Cropping Systems

Wheat, rye, triticale, barley, einkorn, emmer, spelt, field peas, sorghum, millet, oats, sunflowers, quinoa, garbs

Inland Northwest Artisan Grains Conference July 12th-13th, 2019

Session: Cropping Systems

Facilitator

Julianne Kellogg

- WSU PhD Student in Crop Science
- Current research emphasizes understanding crop variety impact on human health.
- Past MS research on participatory quinoa breeding for organic systems.
- Included publishing a WSU Extension bulletin on growing quinoa

Email: julianne.kellogg@wsu.edu

Session: Cropping Systems

Session Speaker

Jason Bishop

- 5th Generation Farmer
- Edwall Washington
- Aerospace Manufacturing Engineer
- Sharing Observations of: Wheat, Rye, Trit, Barley, Einkorn, Emmer & Spelt, Field Peas, Sorghum, Millet, Oats, Sunflowers

Email: livingheritagefarms@gmail.com

Session: Cropping Systems

Session Speaker

Rachel Wieme

- Postdoc Researcher at WSU Pullman
- PhD in Soil Science from WSU
- Presenting on alternative cropping systems for Palouse Agriculture: Organic crop rotations with quinoa

Email: Rachel.wieme@wsu.edu

Session: Cropping Systems

Session Speaker

Kevin Murphy

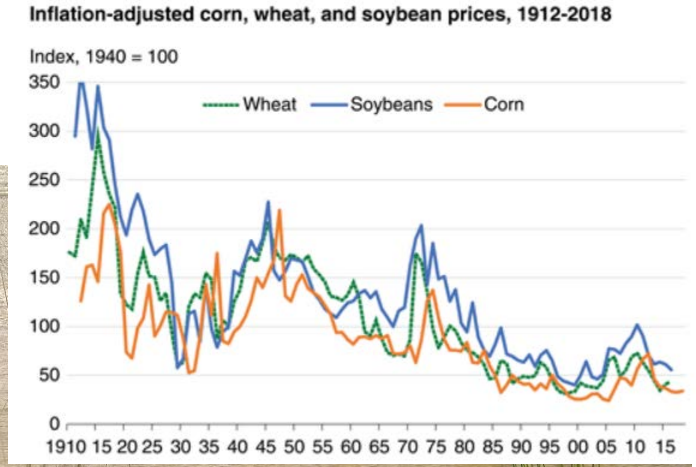
- Associate Professor, International Seed and Cropping Systems
- Sustainable Seed Systems Lab
- Breeding seeds and grains for diversity, flavor, and nutrition
- Talking about food barley, spelt, and quinoa cropping systems research

Email: kmurphy2@wsu.edu

Wheat

- Diversity
  - l

Expenses: $115
Yield: 45 bu/ac
Price: $6 / bu
Gross: $270 / ac
Net: $85 / ac



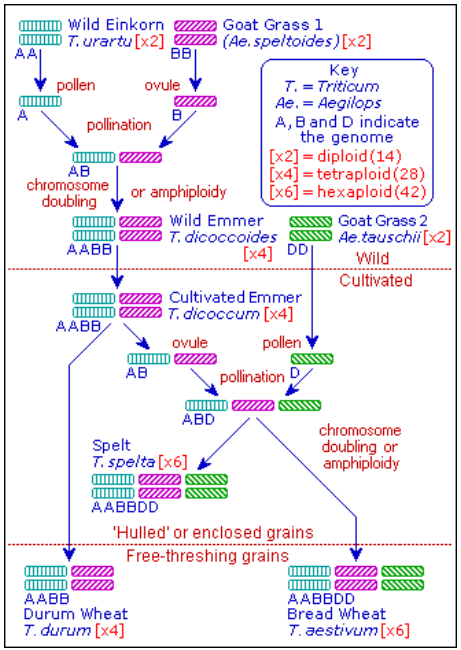
Barley

- $150/Ton

Expenses: $115
Yield: 1 ton / ac
Price: $140 / ton
Gross: $140 / ac
Net: $25 / ac

Emmer & Spelt

- Farro (hulled)



Einkorn

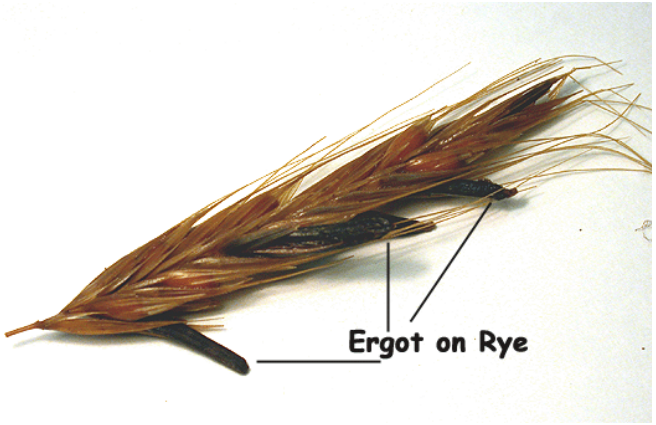
- Small Kernel
- Low Yield
- High Tillers
- Hulled
- Low Gluten Strength
- Low Water Absorption

Rye

Class C Weeds

Class C weeds are non-native weeds found in Lincoln County. Many of these species are widespread in the county. Long-term programs of suppression and control are a local option, depending upon local threats and the feasibility of control in local areas. **Underline means surveys for those weeds will occur after a complaint is filed.**.

Common Name	Scientific Name
Absinth wormwood	*Artemisia absinthium*
Babysbreath	*Gypsophila paniculata*
Bull thistle	*Cirsium vulgare*
Canada thistle	*Cirsium arvense*
Common St. johnswort	*Hypericum perforatum*
Common tansy	*Tanacetum vulgare*
Cereal rye	*Secale cereale*
Field bindweed	*Convolvulus arevensis*
Hoary cress	*Lepidium appelianum*
Jointed goatgrass	*Aegilops cylindrical*
Medusahead	*Taeniatherum caput-medsae*
Ventenata	*Ventenata dubia*
Yellow flag Iris	*Iris pseudocorus*
Yellow toadflax	*Linaria vulgaris*



Triticale

- Rye/Cross
- Ergot

Expenses: $140
Yield: 2 ton / ac
Price: $145 / ton
Gross: $290 / ac
Net: $150 / ac

Peas

Expenses: $130
Yield: 1.5 ton / ac
Price: 12¢ / lb
Gross: $360 / ac
Net: $230 / ac

Millet

- C4 Plant
- Regional Qs
- Shallow Root
- Storage

Expenses: $145
Yield: 1.25 ton / ac
Price: $11.5 / 100wt
Gross: $287.5 / ac
Net: $142.5 / ac

Grain Sorghum / Milo

Expenses: $160
Yield: 1 ton / ac
Price: $18 / 100wt
Gross: $360 / ac
Net: $200 / ac

Oats

- Likes Water
- Likes Cool
- Plant Early

Expenses: $100
Yield: 1 ton/ac
Price: $225 / ton
Gross: $225 / ac
Net: $100 / ac

Sunflowers

- Birds
- Gawkers

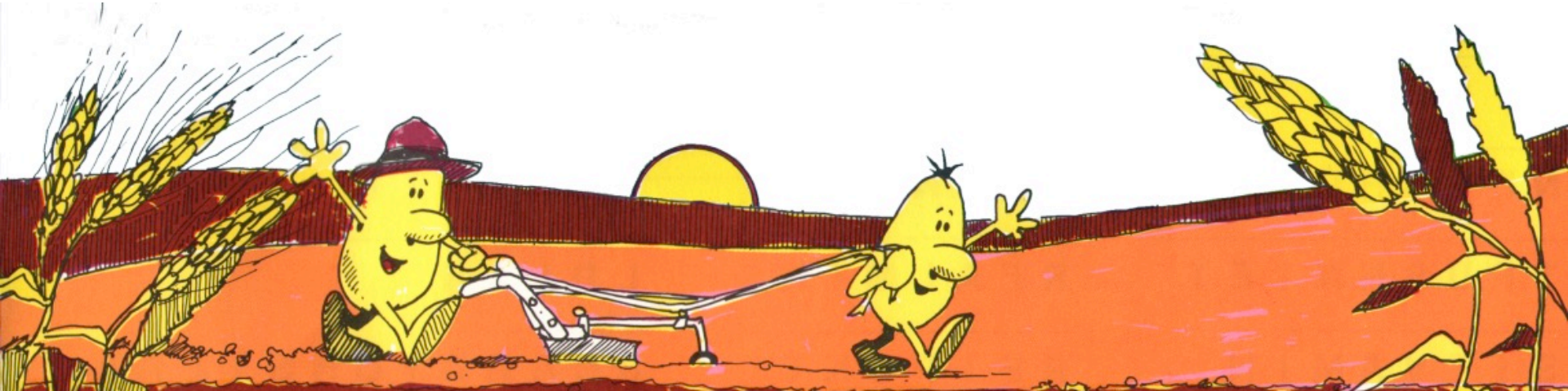
Expenses: $200
Yield: 1500 lb/ac
Price: 19¢ / lb
Gross: $285 / ac
Net: $85 / ac

Others

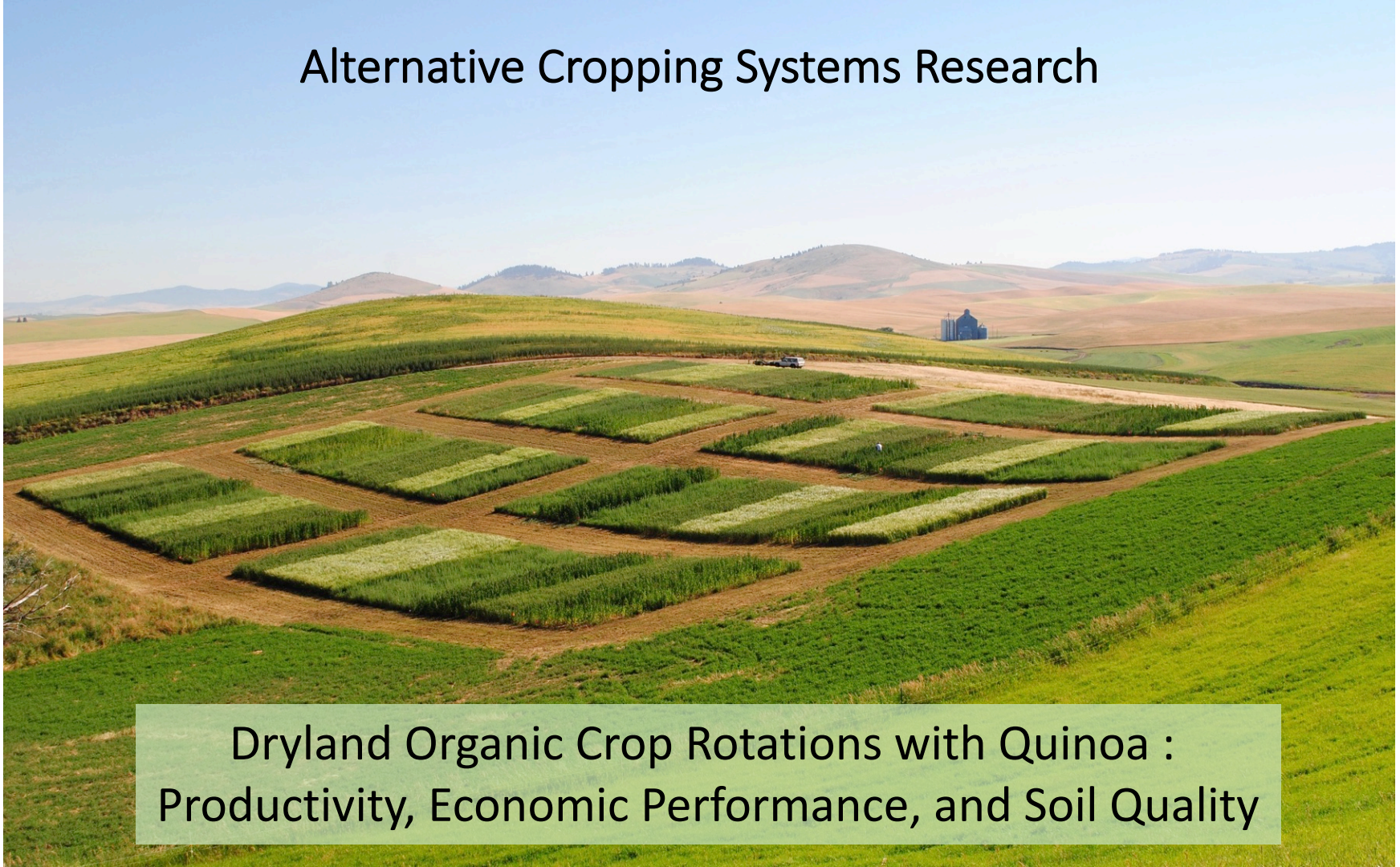
- Buckwheat
  - Export/Allergies
  - Wireworm
  - Phosphorus
- Flax
  - Indeterminate
  - Prussic Acid
  - Omega 3
  - Sharp Sickles

Seed Sources

- https://www.ancientcerealgrains.org/
- https://rockymountainseeds.org/
- https://www.ars-grin.gov/npgs/



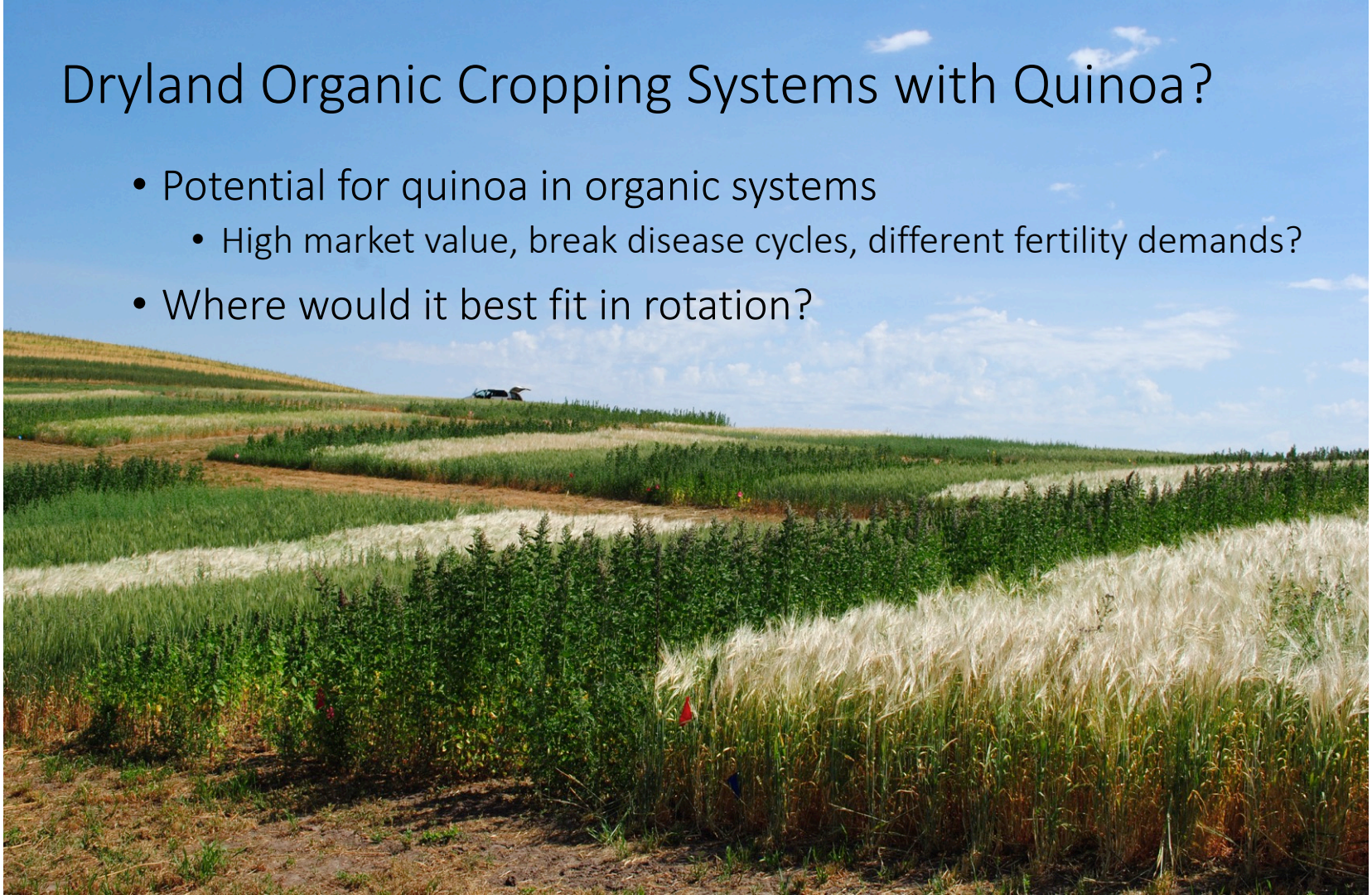
Alternative Cropping Systems Research



Dryland Organic Crop Rotations with Quinoa : Productivity, Economic Performance, and Soil Quality

Dryland Organic Cropping Systems with Quinoa?

- Potential for quinoa in organic systems
  - High market value, break disease cycles, different fertility demands?
- Where would it best fit in rotation?



Tested eight 3-year “grain crop sequences” with and without quinoa

- As part of a longer rotation with alfalfa (5 years)
- Organically managed

Treatments:

- **B**arley – **C**hickpea - **Q**uinoa (BCQ)
- **B**arley – **C**hickpea – **W**heat (BCW)
- **B**arley – **Q**uinoa - **C**hickpea (BQC)
- **B**arley – **W**heat – **C**hickpea (BWC)
- **C**hickpea – **B**arley – **Q**uinoa (CBQ)
- **C**hickpea – **B**arley – **W**heat (CBW)
- **C**hickpea – **Q**uinoa - **B**arley (CQB)
- **C**hickpea – **W**heat – **B**arley (CWB)

Yield & Economics

- Very different weather years had a large impact on sequence yields
  - Especially quinoa and chickpea (very low yields with hot summers)
  - Quinoa yielded better following barley than following chickpea
  - Chickpea yielded better earlier in the sequence
  - Barley yielded better later in the sequence
- Some agronomic lessons learned:
  - Quinoa heat intolerance, Soil crusting impact on quinoa
  - Chickpeas vs. weeds
  - Alfalfa termination



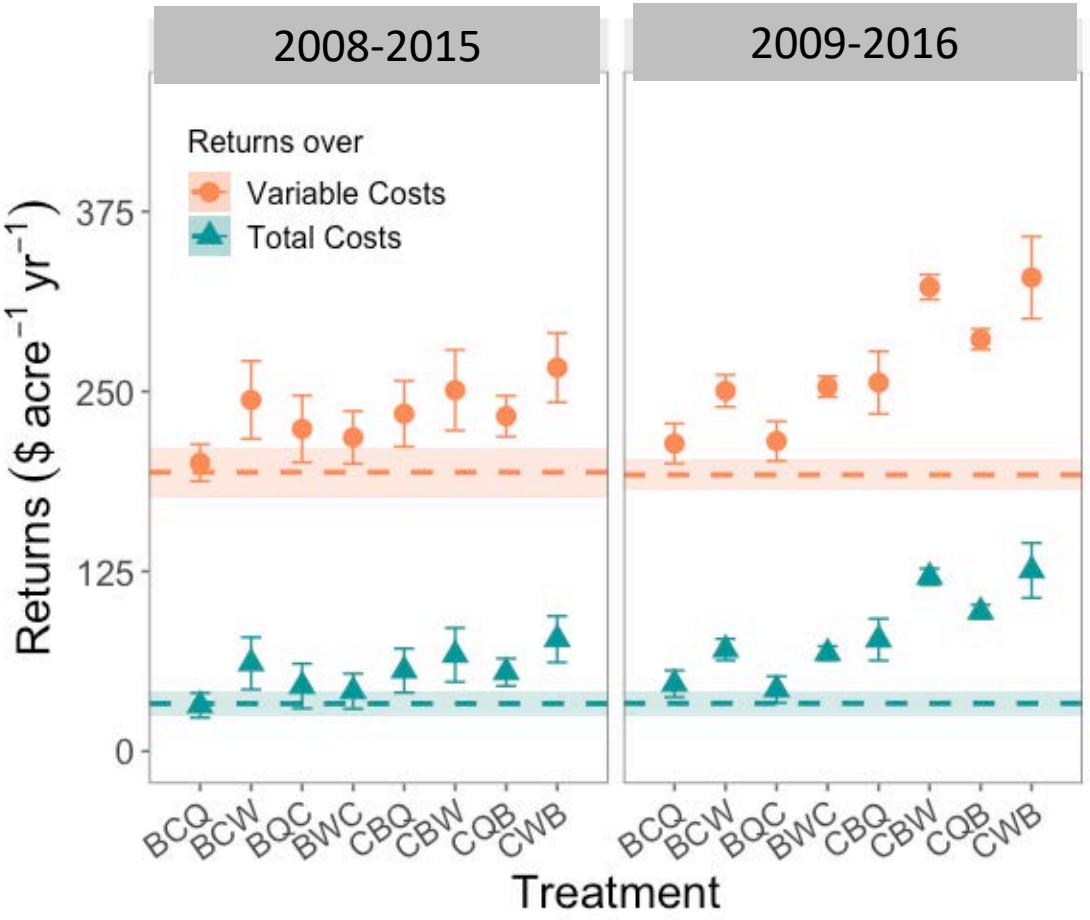
Crop Budgets

	Barley	Chickpea	Wheat (spring)	Quinoa
Expenses ($/acre):	200	240	130	128
Yield:	0.7-2.6 ton/acre	2-1370 lbs/acre	23-75 bu	10-470 lbs/acre
Price:	$400/ton	$0.50/lb	$10/bu	$1.52/lb
Average Gross: ($/acre)	455	244	390	142
Average Net: ($/acre)	255	5	260	14




Financial Performance: 8-year cropping system

- Moderate yields of quinoa had similar economic returns as wheat
  - But because of low quinoa yields most years and a drop in price, wheat sequences performed better on average
- Organic cropping systems had higher returns compared to the “typical” conventional with county average yields
- Alfalfa provided economic & agronomic support
  - Weed control, soil quality/fertility



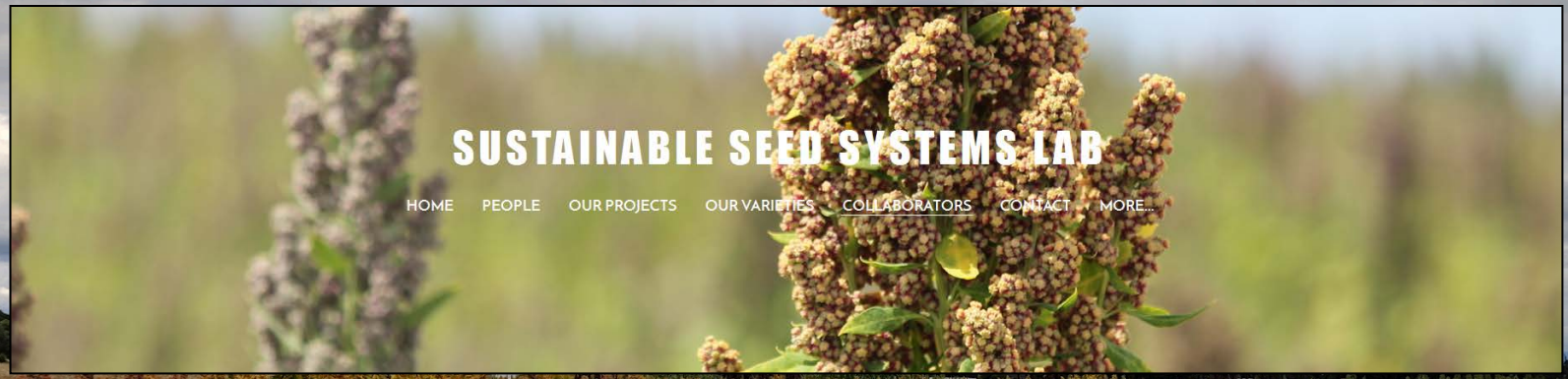
Soil Quality

- Efficient nitrogen cycling through grain sequences
  - Lower available N after cereals, but higher mineralizable N (residues)
  - Overall higher available N in quinoa treatments vs. wheat treatments
  - Lower available N over time
- Quinoa often similar to chickpea, but what if yields improved?

Conclusions

- Organic management on the Palouse requires a revision of the current dominant system
  - Diversification, perennial crops, animals?
- Organic price premiums help ensure economic success despite lower organic yields
- Many challenges and more questions!
  - Locally adapted quinoa varieties
  - Weed control

Quinoa, Food Barley, Millet, Spelt



Inland Northwest Artisan Grains Conference

July 12, 2019

Kevin Murphy

Sustanable Seed Systems Lab

Washington State University

kmurphy2@wsu.edu

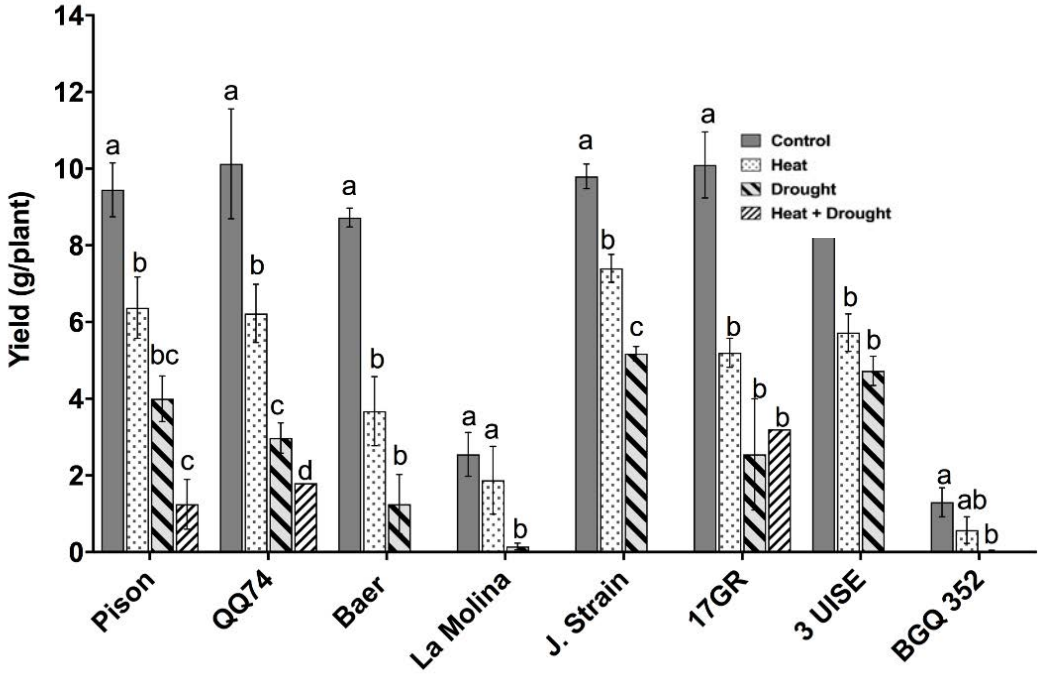
Quinoa Research Projects Washington State University 2010-2019

Hannah Walters & Adam Peterson

EFFECT OF HEAT AND DROUGHT STRESS IN QUINOA (*Chenopodium quinoa* Willd.)

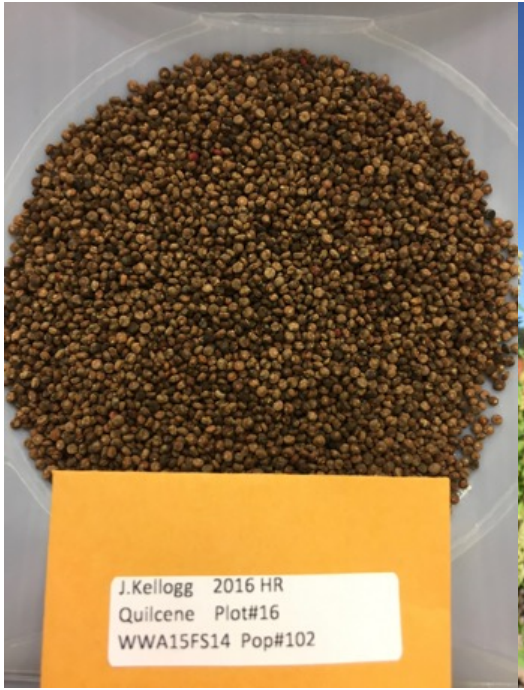
Leonardo Hinojosa
Ph.D. Candidate. Crop Science WSU
October - 2018

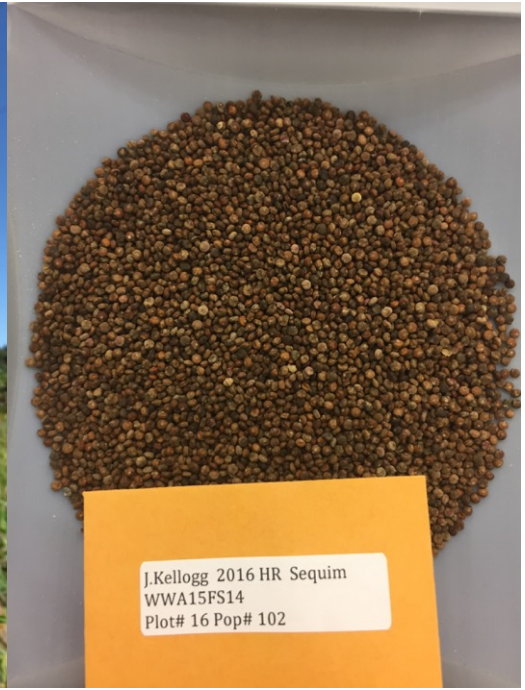
Effect of Heat and Drought Stress on Quinoa Yield in 8 Cultivars



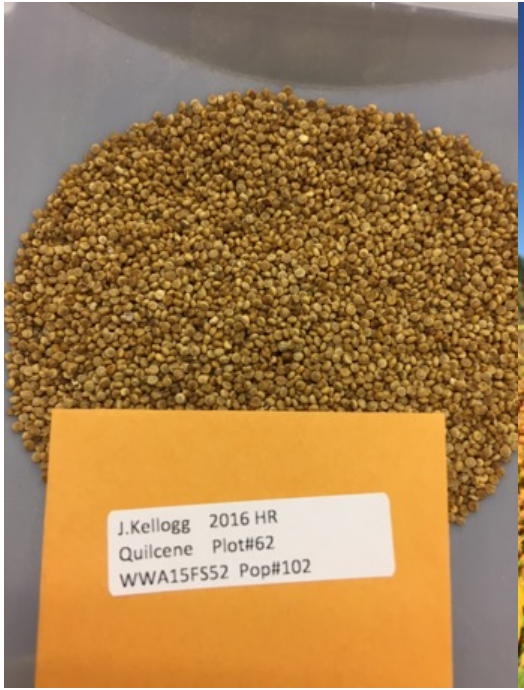
Heat, drought and combination of both reduced seed yield in quinoa

11WAQ-102.14


J.Kellogg 2016 HR
Quilcene Plot#16
WWA15FS14 Pop#102


J.Kellogg 2016 HR Sequim
WWA15FS14
Plot# 16 Pop# 102

11WAQ-102.52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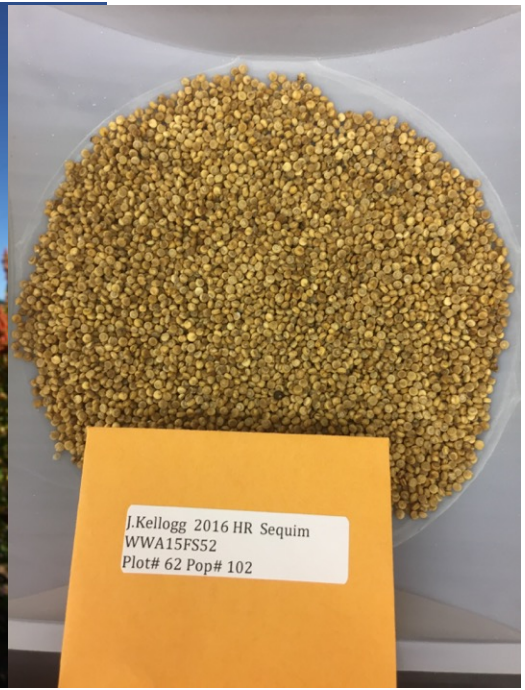
Quilcene Plot#62
WWA15FS52 Pop#102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Plot# 62 Pop# 102

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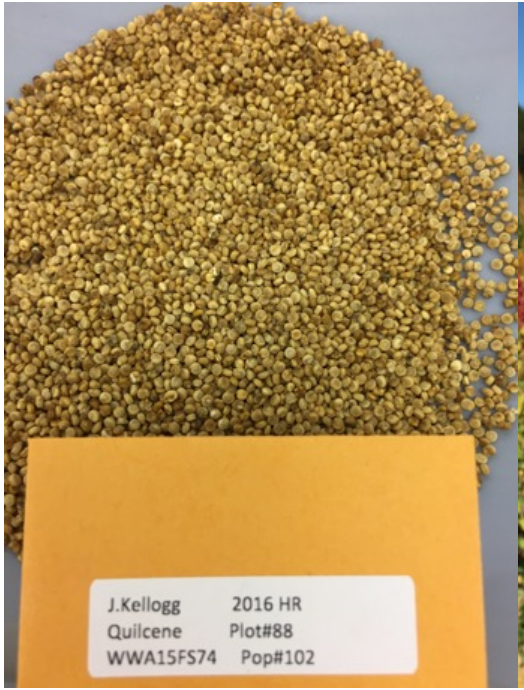
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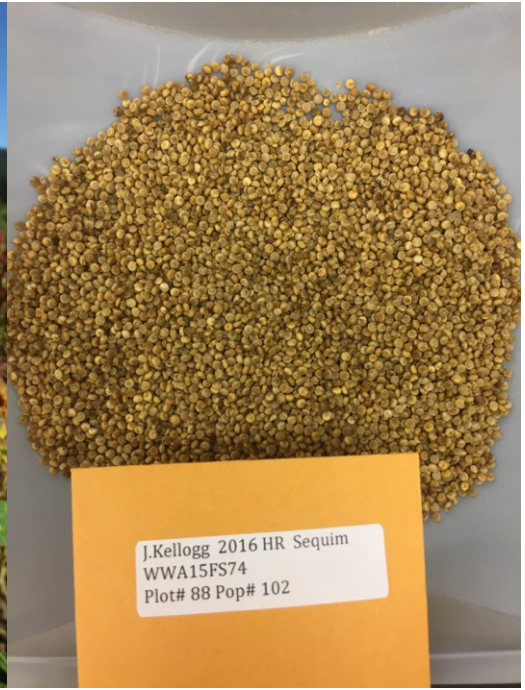
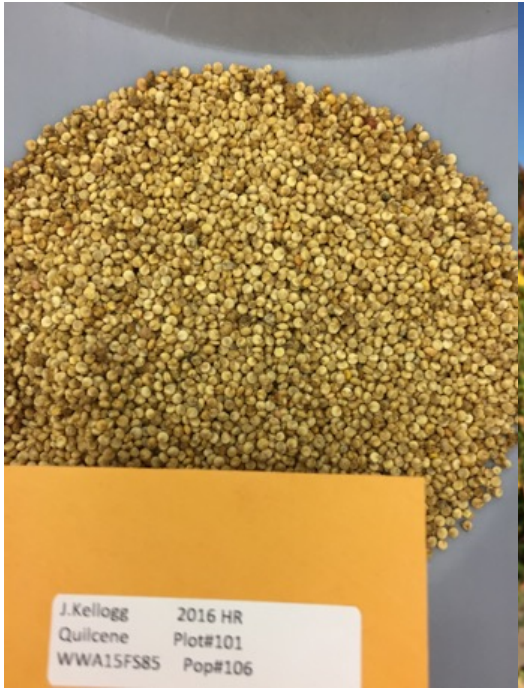
Quilcene Plot#88
WWA15FS74 Pop#102


J.Kellogg 2016 HR Sequim
WWA15FS74
Plot# 88 Pop# 102

11WAQ-104.60


J.Kellogg 2016 HR
Quilcene Plot#72
WWA15FS60 Pop#104
J.Kellogg 2016 HR Sequim
WWA15FS60
Plot# 72 Pop# 104

11WAQ-106.85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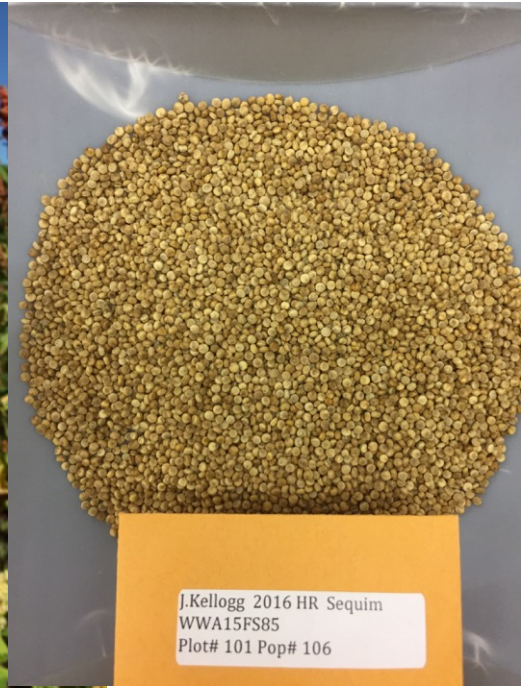
Quilcene Plot#101
WWA15FS85 Pop#106


J.Kellogg 2016 HR Sequim
WWA15FS85
Plot# 101 Pop# 106

11WAQ-105.43


J.Kellogg 2016 HR
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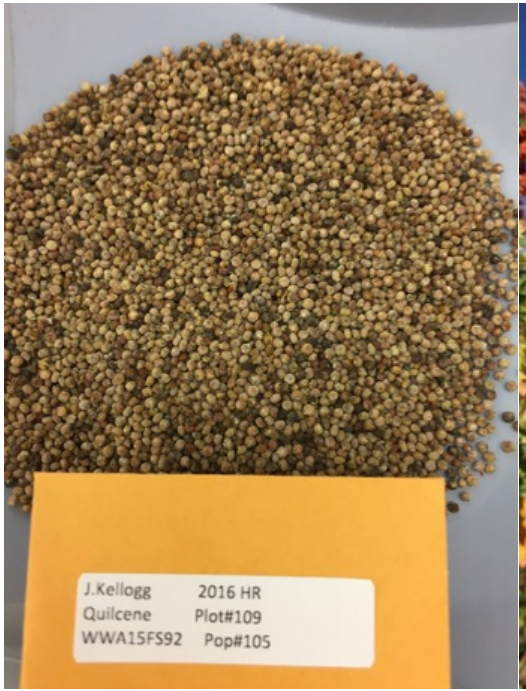
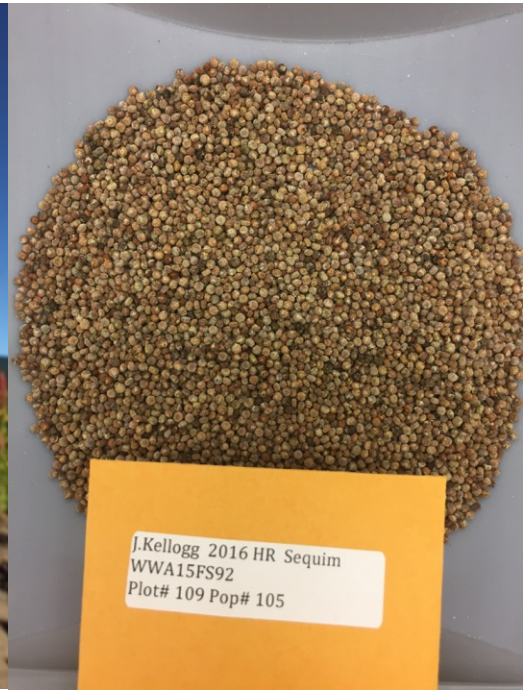
WWA15FS43 Pop#105
J.Kellogg 2016 HR Sequim
WWA15FS43
Plot# 52 Pop# 105

11WAQ-105.92


J.Kellogg 2016 HR
Quilcene Plot#109
WWA15FS92 Pop#105


J.Kellogg 2016 HR Sequim
WWA15FS92
Plot# 109 Pop# 105

11WAQ-108.42


J.Kellogg 2016 HR
Quilcene Plot#51
WWA15FS42 Pop#108
J.Kellogg 2016 HR Sequim
WWA15FS42
Plot# 51 Pop# 108

Intercropping Trials

- **Variety x Irrigation x Intercrop Trial:** Two quinoa varieties intercropped with a clover/medic mix and Fescue/clover mix at 3 irrigation levels
- **Key Results:** The fescue grass/clover mix created more biomass and winter cover compared to the clover/medic intercrop whereas the clover/medic mixture increased quinoa seed protein.
- **Conclusions:** Intercrops improved weed control, soil fertility, and protein in the seed and had no negative impacts on yield

Walters et al., 2016 *Agroecology and Sustainable Food Systems*

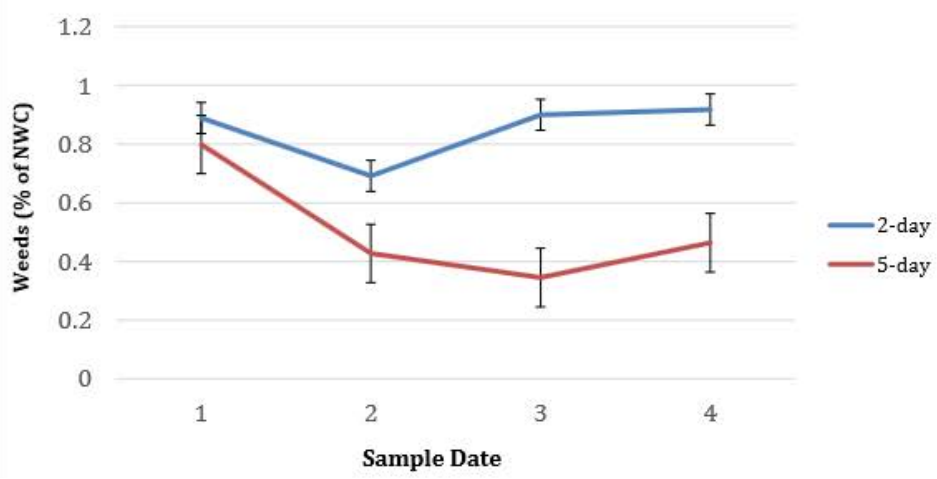
Livestock Integration

- Using Geese for weed control
- 3 varieties x 3 goose density treatments

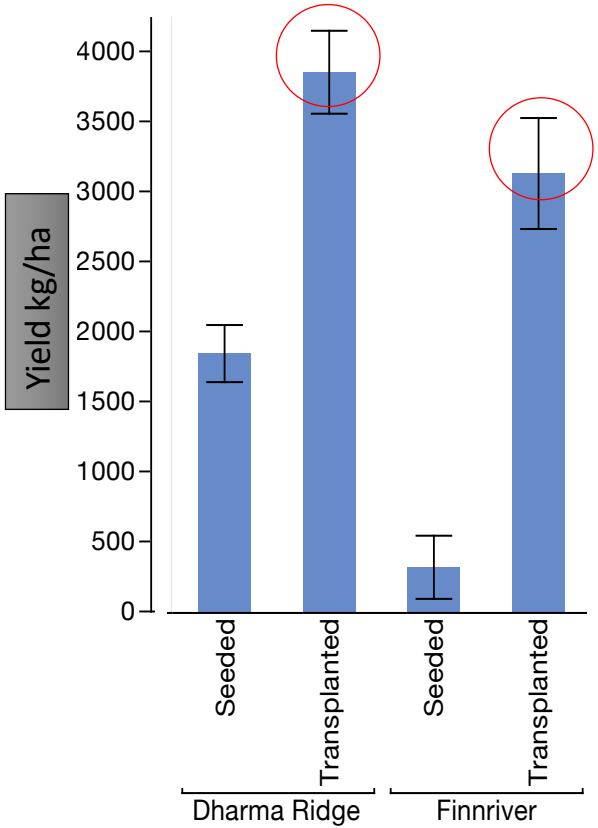
Kristofor Ludvigson

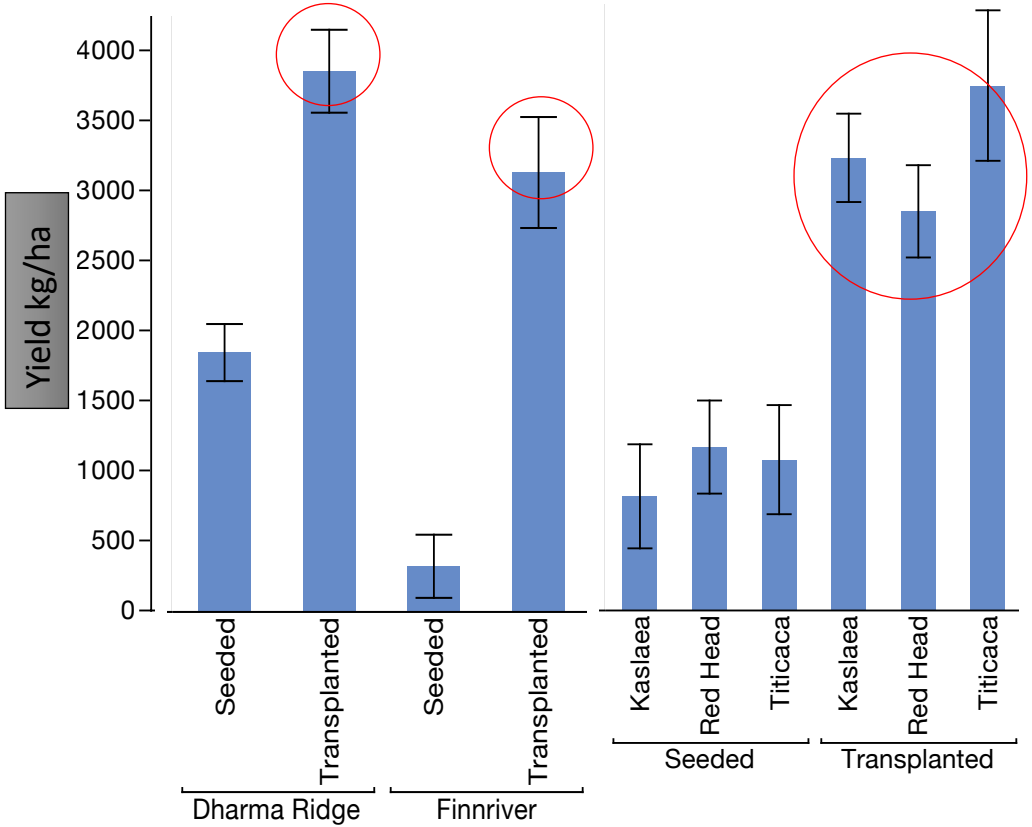
Livestock Integration

- Utilizing geese 5 days per week eliminated approximately 60% of the weeds while improving soil fertility

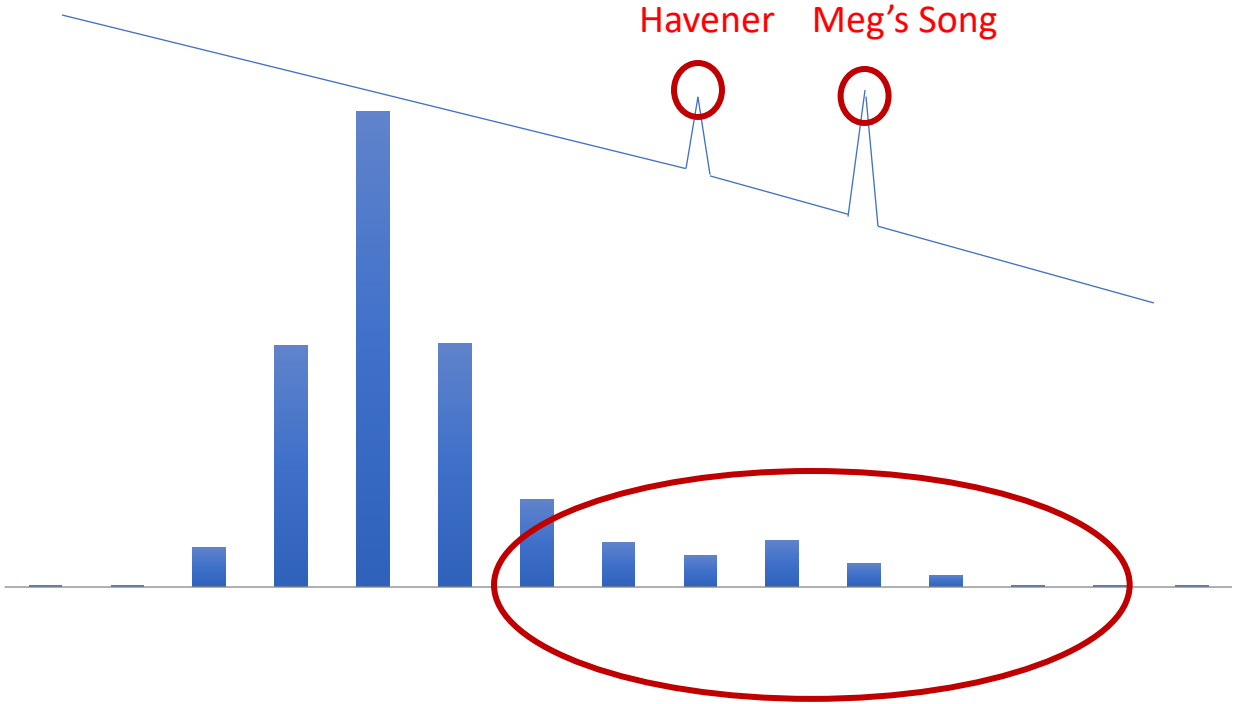


Direct Seeding vs. Transplanting


Yield kg/ha
4000
3500
3000
2500
2000
1500
1000
500
0
Seeded
Transplanted
Seeded
Transplanted
Dharma Ridge
Finnriver


Yield kg/ha
4000
3500
3000
2500
2000
1500
1000
500
0
Seeded
Transplanted
Seeded
Transplanted
Dharma Ridge
Finnriver
Kaslaea
Red Head
Titicaca
Kaslaea
Red Head
Titicaca
Seeded
Transplanted

Food Barley: Meg’s Song and Havener


Havener
Meg's Song

Hulless Barley Food Quality Testing

Bread Quality

	Buck	Havener	Meg's Song
Loaf Volume (mL)	**931.9**	971.4	957.6

Food Barley Research: GxE for β-glucan

How does environment play a role in β-glucan content?

Can we identify stable varieties across contrasting environments?

8 locations, 2 years (2017-2018), 18 entries

Halle Choi, MS student

Univariate Measures of Stability

Genotype	Mean (%w/w)	Deviation from the Regression	Shukla's Stability Variance (σ_i^2)	Wricke's Ecovalence (W_i^2)	Kang's Yield Stability
107.43	3.359	0.239***	0.201 *	1.543	-10
Genie	3.452	0.373***	0.318 **	1.737	-9
Odyssey	3.496	0.354***	0.347 **	1.891	-8
107.58	3.524	0.213*	0.203 *	1.122	-3
Oreana	3.616	0.268***	0.316 **	1.722	-6
Champion	3.654	0.197**	0.122	0.694	4
Copeland	3.673	0.123**	0.072	0.573	5
120.23	3.768	0.099	0.040	0.348	6 +
120.14	3.771	0.159	0.066	0.487	7 +
Claymore	3.797	0.209	0.051	0.475	9 +
Muir	3.889	0.121	0.056	0.350	10 +
Survivor	3.934	0.181*	0.122	0.723	13 +
Altorado	3.947	0.143*	0.093	0.596	14 +
Vespa	3.974	0.124*	0.042	0.279	15 +
Lenetah	4.084	0.061	0.034	0.230	17 +
Lyon	4.393	0.319***	0.142	0.829	19 +
Havener	6.206	0.403***	0.139	1.083	16 +

Level of significance is indicated as 0.05, 0.01, 0.001, or not significant by the following *, **, ***, or no star, respectively

Effect of Nitrogen and Seeding Rate on β-glucan Content and Yield in Barley GxExM (Management)

- No-till Systems
- 3 years (2016-2018), 2 locations (Genesse, ID and Almota, WA)
- 5 nitrogen rates
- 3 seeding rates
- 2 varieties

Cedric Habiyaremye, PhD student

N (kg/ha)	B-glucan (%)		Protein (%)	
	Almota	Genesee	Almota	Genesee
2016				
0	6.8	7.3	10.7	9.2
62	6.6	7.2	10.9	9.2
95	6.7	7.4	11.7	10.4
129	6.7	7.3	12.1	10.8
162	6.8	7.7	12.6	12.2
Mean	6.7	7.4	11.6	10.4
LSD ($p < 0.05$)	0.38		0.89	

HAVENER

SPRING BARLEY

MUIR

SPRING BARLEY

MEG'S SONG

SPRING BARLEY

SURVIVOR

SPRING BARLEY

LYON

SPRING BARLEY

Millets

- Warm season crops, Poaceae family
- Five most important millet species commonly grown as commercial crops:
  - proso *(Panicum miliaceum* L.*)*
  - foxtail *(Setaria italica* L.*)*
  - pearl *(Pennisetum glaucum* L.R. Br.)
  - Japanese barnyard *(Echinochloa esculenta)*
  - browntop millet *(Urochloa ramosa*)

Source: (Oelke et al., 1990; Wen et al. 2014)

Foxtail millet WSU, 2015

Proso millet WSU, 2015

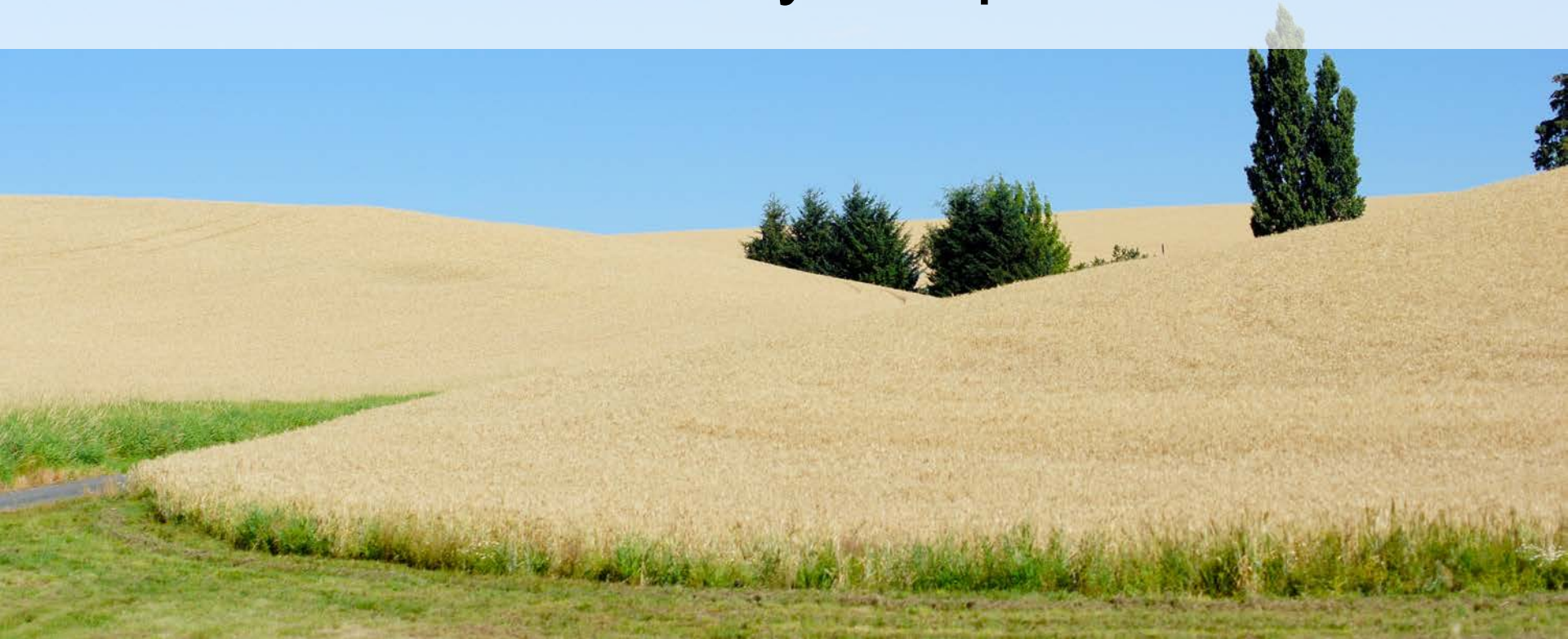
Variety	Days to Maturity	Plant Height (cm)	Yield (kg/ha)
Huntsman	107.6	73.79	1218.21
Sunup	104.4	74.4	1487.09
Sunrise	104.4	74.2	1900.23
Horizon	103.4	73.4	1652.84
Prosos	99	71.2	2015.81
USSR 63	89	57.6	2052.45

Top yielding proso millet varieties
Organic

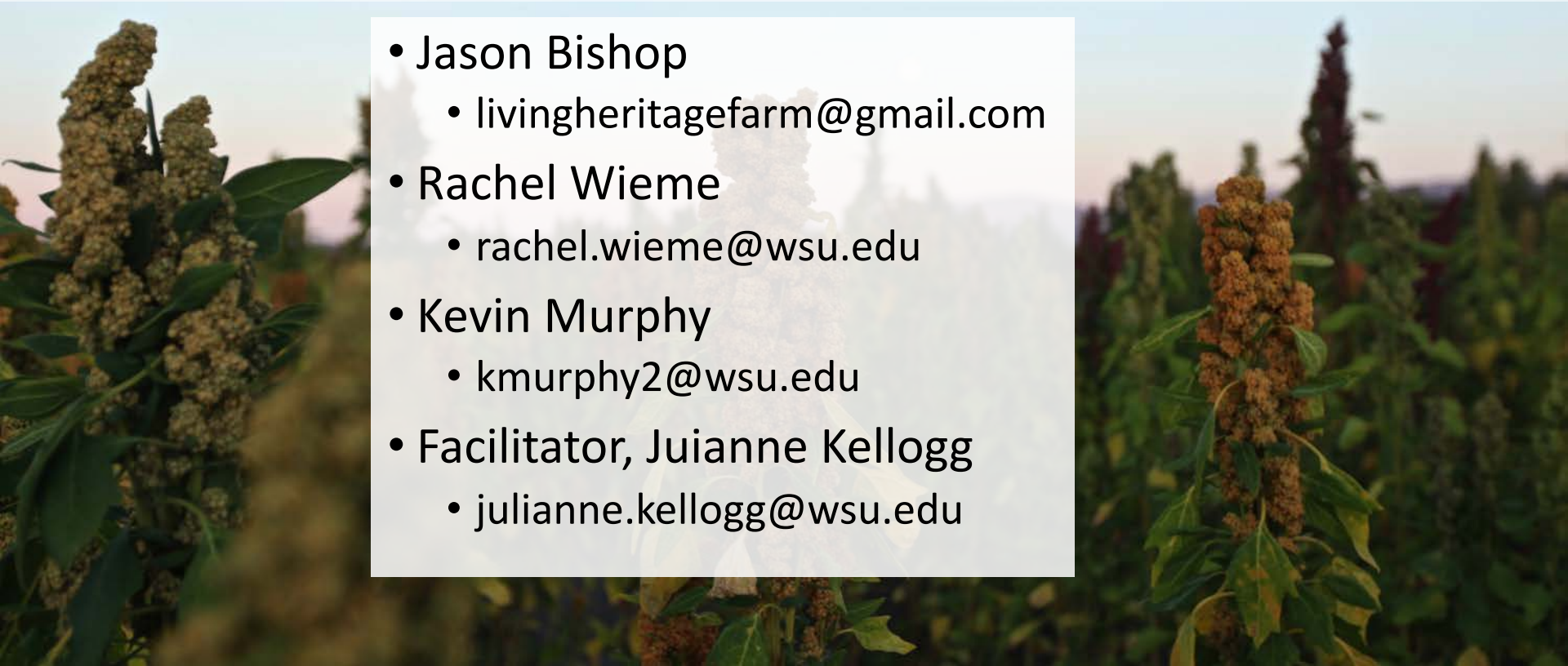
Varieties	Yield (kg/ha)
GR 665	**1,230**
Earlybird	**1,081**
Sunup	**1,044**
Sunrise	**1,007**
GR 664	**926**


Elwha River Spelt

Audience, ask your questions!



More questions? Contact a speaker:



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- Kevin Murphy
  - kmurphy2@wsu.edu
- Facilitator, Juianne Kellogg
  - julianne.kellogg@wsu.edu