Breeding Meadowfoam – A Crop with Unique Oil Quality and Seedmeal Properties

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About Meadowfoam

- *Limnanthes alba* Benth. and related species are native plants adapted to vernal pools of the Pacific Northwest.
- Meadowfoam seed oil contains novel long-chain fatty acids (C_{20}-C_{22}) with an unusual Δ5 desaturation. The oil is light-colored, odor free, and has exceptional oxidative stability.
- Current market for oil is in personal care products. Potential exists for use in biolubricants and other industrial applications.
- Seed meal contains the glucosinolate glucolimnanthin. Degradation products are known to have biopesticidal properties. New markets for the seed meal would add value to the crop.
- One of the few winter annuals that can be grown as a rotation crop in grass seed production systems in the Willamette Valley of Oregon. Provides a much-needed alternative to field burning.

Breeding Needs

- First produced as a crop in 1980.
- Current production area is about 4000 acres (1619 ha) per year.
- Cultivars developed over the past 30 years have more upright growth, higher oilseed yield and reduced shattering compared to wild relatives.
- Under favorable conditions growers obtain seed yields of 1500 kg ha^{-1}, producing 400 kg oil ha^{-1}. Average seed yields are about 1000 kg ha^{-1}. Increased oil yields are needed to improve the stability and profitability of meadowfoam production.

Pests and Diseases

Meadowfoam fly larvae (*Scaptomyza* sp.) feed on actively growing plant tissues and flower buds and can cause serious crop damage. Application of bifenthrin in February and March provides effective control. In 2008, crown rot symptoms caused by *Fusarium* sp. were widely observed for the first time. Selections were made for high and low disease severity in two breeding populations to determine if resistance could be improved through selection. Selected genotypes were evaluated for two years using varying levels of *Scaptomyza* control.

Effect of Insecticide on Oil Yield Components in 2009

Insecticide Treatment	1000-Seed Weight g	Seed Yield kg ha^{-1}	Oil Content %	Oil Yield kg ha^{-1}
No Spray	8.74	1532	24.02	368.3
Two Sprays	7.99	1740	23.78	414.1
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There were no interactions between genotypes and insecticide treatments for any of the traits measured. Control of the fly increased oil yields by 12% in 2009. High and low disease selections differed significantly for many traits, including disease severity, lodging resistance, and oil yield. However, experimental varieties developed by direct selection for yield had 7-12% higher seed yields than the low disease selections.

Seed Yield (kg ha^{-1}) of Selected Genotypes in 2010

Source	High Yield	Low Disease	High Disease
OMF 58 C5 (MF 187)	**MF 189** 1652	**PinL-B** 1479	**PinH-B** 1379
GJ Pool	**MF 190** 1505	**GJPL-B** 1408	**GJPH-B** 1185

LSD(.05) = 116

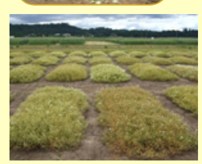
Pollinators

Honeybees (*Apis mellifera*) are used commercially for meadowfoam pollination. Although meadowfoam produces ample pollen and can support healthy bee colonies, nectar production is less than optimal. Pollination may be limited when there is cool, rainy weather during flowering, or when competing crops that are preferred by the bees are grown nearby.

Blue orchard bees (*Osmia lignaria*) are ideal pollinators for meadowfoam in large field cages and in isolated field plots. Although adults are fully mature and ready to emerge in early spring, they can be stored at cool temperatures and released when the meadowfoam begins to flower in May.

Blue bottle flies (*Calliphora* sp.) are good pollinators of meadowfoam in small cages and are available year round. The capacity to self large numbers of plants and to intermate selected lines without the need for hand pollinations has provided new options for developing effective breeding strategies.

Breeding Methods



A half-sib family recurrent selection system has been carried out in the OMF 58 population since 1990. Plants are grown at wide spacing in isolated nurseries. Half-sib progeny are evaluated in replicated trials in the next season. For Cycles 5 and 6 we used blue bottle flies to self a branch on each parent plant. Selfed progeny from selected families can be recombined to form experimental varieties and to generate the next cycle of selection.

One limitation of the half-sib method is that it favors large parental plants that produce sufficient seed for progeny tests. This may not be the optimum ideotype at high plant densities. We are now implementing an S_1 testcross selection scheme that should provide ample seed for progeny trials. Improvement of three populations can be phased to make efficient use of greenhouse facilities and generate new experimental varieties every year.

<table>
<tr><th rowspan="2">Year</th><th rowspan="2">Season</th><th colspan="3">Breeding Population</th></tr>
<tr><th>OMF 58</th><th>GJ Pool</th><th>Autofertile Pool</th></tr>
<tr><td rowspan="2">1</td><td>Spring</td><td>S_1 isolation</td><td>Selfing</td><td>Progeny Trial</td></tr>
<tr><td>Fall</td><td rowspan="2">Progeny Trial</td><td rowspan="2">S_1 isolation</td><td>Recombination</td></tr>
<tr><td rowspan="2">2</td><td>Spring</td><td>Selfing</td></tr>
<tr><td>Fall</td><td>Recombination*</td><td rowspan="2">Progeny Trial</td><td rowspan="2">S_1 isolation</td></tr>
<tr><td rowspan="2">3</td><td>Spring</td><td>Selfing*</td></tr>
<tr><td>Fall</td><td>S_1 isolation</td><td>Recombination</td><td>Progeny Trial</td></tr>
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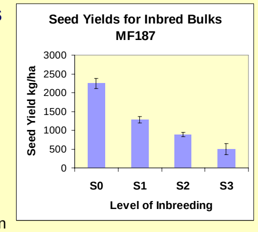
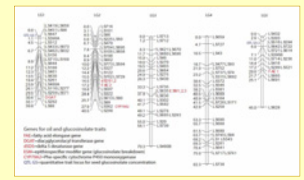
*Daylength can be controlled in the greenhouse to complete a generation in four months

Autofertile Varieties



There has been considerable interest in development of autofertile varieties that would reduce reliance on commercial honeybees. Autofertile lines from *L. alba* ssp *versicolor* have been crossed to elite *L. alba* ssp *alba* breeding populations. *L. alba* ssp *alba* suffers from inbreeding depression. Additional selection is needed to increase levels of autofertility and improve the vigor of these germplasm pools.

Molecular Genetics



- More than 120 SSR markers have been developed from repeat sites mined from a developing seed EST library and a genomic DNA library.
- A candidate gene approach has also been used to map and develop markers for oil synthesis genes and glucosinolate synthesis and degradation genes that determine the unique seed oil and glucosinolate profiles of meadowfoam.

Meadowfoam Meal

- Constitutes 70% of harvested crop yield, yet current commercial outlets are limited.
- Unique among oilseed meals in containing two classes of plant secondary compounds with biopesticidal activity: glucosinolates (glucolimnanthin) and phytoecdysteroids.
- Glucolimnanthin constitutes 2-4% of meal, but the myrosinase enzyme that converts glucolimnanthin to biopesticidal compounds is denatured by heat during the oil extraction process.
- Addition of enzyme-active seed material to the meal produced enhanced bioproducts with greater herbicidal activity in controlled experiments.
- Current efforts aim to scale up the fermentation process and identify best practices for use of the meal under field conditions.

Acknowledgements

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References

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