LIBBIO Lupin Bioeconomy Development

Andean lupin (Lupinus mutabilis)

Cropping and its opportunities for Europe

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Lupin as sustainable crop

The Andean lupin, Lupinus mutabilis, is one of the four lupin species which is suitable for human consumption. The Andean lupin originates from South-America where it has been part of the menu for thousands of years. The other three lupin species originate from the Middle East, Southern Europe and North Africa. These lupins are the White, Yellow and the Blue (narrow-leaved) lupins. Andean lupin is like the soy bean high in oil and protein content and therefore has the potential to be a good alternative to many soy bean applications. The objective of the LIBBIO project is to introduce Andean lupin to Europe, as a new crop for food and non-food applications. Andean lupin has the advantages that it grows on marginal soils, makes its own nitrogen fertilizer from air by natural symbiosis with bacteria and, when harvested, has nutritious beans, rich in proteins, vegetable oil and prebiotics. Andean lupin oil is rich in unsaturated fatty acids and high in anti-oxidants and Vitamin-E (tocopherol), thereby contributing to a healthy menu.

Lupin pod with lupin beans

Good for the soil

A farmer with care for his soil might consider cultivation of lupin crops. Lupins offer many benefits in a sustainable cropping rotation scheme. Symbiotic bacteria living in root nodules on the roots of lupins fixate nitrogen from the air into N-fertilizer for the crop. In addition, lupins increase soil organic matter, which subsequently increases soil biodiversity and water holding capacity. Lupins are known for mobilizing phosphates by making phosphates available for the growing crop by lupin root extrudates.

Root nodules with symbiotic N-fixing Rhizobia bacteria

Lupin crop yields

Crop yields of all lupin species are relatively low. Average crop yields for all lupin species in NW-Europe are between 2,5 – 3,5 ton/ha. Break-even crop yields, when compared with wheat, would be between 3-4 ton/ha for NW-Europe and around 1,5-3 ton/ha for East and South Europe. Breeding efforts for increasing crop yield and improved

disease resistance is ongoing and results are promising. The Andean lupin has an additional economic benefit because of its high oil content of 18-20%.

Lupin for Soy, opportunities for Europe

The lupin bean can easily replace the soy bean. Soy is used extensively and globally as an ingredient for food, feed and non-food applications. European consumers are reluctant to use genetically modified soy or soy products. This opens up possibilities for alternative protein and oil crops such as lupin. Cropping lupin in the EU would make the EU more independent from North and South-American soy imports and, moreover, also prevent loss of rain-forest and biodiversity in South-America. The blue (small leafed), yellow and white lupins are adapted to the climatic conditions of NW-Europe, regions where growing soy is not favourable because of temperature constraints. The Andean lupin is new to Europe and can be adapted through cultivation and selection to European agro-climatic conditions.

Lupin field in the Netherlands

Traditional Andean lupin cropping in Ecuador

Andean lupin (Lupinus mutabilis)

Andean lupin (Lupinus mutabilis) is a lupin species traditionally grown in the Andean highland regions of Bolivia, Ecuador and Peru. This crop has not yet been adapted to modern agricultural practices, despite its promising nutritional qualities. Cultivation of this lupin species has begun in Chili, Ecuador and now also in Europe within the LIBBIO project. Compared to other grain legumes this lupin species has the highest levels of protein (45-50%), which is even higher than that of soy. Andean lupins also contain a similar amount of oil as soy (18%) making the grains interesting for both feed and food. Another feature that makes this crop interesting is the fact that the material shows very vigorous growth, producing large amount of biomass without the need for extensive N-fertilisation.

Composition lupin seeds compared with other major protein-oil crops								
		White lupin	Bleu lupin	Yellow lupin	Andean lupin	Soy bean	Sunflower	Rapeseed
Moisture	g /100 g fw	8.6	9.0	9.4	8.1	8.54	4.73	9.4
Metabolic energy	kJ/ 100 g dw	2078	2032	2164	2307	2040	2565	1920
Crude protein	g/100 g dw	38.2	33.9	42.2	43.3	39.9	21.8	20
Crude lipids	g/100 g dw	11.2	6.3	5.5	18.9	21.8	54.0	46
Fiber	g/100 g dw	8.9	16.0	15.8	8.2	10.2	9.0	
Ash	g/100 g dw	3.4	3.0	3.8	3.9	5.3	2.8	
Carbohydrates	g/100 g dw	39.3	41.0	38.8	32.9	33.0	21.0	

Agronomic features compared to other lupin species

Availability of seeds

As opposed to the other lupin species (blue - narrow-leaved), white and yellow lupin) Andean lupin is not readily available on the market yet. Worldwide there is only one registered variety which is cultivated in Chili, but this is not available in Europe. Field trials and small-scale primary production is therefore still conducted with landraces from the Andean region or from purified lines from this material. In LIBBIO we are working on the registration of the first, early flowering variety which hopefully will be the starting point of the introduction of this crop to Europe.

Feldversuch mit Andenlupinen an der Agraruniversität Lissabon, Portugal

Cropping aim

At this moment LIBBIO is looking into two possible uses for Andean lupins: high protein, dry grain production and biomass production, either for feed, biogas or biobased materials. For northern Europe most of the landraces have a long growing season of more than 200 days. In the LIBBIO project selected lines have proven to be relatively early in flowering and pod setting, making these lines suitable for dry grain production in the South and Eastern parts of Europe. Some promising lines are in development for NW-Europe as well, making them suitable as a dry grain harvestable crop in that specific ecoregion. Furthermore, progress has also been made in Poland for more restricted branching, earlier ripening cultivation lines that could make the crop also suitable for northern Europe in the near future.

Agronomic needs compared to other lupins

Blue (narrow-leaved) lupin *(Lupinus Angustifolius)*

Blue lupins have a very high frost tolerance to -8 to -10 degrees Celsius. This makes early sowing in NW-Europe possible. Blue lupin is best adapted to low calcareous soils with a maximum calcium content (free CaCO3) of 0,8%, the optimal pH is between 4,5 and 6,8. The number of growing days is between 120-150 days. There are varieties which are early and branching, other varieties are late and non-branching. Blue lupin is relatively tolerant to anthracnose. Yield potential is 2-5 t/ha.

Bleu lupin flower (cv Haags Blaue) and seeds (cv Regent)

White lupine *(Lupinus Albus)*

White lupins are moderately frost tolerant to -6 to -8 degrees Celsius. White lupin is less sensitive to high calcium levels in soils, variation between varieties occurs. The optimal pH is between 5,5 en 8,0. The number of growing days is between 140-175 days. There are varieties which are early and branching, other varieties are late and non-branching. White lupin is sensitive to anthracnose. Yield potential is 2-6 t/ha.

White lupin and seeds (cv Boros)

Yellow Lupin (*Lupinus Luteus*)

Yellow lupins have a low pH tolerance of 4,5-6,0. Yellow lupins are drought tolerant. The number of growing days is between 135-150 days and the yield potential is 1-3 t/ha.

Yellow lupin flowers and seeds (cv Puma)

Andean Lupin (*Lupinus mutabilis*)

Andean lupins have a frost tolerance to -3 to -5 degrees Celsius. Andean lupin can grow on a large diversity of soil types. It can also be cultivated on more productive soil types like loamy soil or light clay soils. In contrast to the other lupins this lupin is the most calcium tolerant. Free CaCO3 levels of up to 20% are possible. The length of the growing period is the largest of all lupins, there are early lines with 150 growing days to full yellow ripeness or late lines with more than 200 growing days under northern European conditions. Under Southern European conditions growing days can be between 140-170. The LIBBIO project has selected some promising early lines for NW-Europe with 150 growth days to full yellow ripeness, For southern Europe the yield potential seems to be 2,5-3,0 t/ha at this moment. Andean lupin is susceptible to anthracnose.

Andean lupin with flower, pod and seeds

Crop Management

Sowing
Sowing date: due to the high frost sensitivity, Andean lupins need to be sown relatively late in the growing season similar to the sowing time of soy.

Sowing density: due to the high biomass growth, Andean lupins need to be sown at a much lower plant density than other lupins.

Sowing density,	**plants/m2**
Not branching blue lupin:	120-140
Branching blue and yellow lupin	80-100
White lupin	60-70
Andean lupin	20-25

Inoculation: in contrast to other lupin species, Andean lupins seem to be able to cope with the naturally available rhizobia in most soils. In field trials, crop development did not respond to an addition of commercially available inoculum developed for European lupin species.

Due to the large crop heigh Andean lupins can easily be sown in rows with a row spacing of 50 cm, making mechanical weed control by means of a hoe very effective. The sowing depth is comparable to white lupins (3-5 cm).

Weeds, pests and diseases
Weeds: in a lot of countries in Europe, lupins are not cultivated regularly, leading to a limited availability of agrochemicals for crop protection. This is certainly the case for Andean lupins. For weed control some pre-emergence herbicides are allowed in lupins in general or in dry pulses and these might be used for Andean lupins as well. In a herbicide screening it was found that commonly used herbicides like Stomp and Boxer can be used safely for Andean lupins as well. Due to the fact that hardly any post-emergence herbicides are available, weed control in lupins needs an additional effort made by mechanical weed control (harrowing and/or hoeing). As Andean lupins can be sown with a wide row-spacing, hoeing is the most effective way of weed control. Andean lupins are quite tolerant to harrowing.

Diseases: in the early phases of development lupins are sensitive to soil borne fungi and to Agriotes (click beetle, wireworm). Significant diseases during development are Botrytus and Anthracnose.

Pests: compared to grain legumes like Fava beans, lupins are relative insensitive to black-bean aphids. The specialized Lupin aphid though, which is immune to lupin alkaloids and uses the alkaloids for its own protection, can become a problem especially in varieties with (relatively) high alkaloid levels. As the breeding of sweet Andean lupin varieties is still in progress, most Andean lupin landraces are high in alkaloid and therefore sensitive to Lupin aphid. These alkaloids make lupins less attractive to hares, rabbits and deer.

Harvest

Harvesting time: The early Andean lupin lines in N-Europe reach their "date of yellow ripeness of whole plant (BBCH 87)" at the end of August and the beginning of September. Late lines, if the plants stay healthy, can keep on growing till October or November and still produce new flowers. In the southern parts of Europe, dry grain harvest is done in May/June when the drought stops plant growth in general. Andean lupin lines are in development for optimizing dry grain harvest.

Anthracnose in lupin

LIBBIO, lupin beauty from marginal soils

Perspective

The Andean lupin, one of the lost crops of the Incas, still has great and unlocked potential. Intensive research and development in Peru, Ecuador and Europe contribute to adaptation of this traditional crop to modern agricultural practices. The Andean lupin bean composition, rich in proteins and oils, makes it a precious crop for applications in, food, animal feed and cosmetics. Its capacity to grow on marginal lands makes it an interesting crop in addition to traditional European cropping systems. Added value applications for cosmetics and food such as lipsticks, anti-aging skin care, prebiotic yoghurts, tasty chocolate spreads and vegan chocolate bars, make this crop an interesting opportunity for both European consumers, interested producers and entrepreneurs. ZoiY® natural cosmetics is one of the first cosmetic brands that recognises the potential of lupin ingredients for protective skin and hair care products. The LIBBIO project contributes with a substantial investment in supply chains and new product development for establishing a sustainable Andean lupin production and supply chain in Europe.

ZoiY® natural cosmetics with lupin ingredients for skin and hair care www.zoiy.eu

LIBBIO: Lupinus mutabilis for Increasing Biomass from marginal lands and value for BIOrefineries

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