generally slightly lower in the 3-year rotation (Fig. 1). This yield trend is likely due to soil water. Averaged over the four years, total water in fallow at the time of winter wheat planting in late August is 0.5 inches greater (P < 0.001) in the 2-year compared the 3-year rotation (Table 1). There are no differences in soil water content after the time of harvest of wheat and camelina nor are there differences in over-winter water gain on WW versus camelina stubble. The differences in water loss between the two fallow rotations occur during the summer (P < 0.005, Table 1). The average of 0.5 inches more water in the 2-year rotation would account for the 3-4 bushels/acre winter wheat grain yield increase in the 2-year rotation.

Why is greater water loss occurring during the summer in the 3-year rotation when both fallow systems are treated the same (i.e., plots are always undercut, rodweeded, and planted to winter wheat at the same time)? The answer could be that greater surface residue in the 2-year rotation provides better shading. Line-point residue measurements obtained after planting of winter wheat in 2012 showed 35% residue cover in the 2-year rotation versus 18% in the 3-year rotation (P < 0.02). These differences have been statistically significant every year and when averaged over the four years (P < 0.001, data not shown).

Table 1. Soil water content at the beginning (after harvest), early spring, and end of fallow (before planting) and associated gain or loss of water and precipitation storage efficiency (PSE = gain in soil water/precipitation) in the 6-ft soil profile in summer fallow in a 2-year winter wheat-summer fallow rotation versus a 3-year winter wheat-camelina-summer fallow rotation. The top portion of the table shows water content during the 2011-2012 fallow cycle and the bottom portion of the table shows water content for the 4-year average.

	Timing in fallow period					
	Beginning (late Aug.)	Spring (mid Mar.)	Over-winter gain	End (late Aug.)	Mar. to Aug. water	PSE† (%)
	Soil water content (inches)					
			A. 2011-2012			
Fallow treatment						
After winter wheat (2-yr rotation)	5.7	8.1	2.4	9.0	+ 0.9	30
After camelina (3-yr rotation)	5.8	8.6	2.8	9.1	+ 0.5	30
p-value	ns	ns	ns	Ns	ns	ns
			B. 4-year average			
Fallow treatment						
After winter wheat (2-yr rotaion)	6.1	9.3	3.2	8.9	- 0.4	29
After camelina (3-yr rotation)	5.8	9.3	3.6	8.4	-0.9	26
p-value	ns	ns	ns	0.001	0.005	ns

Camelina: What Will it Take to Make this Crop Attractive to Pacific Northwest Growers?

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What will it take to make camelina production attractive to growers? During the past winter, I discussed this question with progressive farmers from Washington, Oregon, Idaho, Montana, and Colorado. The main factor is price. The price offered to PNW farmers for camelina seed in the past several years has ranged from $0.12 to 0.15 per pound. During this same time period, the price offered for canola seed has been $0.24 to 0.30 per pound (i.e., double). There are several oilseed crushing facilities in Washington and Oregon – all geared to “cold press” canola seed for oil extraction. The same crushing machinery can be used to cold press camelina seed, but crushers need certain minimum quantities of seed to keep their facilities in full-time operation.

All growers with whom I talked said they would sign contracts to produce camelina for $0.30 per pound. Included in this price was an agreement to deliver the camelina seed to a crushing facility within a 40 mile (one way) hauling distance from their farm. Two growers said they would consider producing camelina for a guaranteed $0.25 per pound. None of the growers interviewed would produce camelina for less than $0.25 per pound.

Unlike canola, crop insurance for camelina is not yet available through the USDA crop insurance program. All growers interviewed mentioned the lack of crop insurance as a drawback to growing camelina, but more than half said they would be willing to take the risk due to the fact that camelina is a hardy plant and camelina seed yield for a given quantity of precipitation appears to be relatively stable and predictable.

A third factor for the slow adoption of camelina production is the US Food and Drug Administration (FDA) has not yet provided approval for camelina oil for human consumption. Approval will likely come with time but, until then, camelina oil cannot be sold in the US for human food. The FDA has approved camelina meal (a very valuable bi-product after oil extraction) for up to 10% of the total ration fed to cattle and poultry.

I also discussed the question of how to increase camelina production with owners of two PNW oilseed crushing facilities. Both facilities have crushed camelina in the past and would welcome future opportunities. One plant crushed 1000 metric tons of camelina seed in 2012 with all the oil exported to other countries for human consumption. Both of the crushing plant owners stated that, if the grower required $0.25 or 0.30 per pound to deliver camelina seed, they would sell the oil at $0.55 or 0.60 per pound. The oil would be shipped FOB (freight on board) in totes of 275 gallons or bladders of 6,500 gallons. A dedicated food-oil rail tanker car with a capacity of 25,000 gallons would also be suitable for oil shipment. Both crushing facility owners said they could process about 35 metric tons of seed per day, but would need to have at least of three month supply seed (3200 tons) to make it worthwhile. Both owners said that they would keep the camelina meal as part of the business deal.

Bruce Sauer, in the camelina cropping systems experiment study at Lind, WA.

From discussions with farmers and crushing facility owners, the meal from camelina seed is about of equal monetary value as the oil. Cattle producers are eager to buy camelina meal because, in addition to being high in protein and vitamin E, camelina meal is also a great source of omega 3 fatty acids and energy. The combination of these attributes is beneficial in healthy weight gain for cattle.

In summary, it appears that the following are “drivers” for increasing production of camelina in the inland Pacific Northwest:

1. The farmer needs to receive $0.30 per pound for camelina seed.
2. The crushing facility will sell camelina oil for $0.55 to 0.60 per pound FOB.
3. Farmers will want a guaranteed price in their production contract.
4. If an individual crushing facility needs a minimum of 3200 tons of camelina seed, then between 3,000 and 12,000 acres of production need to be contracted, depending on the cropping zone (i.e., low, intermediate, or high precipitation).

Development of Herbicide Tolerant Camelina Varieties

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Camelina is a low input oilseed crop that we and others are trying to develop as a rotation crop for wheat, especially in the low-intermediate rainfall areas where few good rotation crops are available. One hindrance of establishing Camelina production in the Pacific Northwest has been its intolerance to residual levels of commonly used herbicides, especially group 2 herbicides (imidazolinones and sulfonylureas), which can damage subsequent camelina crops for several years. The problem is exacerbated by the growing popularity of Clearfield wheat varieties which are commonly sprayed with Beyond, an imidazolinone herbicide. We have generated a mutant line that is tolerant to both types of herbicides. Breeding populations established from the mutant were unaffected by the herbicide when planted after a Clearfield wheat crop to which four times the labeled rates of beyond had been applied. Plants in the control camelina variety plots (non-mutant) were generally destroyed except for occasional plants that set seed (Table 1). This demonstrated the utility of the mutation in reducing risk of including camelina in crop rotations without restricting the use of these herbicides.