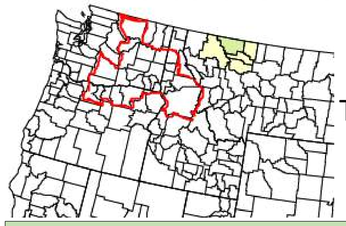
Rotational nitrogen and water use efficiencies in intensified and diversified cropping systems across the precipitation gradient of Eastern WA



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REACCH Regional Approaches to Climate Change – PACIFIC NORTHWEST AGRICULTURE

Study objectives and location details

Aim: To assess the impacts of rotational designs with estimates of rotational nitrogen (N) use efficiency across the precipitation gradient of Eastern WA

Rationale: To calculate nitrogen and water use efficiency across multiple years rather than within a single season window in order to capture potential carry-over from one season to the next

Objective: To quantify effects of intensification and diversification on N use efficiency across the regional precipitation gradient

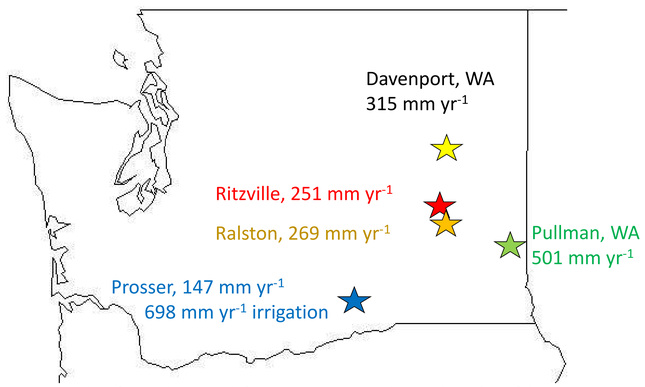


Figure 1. Site locations with average precipitation (and irrigation inputs) for the study period

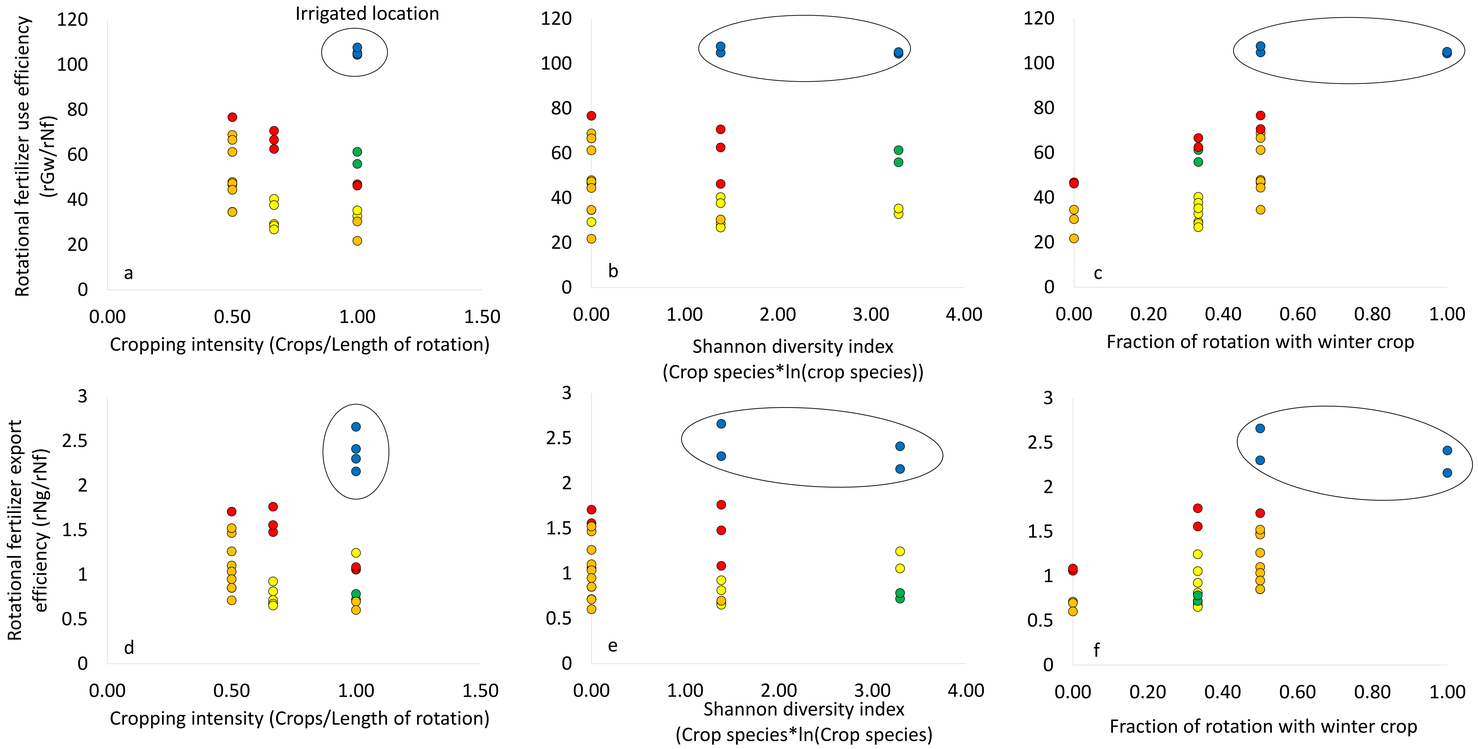
Table 1. Site characteristics

Location	Study period	Avg ppt (mm Sept-Aug)[1]	Avg temp °C	Soil series	Rotation	
					Convention	Experimental
Pullman	2011-2014	501	8.4	Palouse silt loam	WW-SW-SP[2]	WW-SC-SP WW-SW-SP
Davenport	2011-2014	315	7.9	Broadax silt loam	WW-SW-F	WW-SC-SP WW-SW-SP WW-SC-NTF WW-SW-NTF WW-SW-SW WW-SW-SM WW-SW-SC
Ralston	1996-2000	296	9.3	Ritzville silt loam	WW-F	WW-F SW-F SW-SB Cont SW
Ralston	2012-2013	253	9.4	Ritzville silt loam	WW-F	WW-NTF WT-NTF
Ritzille	2012-2014	251	9.3	Ritzville silt loam	WW-F	WW-F WT-SW-NTF WW-SF-TF Cont SW SW-SB
Prosser	2013-2014	137 + 698 irrigated	11.3	Warden silt loam	P-WW-C	cc-P-WW WF-P-WW

[1] Washington AgWeatherNet data http://weather.wsu.edu/ for years after 2010

[2] Rotation key: WW = winter wheat, SW= spring wheat, SP = spring pulse, SC = spring canola, F = fallow, NTF = no-till fallow, SM= spring camelina, SB = spring barley, Cont = continuous, C = corn, cc = winter cover crop, P = potato, WF = winter fallow

Results and Conclusions



Abbreviations:
- r= rotational sums
- Nf = fertilizer inputs
- Gw = yield
- Ns[3] = N supply (initial soil inorganic N-120 cm + mineralized N + Nf)
- Ng = N removed in crop
- Nt = plant N uptake
- Nav = Nt + final soil inorganic N-120 cm

[3]Calculated according to Koenig, R.T. 2005. Dryland Winter Wheat Eastern Washington Nutrient Management Guide. WSU Extension. EB 1987E.

Figure 2. Effects of cropping intensity, Shannon diversity index, and fraction of the rotation planted with winter crop on rotational fertilizer use efficiencies (a-c) and the proportion of rotational removal of crop N of the fertilizer inputs (d-f) at several locations in Eastern WA differing in annual (Sept-Aug) precipitation[4] and irrigation[5] (mm/yr)

[4]Precipitation for Ralston is a weighted average for the two separate study periods, [5]Prosser only

Table 2. Rotational nitrogen use efficiency components of rainfed rotations[6] with varying cropping intensity, diversity, and winter cropping frequency

Cropping intensity index	Avg precipitation (mm/yr)	rGw/rNs	rNt/rNs	rGw/rNt	rNav/rNs	rNt/rNav	rNg/rNt	rGw/rNg	rNg/rNs
0.50	261	21	0.60	34	0.84	0.71	0.74	46	0.44
0.67	291	20	0.63	33	0.72	0.87	0.77	43	0.47
1.00	341	24	0.80	31	0.96	0.83	0.74	42	0.58
Shannon diversity index	Avg precipitation (mm/yr)	rGw/rNs	rNt/rNs	rGw/rNt	rNav/rNs	rNt/rNav	rNg/rNt	rGw/rNg	rNg/rNs
0.00	266	22	0.65	33	0.87	0.75	0.74	45	0.48
1.39	288	21	0.71	32	0.82	0.86	0.74	43	0.48
3.30	408	21	0.65	32	0.78	0.83	0.77	42	0.52
Fraction of rotation with winter crop	Avg precipitation (mm/yr)	rGw/rNs	rNt/rNs	rGw/rNt	rNav/rNs	rNt/rNav	rNg/rNt	rGw/rNg	rNg/rNs
0.00	278	27	0.90	31	1.07	0.84	0.71	43	0.63
0.33	337	19	0.61	32	0.71	0.86	0.77	42	0.46
0.50	267	21	0.61	34	0.87	0.70	0.74	46	0.46

[6]Sites included Pullman, Davenport, Ritzville, and Ralston. Irrigated Prosser was not included in summary

Summary: **(1)** In rainfed locations**, rotational fertilizer N and export use efficiency** decreased with cropping intensity, increased with proportion of winter crops in the rotations, and were unaffected by diversification. The irrigated site exhibited a high fertilizer use and export efficiency relative to the rainfed locations (Figure 2).
(2) Opposite trends were observed for **nitrogen and export use efficiency (rGw/rNs and rNg/rNs)** (Table 2). **Rotational N uptake efficiency (rNt/rNs)** increased with cropping intensity due to enhanced **rotational N retention (rNav/rNs)** and **available N uptake (rNt/rNav)**, while **rotational N utilization efficiency (rGw/rNt)** decreased due to a reduction in **grain N utilization efficiency (rGw/Ng).** Increasing winter cropping decreased **rotational N uptake efficiency (rNt/rNs)**, but increased **rotational N utilization efficiency (rGw/rNt).**