MOLECULAR BREEDING APPROACHES TO SUPPORT ORGANIC WHITE LUPIN BREEDING IN SWITZERLAND

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Abstract Text:

White lupin (*Lupinus albus*, L.) is a very promising crop in organic farming. White lupins are extraordinarily efficient atmospheric nitrogen fixers through their symbiosis with *Bradyrhizobium lupini*. Under phosphorus deficiency, they form specialized root structures, cluster roots, that improve soil exploration and phosphorus use efficiency. Lupins are also biodiversity-friendly crops: their flowers are frequently visited by insects as they attract many pollinators to forage for their pollen. White lupin seed also has great potential as ingredient in plant-based protein foods because of the high protein content, ranging from 28 to 40% in materials (landraces, varieties and breeding lines) tested by FiBL. It has an excellent fibre content and it is gluten-free. Thanks to its desirable ratio of omega-3 to omega-6 fatty acids, non-starch carbohydrates, oligosaccharides and antioxidant content, white lupin seed can be an excellent component of a healthy diet.

FiBL is conducting a pre-breeding programme with the aim of developing material with (i) increased anthracnose resistance (the major fungal disease threat to this crop), (ii) low quinolizidine alkaloid content (these toxic and bitter compounds accumulating in white lupin seeds are a major obstacle to its use in food processing) and (iii) adapted maturation time for Central Europe (as it is used as a spring sown crop in this region). FiBL collaborates with gzpk (non-profit organic breeding organization) to jointly develop varieties for market-release.

In white lupin, anthracnose resistance is polygenically controlled, no complete resistance was observed and only few sources of resistance were identified. Quinolizidine alkaloids (QA) are water soluble and can be removed from the grain by water-based debittering, but this is water, energy and time consuming and difficult to apply where there is no wet step in the food production process. Hence, low QA content is a highly important breeding target. Alkaloid accumulation in the seeds has been described to be controlled by multiple loci, one major locus, *pauper*, with known causal mutation, and several other loci reported, but not genetically mapped.

The organic breeding programme started in 2014, with greenhouse crosses (from 2024 in the field) and all selection steps carried out in certified organic fields, supported by additional phenotyping of breeding lines for anthracnose resistance in climate chamber

conditions. Since both anthracnose resistance and QA content are complex traits, the integration of molecular marker based diagnostic tools is envisaged to support the selection process. We are therefore working to define strategies for combining phenotypic selection under organic conditions with molecular marker-based approaches that are affordable in our small-scale organic breeding programme. As with other minor crops, selection in white lupin lacks the molecular breeding tools (e.g. validated molecular markers) available for major crops, making our objective more challenging.

Therefore, as a first step, we have identified marker-trait assocations for anthracnose resistance and low-alkaloid content through GWAS, Genomic Prediction and Bulked Segregant Analysis. PCR-based markers were developed based on the identified associations from own studies and literature in order to apply marker assisted selection (MAS).

We present our current state of play in complementing phenotypic selection for anthracnose resistance and low alkaloid content with validated diagnostic PCR-based markers