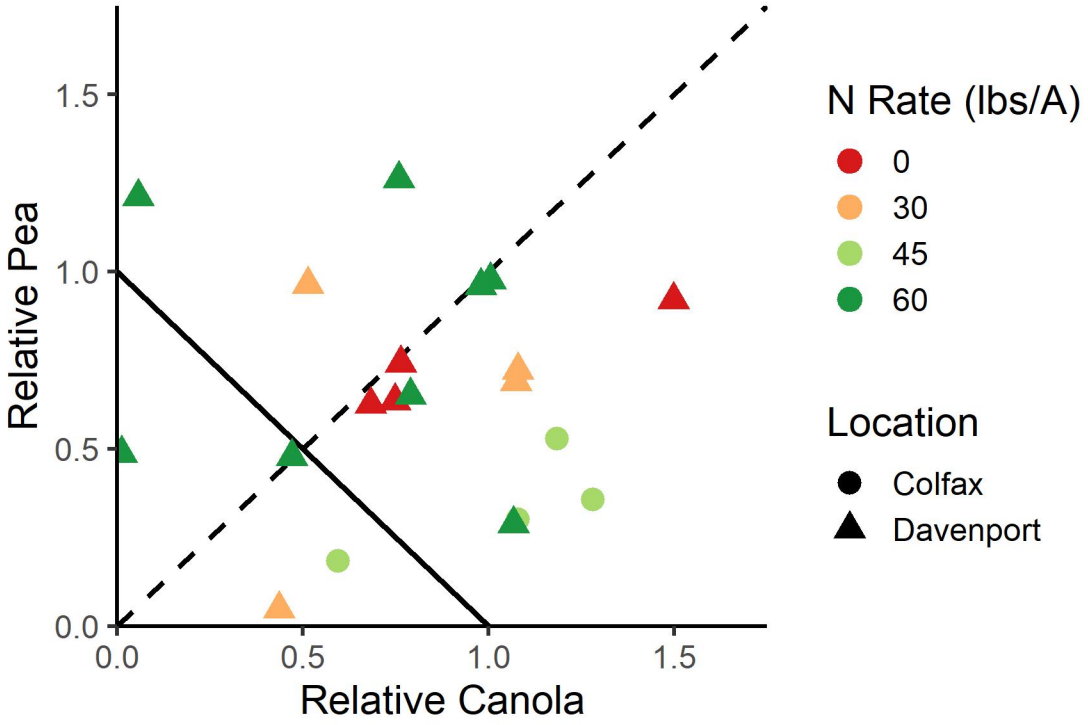

Figure 1: Relative pea vs. relative canola yield from peaola trials conducted harvested in 2020. Trials conducted at the Colfax location were spring seeded, while the trial conducted at Davenport were fall seeded. All points to the right and above the solid line have a cumulative LER of above 1. The points to the left and above the dashed line favor a higher proportion of peas relative to the control, and the point to the right and below the line favor a higher proportion of canola relative to the control. No significant trend in LER, relative pea, or relative canola yield was found based on N rate.

2020-2021 Field Season:

As in the 2019-2020 growing season the fall seeded canola failed to establish in at the Ralston Washington location. However, plots were successfully established at the Davenport location. As in the 2019-2020 field season N fertilizer was streamed on in the spring. However, it is unlikely that the N streamed on in the spring was accessed by the plants as the unusually dry spring of 2021 hampered the mobilization of N to the plant roots. Yield data will be collected from these trials in 2020 and the final analysis of this data will be collected in the fall of 2021.

Publications, Handouts, Other Text & Web Products:

Madsen, I. J., Ford, J. (2021). Peaola Yield and Land Equivalence Ratio Experiments. 2021 Field Day Abstracts: Highlights of Research Progress (pg. 66-67). Pullman, WA: Washington State University. https://css.wsu.edu/extension/field-day-abstracts/

Lyon, D., Madsen, I. J., (2020). Intercropping with Isaac Madsen. WSU Wheat Beat Podcast. https://smallgrains.wsu.edu/wsu-wheat-beat-episode-82/

Outreach & Education Activities:

- Dr. Madsen presented the conceptual framework for this project and root videos at two grower meetings in the summer and fall of 2019. Additionally, at one field day this summer, Dr. Madsen introduced the concept of peaola and engaged producers in conversations regarding their interest in intercropping methods. Field days were cancelled during the 2020 season due to COVID-19. However, field days were resumed during the 2021 growing season and the Davenport trial was featured in a field day at the Wilke farm.

- Four undergraduate timeslips (Robin Turner, Sarah Hallyburton, Serena Hansen, and Katie Doonan) were employed during the summer of 2019 and assisted in designing and conducting root box experiments as well as planting filed trials. Education regarding intercropping was integrated into the work experience.

Impacts

- Short-term: Over the short run the research program presented here will generate knowledge of the suitability and efficiencies of winter peaola intercropping systems within the iPNW. We will establish water and nutrient (P and N) balances for control (non-intercropped winter peas and winter canola) and intercropped peas and canola. We expect many farmers will be interested in learning more about and potentially attempting their own intercropping tests following our experiments.

- Intermediate-term: In personal communications with ‘early adopters’ we have already identified multiple growers who are interested attempting intercropping on their own farms. If these farmers are supported by the university and researchers we will expect

to see intercropping attempted on a minimum of 3 commercial farms within the next 2-3 years. Pending the success and demonstrated of economic feasibility of the early adopters we would expect to see a minimum of 10 farms attempting intercropping over the next 3-6 years. If intercropping retains its reputation as an economically feasible over 6 years we would expect to see a massive increase in grower adoption.

- Long-term: Over the long term we expect intercropping, along with mixed cropping, cover cropping, diversified rotations, and reduced tillage to increase the efficiency of existing cropping systems to such an extent that global food security can be projected to the year 2050. Intercropping will play a critical role in the intensification and diversification of these cropping systems, thereby increasing the overall efficiency and ability to produce the necessary food and fiber for a growing population.

Additional funding applied for/secured:
Two additional grants have been applied for as a part of this project.

- WSARE research and extension grant pre-proposal was submitted in the 2021. However, WSARE did not request a full proposal.
- In the original funding plan we had planned to apply for a pea commission grant, but due to the difficulties in the pea market, we have postponed submitting a proposal.

Graduate students funded:

None. However, we plan to re-allocate funding originally intended to go to a postdoctoral research associate and allocate it to a graduate student this year.

Recommendations for future research:

The current research should be augmented by research assessing the impacts of intercropping on soil biology. Specific focus should be given to the presence or absence of arbuscular mycorrhizae fungi (AMF) following the intercrop plots in comparison to the monocrop plots. It is well known that legumes serve as a host for AMF while canola does not serve as a host. It is possible that the intercrop treatments will leave a more abundant population of AMF in the soil than the canola monocrop. Higher levels of AMF would likely lead to greater nutrient use efficiency of immobile nutrients such as P and zinc.