NARROW LEAFED LUPIN BREEDING IN SAATZUCHT STEINACH A PRIVATE COMPANY INTEGRATED IN A NETWORK OF RESEARCH AND DEVELOPMENT

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ABSTRACT

Saatzucht Steinach GmbH is a medium sized private breeding company in Germany. Since about 1997 the focus of lupin breeding has been on *Lupinus angustifolius*. Traditionally lupins are grown in the north-eastern part of Germany on poor sandy soils. In 2003 a series of applications for public funding of breeding research was started to collaborate with public research institutes and this has resulted an expansion of the lupin breeding program enormously. Currently, we have started research in topics, such as *Colletotrichum*- and soil borne fungal-disease resistances, Setoria resistance, interspecific crosses, pH-tolerance, protein content and protein quality, pod set and seed shattering, branching and use of lupins for food.

KEYWORDS

Lupinus angustifolius, breeding, research and development

INTRODUCTION

Growing narrow leafed lupins has a short history in Germany. Until the mid 1990s yellow lupins were grown especially in the north-eastern part of the country. After 1997 the area of yellow lupins decreased dramatically (Fig. 1) due to the fact that no seed propagation was possible because of Anthracnose disease. It was nearly impossible to get positive field inspection results from the multiplication areas of yellow lupins. White lupins did not reach a remarkable acreage in Germany because of their long growing period.

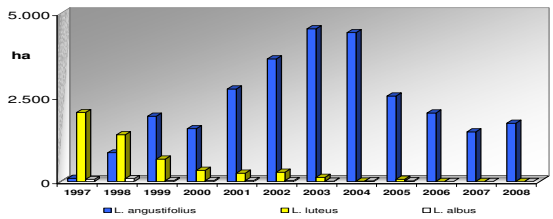

Fig. 1. Seed multiplication area of lupin species in Germany 1997-2008.

In the mid 1990s Franz Haag (1948-2006) started to breed narrow leafed lupins in the Saatzucht Steinach breeding station Bornhof, near to Klink/Müritz. In 1997 the varieties Borweta and Bordako were listed in Germany and after that several varieties have been added to the national list. The latest releases are 'Haags Blaue' and 'Sonate' (BSA, 2007). In recent years these varieties raised considerable interests in neighbouring countries, such as Austria, Czech Republic, Denmark, Poland, Sweden, United Kingdom, Lithuania, Belorussia and Russia. Fig. 1 shows a decreasing interest in narrow leafed lupins from 2005, however in 2008 the seed multiplication area increased slightly. Furthermore there is an increasing request for lupin seeds from the industry and strong signals and impulses are coming from the ministry of agriculture to increase local grain legume production, especially narrow leafed lupins.

Currently, about 15 ha breeding nurseries of *Lupinus angustifolius* are planted each year in Bornhof (responsibility Regine Dieterich) and the breeding intensity is increasing from year to year. The most important breeding goals for *L. angustifolius* in Saatzucht Steinach GmbH are as follows:

Productivity

1. Seed yield
2. Raw protein yield
3. Number of pods
4. Number of seeds per pod
5. Thousand kernel weight

Yield stability

1. Frost tolerance
2. Drought tolerance
3. Lodging resistance
4. Pod shattering resistance
5. Flower dehiscence (abortion)
6. Soil pH tolerance
7. Early ripening
8. Equal ripening

Disease resistance

1. *Colletotrichum*
2. Soil borne fungal pathogens
3. *Setoria* beetle

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Seed quality

1. Protein quality
2. Antinutritive substances
3. Alkaloids
4. Fibre content and quality
5. Phytoestrogens
6. Oil quality

To reach and combine all these goals means a huge amount of breeding effort. Since the Saatzucht Steinach GmbH has none of its own laboratories or biotech-branch it became necessary to start collaborations with breeding researchers and biotech institutes. In the meantime the company is integrated in a network of several institutes and partners working on lupin topics with different disciplines and on different levels. In the following several important topics, partners and results are being described and a short outlook on future breeding and research activities is given.

PRODUCTIVITY

Yield trials within Saatzucht Steinach GmbH are carried out at two locations. One location is the breeding nursery in Bocksee of the breeding station Bornhof with very poor sandy soils and strong spring- and summer drought in the north eastern part of Germany. Selection for drought tolerance is of increasing interest at this location. The other location is in the south of Germany in Steinach in Bavaria with very good soils and more than 800 mm of natural precipitation with good distribution of the precipitation. At the northern testing location in and around Bocksee a reliable and equal maturation can be expected, however with low seed yield levels (2.0-2.5 to/ha). Disease notations are very important there because this area is the most important seed production area. At the southern location in Steinach characters like pH-tolerance, reliable and early ripening, branching and lodging are in the focus of observation. Seed yield potential in Steinach is about 3.0 to 4.0 to/ha on adequate soils with favourable pH.

YIELD STABILITY

Under optimal conditions a grain yield of 5.3 to/ha has been harvested with the variety 'Boregine'. This shows that there is already a high seed-yield potential in narrow leafed lupins. This potential is limited by pod shattering and flower abortion, amongst others. There is a limited variation in narrow leafed lupins for the characters 'pod shattering' and 'flower dehiscence'. For efficient selection, however this natural variation is too low. According to the law of homologous series it should be possible to find non-pod-shattering and non-dehiscence mutants in *Lupinus angustifolius*. For this reason an EMS mutation program of the variety 'Boruta' was carried out together with the Julius Kühn Institute for breeding research in agricultural crops. In M_2 and M_3 these characters have been observed. However no positive mutants for these specific characters have been found so far, while for other characters several interesting mutants have been identified. It is planned to carry out further EMS applications within other genetic backgrounds (Rudloff and Eickmeyer, 2008).

Another limiting factor is the tendency of indeterminate types to form side-branches before harvest, when there is enough humidity in the ground. This leads to a ripening delay and deteriorates the seed quality. Variety types like 'Boruta' show this negative character. Studies of the root system are conducted in order to answer the question why single plants within 'Boruta' tend to form side branches while others don't show this character.

PROTEIN CONTENT AND QUALITY

In the Julius-Kühn-Institute of abiotic stress tolerance a calibration was developed for NIR single kernel analysis of protein content (Jansen and Kuhlmann, 2007). Reliable ($r^2 = 0.907$) predictions about single kernel protein content can be made. To use this non destructive, cheap and quick technique is a very valuable tool in breeding for protein content. However it was found that there is a broad range of variation in protein content within the single kernels harvested from a single plant. Furthermore, there seems to be no systematic distribution of different levels of protein in different pod position and in the kernel position within the pods. Efforts to separate the genetic component of protein content from environmental effects are being made, especially with emphasis on the effect of temperature during seed maturation (Jansen, 2008) and this shall be further investigated from 2009-2012.

As a limiting factor in the use of lupin protein the proportion of the amino acid methionine should be improved. It was found that in seeds with low levels of protein content the relative amount of methionine was quite high. From soybean it is known that there are phenotypic hints (dark leaf colour) closely correlated with a high methionine proportion. This will be checked in a series of *L. angustifolius* mutant lines (Rudloff and Eickmeyer, 2008) in the near future. Again for methionine content the genetic component has to be separated from environmental effects in order to reach an efficient breeding program for this character.

PESTS AND DISEASES

In *Colletotrichum* resistance breeding a marker based transfer (Yang *et al.* 2004; You *et al.* 2005) of the resistance described in the varieties 'Tanjil' and 'Wonga' was successfully carried out. Furthermore a presumably new resistance has been detected in the Saatzucht Steinach germplasm, which seems to be even stronger than the lanR1-gene (Thiele *et al.* 2008).

For some soil borne fungi (*Sclerotinia sclerotiorum, Thielaviopsis basicola, Rhizoctonia solani, Fusarium oxysporum and Fusarium culmorum*) differences in the level of tolerance of different varieties have been

detected by Kaufmann (2008) in cooperation with the University of Rostock.

PCR-based detection with pathogen specific primers was established and isolation- and multiplication-procedures of the fungal pathogens have been elaborated (Thalmann *et al.* 2008). For some pathogens artificial infection tests are carried out to overcome the problem of mixed-infection in resistance breeding. Segregating F_2-families are actually produced to be able to analyse the inheritance of some of the differences found in resistance/tolerance level. In the frame of an ERA-Net Plant Genomics project together with the company GeneXPro (Peter Winter) a legume resistance gene-chip shall be developed, which could incorporate candidate genes for the resistances found.

In a new project together with the University of Rostock and the Ruhr-University of Bochum the signal substances (vos = volatile organic substances) which attract the *Setoria*-beetle shall be identified and strategies to overcome the beetle-problem shall be proposed.

OUTLOOK

Several research projects on different topics have just started or are in the application phase. Their results will be presented in future lupin meetings. Saatzucht Steinach GmbH is very much interested in an international cooperation in lupin breeding research and exchange of germplasm, since there are many open questions that have to be answered in lupin breeding.

LITERATURE

BSA. 2007. Descriptive variety list. Beschreibende Sortenliste 2007. Getreide, Mais, Ölfrüchte, Leguminosen (großkörnig) Hackfrüchte (außer Kartoffeln). Deutscher Landwirtschaftsverlag GmbH (In German).

Jansen, G. 2008. Effects of temperature on yield and protein content of *Lupinus angustifolius* cultivars. *IN* J.A. Palta and J. Berger (eds.). Proceedings of the 12th International Lupin Conference, Fremantle, Western Australia.

Jansen, G. and J. Kuhlmann. 2007. Protein analysis in single seeds of lupins to improve protein content by breeding. Proteinuntersuchungen in Einzelsamen von Lupinen zur züchterischen Erhöhung des Eiweißgehaltes. In: S. Zikeli, W. Claupein, S. Dabbert, B. Kaufmann, T. Müller und A. Valle Zárate: Zwischen Tradition und Globalisierung. Beiträge zur 9. Wissenschaftstagung Ökologischer Landbau, 20-23 march 2007 at the University of Hohenheim (In German).

Kaufmann, K. 2008. Development of resistance breeding methods as well as production- and growing-systems for improvement of the cropping ability of new varieties of narrow leafed lupins (*Lupinus angustifolius*) regarding soil borne fungal diseases. Final report of a research project funded by the German Ministry of Economy in the frame of the program PRO INNO II KF0516501MD5 (In German).

Rudloff, E. and F. Eickmeyer. 2008. Some aberrant variants in M_2 lines and the resulting M_3 lines of narrow leafed lupin (*Lupinus angustifolius*) originating from EMS application. This issue.

Thalmann, R., K. Kaufmann and C. Struck. 2008. Black root rot on lupins – an early species-specific detection of the pathogen *Thielaviopsis basicola*. Gesunde Pflanze 60: 67-75 (in German)

Thiele, C., F. Eickmeyer, B. Ruge-Wehling, P. Wehling. 2008. Development of innovative breeding strategies for increasing yield and yield stability and promoting the growing of narrow leafed lupins (*Lupinus angustifolius*) in Germany. *IN* J.A. Palta and J. Berger (eds.). Proceedings of the 12th International Lupin Conference, Fremantle, Western Australia.

Entwicklung und Einsatz innovativer Züchtungsstrategien zur Sicherung und Erhöhung des Ertrages und der Anbaubedeutung der Blauen Süßlupine (*Lupinus angustifolius*). Interim report to the BLE in German, available at http://www.ble.de/cln_116/nn_417426/SharedDocs/Downloads/06__Aktuelles/Publikationen/Broschueren/Innovationstage2008,templateId=raw,property=publicationFile.pdf/Innovationstage2008.pdf page 14-15.

Yang, H., J.G. Boersma, M. You, B.J. Buirchill and M.W. Sweetingham. 2004. Development and implementation of a sequence-specific PCR marker linked to a gene conferring resistance to Anthracnose disease in narrow-leafed lupin (*Lupinus angustifolius* L.) Mol Breed 14: 145-151.

You, M., J.G. Boersma, B.J. Buirchill, M.W. Sweetingham, H.M. Kadambot and H. Yang. 2005. A PCR-based molecular marker applicable for marker-assisted selection for Anthracnose disease resistance in lupin breeding. Cell Mol Biol Lett 10: 123-134.