

New types of faba bean for Danish production of protein

NORFAB: Protein for the Northern hemisphere

Start date April 1st 2016
Innovation Fund Denmark



NORFAB aims and vision

AIMS:

Increase domestic protein production

Maintain global competitiveness

Improve agricultural diversity and sustainability.

VISION:

Assemble key expertise required to develop sophisticated genome-based plant breeding methods

Provide access to germplasm with the relevant genetic diversity.

Improve the yield and quality of faba bean seeds to a level making faba bean a competitive protein crop

Cultivated on up to 10 % of the arable farmland under northern European and Canadian/US northern prairie conditions.

What is special about faba bean based protein production

Plants are primary protein producers synthesizing all amino acids from inorganic nutrients

Protein production based on solar energy

Symbiotic nitrogen fixation provides the nitrogen input to faba beans

Seeds can be stored

Protein can be extracted by dry or wet fractionation

Direct on-farm use

The NORFAB team with complementary expertise

Plant Breeders and feed suppliers:

Nordic Seed: Ahmed Jahoor, Jens Knudsen. Phenotyping and Breeding

Sejet Plant Breeding: Birger Eriksen, Winnie Füchtbauer. Phenotyping and Breeding

DLG-Feed: Thea Dahl Villadsen. Feed value analysis

National academic:

Aarhus University: Jens Stougaard, Stig U. Andersen, Luc Janss, Sabine Ravnskov and Henrik Skovgaard.
Genomics and quantitative genetics/genomic selection. Diseases and pests

University of Copenhagen: Fernando Geu-Flores, Svend Christensen. Biochemistry and drone observations

International:

University of Saskatchewan: Canada. Albert Vandenberg genetics, breeding and crop development

University of Reading: Donal O'Sullivan. Genetics

University of Helsinki: Fred Stoddard and Alan Schulman. Genetics, genomics and quality traits

Short summary, we will:

Develop and characterize a set of 200 geno- and phenotypically diverse faba bean inbred lines

Produce a reference “gene-ome” of gene rich regions to underpin faba bean molecular genetics and breeding

Characterize trait architectures for all relevant faba bean agronomic and disease resistance traits using a novel combined association mapping approach exploiting MAGIC lines.

(**M**ultiparent **A**dvanced **G**eneration **I**nter-**C**ross population app 300 lines)

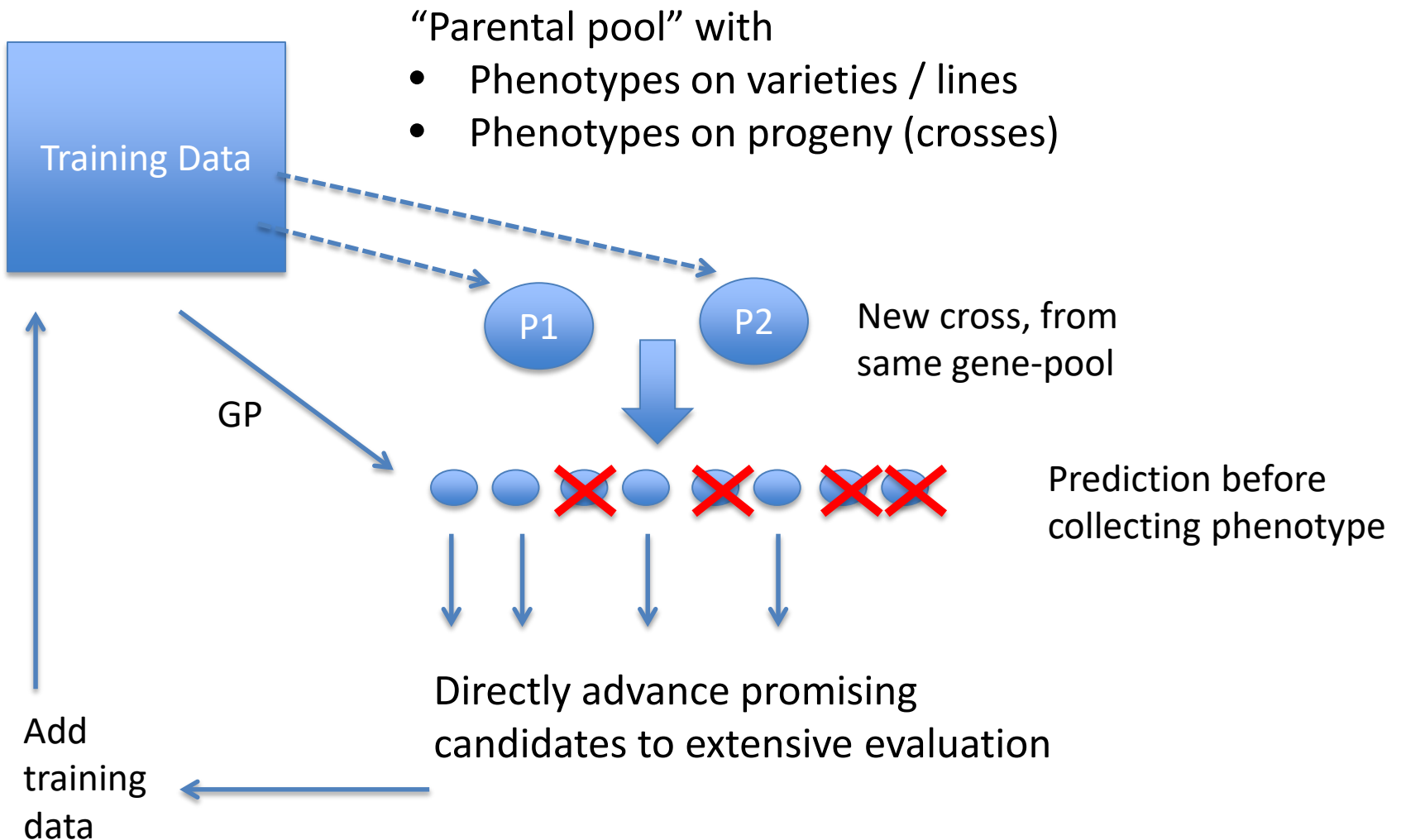
Develop genomic prediction models for parent combining ability and efficient progeny selection

Select a subset of inbred lines as basis for future breeding of synthetic faba bean varieties

Provide the advanced mapping populations, mutant lines, genotyping technology and quantitative genetics methods required to build and sustain a world-leading faba bean breeding platform

NORFAB approach to breeding

Genomic Prediction



Key components in breeding based on genomic prediction

Biodiversity

Phenotyping

Genome information - Genotyping

Modelling

Biodiversity in core collection

The core collection of 200 faba bean genotypes have been assembled and are under propagation.

To reduce the heterozygosity of the previous un-bred landrace material a rapid generation inbreeding scheme developed at Saskatchewan was established at Sejet Plant Breeding. New Zealand propagation under negotiation.

Parents for a Multiparent Advanced Generation Inter-Cross population (MAGIC II) were selected from this material and a cross-pollination scheme decided and initiated.



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Field phenotyping.

Protocols for monitoring the most important agronomic traits (phenotypes) in place at all locations

Emergence and establishment: date, and drone imaging

Earliness (flowering): date of 80% open flowers

Ripening date: 90-95% black pods

Seed size: TGW

Basal branching: Scale 1-5

Stem breaking/lodging: Scale 0-9

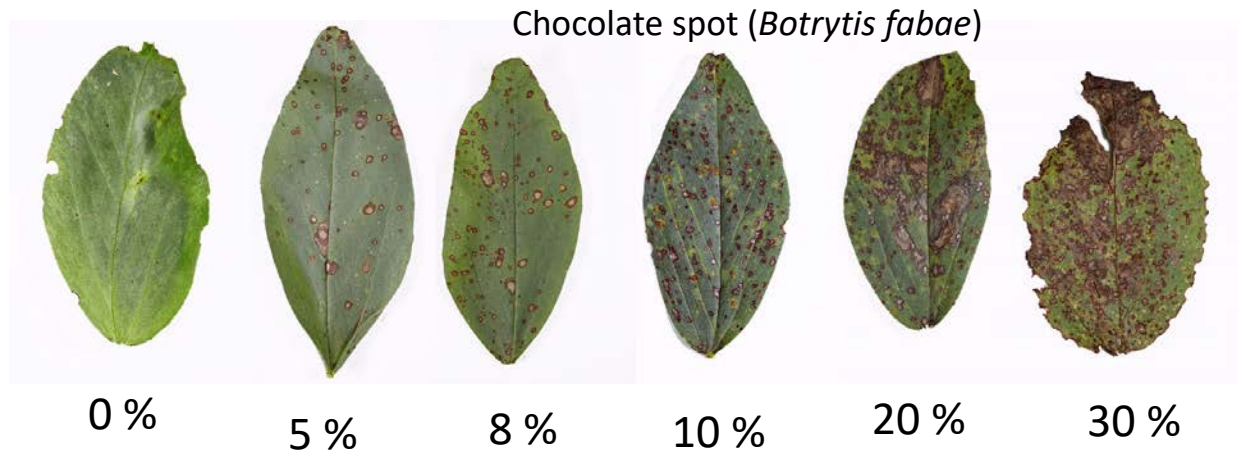
Drought resistance: Helsinki

Yield

Seed protein content

WP2: Field phenotyping.

Protocols for phenotyping aphids and disease tolerance, are now in place and the first field observations using these protocols were obtained.



In parallel, drone based aerial imaging was implemented.



Nordic Seed July 4th



Nordic Seed August 23th



Aphid attack (*Abis fabea*)

WP3: Screening Faba bean lines for disease and pest resistance. WP-leader Ravnskov.

To complement the field phenotype scoring of diseases NORFAB will focus on developing a pathosystem for chocolate spot caused by *Ascochyta fabae*. Chocolate spot is the most prominent disease

Assays for phenotyping selected lines from the core- and Magic populations for disease and aphid resistance under controlled greenhouse conditions are being developed.

Produce *Botrytis fabae* spores and inoculation of plants.



Inoculated and non-inoculated cv. Kontu, one week after inoculation (© Amy Sayer).



Click cages for measuring aphid multiplication

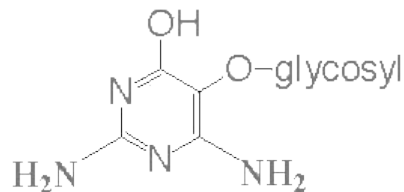
WP4: Antinutrients. WP-leader Fernando Geu-Flores.

A fast mass spectroscopy methods for determining the anti-nutritional pyrimidine glucosides vicine and convicine in the many samples collected from NORFAB plant material has been tested and found to be robust.

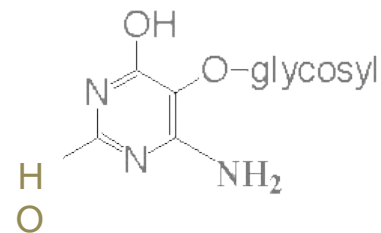
This method is crucial for both the genetic and the biochemical approaches to elucidate the vicine and convicine biosynthetic pathway and ultimately identify faba bean cultivars with low or no vicine and convicine content.

A combined transcriptome metabolome analysis has been initiated the support elucidation of the vicine and convicine biosynthetic pathway .

Vicine



Convicine



Pyrimidine glycosides: ~1% of faba bean dry matter
Reduce feed intake by pigs and poultry

WP5: Genomics. WP-leader Stig Uggerhøj Andersen.

- A high-quality faba reference transcriptome has been completed
- This is being expanded to a pan-transcriptome using 5 additional faba accessions
- A faba gene expression atlas has been completed
- The expression atlas will be extended with a time series of botrytis responses
- Gene structures will be characterised using high accurate long reads (PacBio SEQUEL v. 6)
- 40 X coverage through joint funding
- Genotyping will be carried out using a 50k SNP chip, based on the NORFAB reference gene
- polymorphisms for chip design from both NORFAB RNA-seq data and INRA exome capture data
- Comprehensive database for phenotype data has been constructed this holds information on plot locations, management, phenotype descriptions and scores in a relational database structure

Is faba bean a competitive crop in Denmark?

[Landbrugsavisen.dk](#) | [Nyhedsbreve](#) | [Om os](#) | [Annoncering](#) | [E-paper](#) 

 Derfor Plus: 

Hestebønner kan konkurrere med 70 hkg maltbyg

Hestebønner er et reelt alternativ til korndyrkning.

28. mar | 09:20 |  Skrevet af [Landbrugsavisen.dk](#) | 



Arkivfoto

Af Lars Klausen, planteavlskonsulent og Anders Nielsen, praktikant, begge Agrovi

Seneste fra konsulenterne



Få succes med vækstregulering i vintersæd - koldt vejr har stoppet vækst
4. maj | 08:52 | [Konsulent](#) 



Vinterrapsen skal svampebehandles når varmen kommer tilbage
28. apr | 09:41 | [Konsulent](#) 

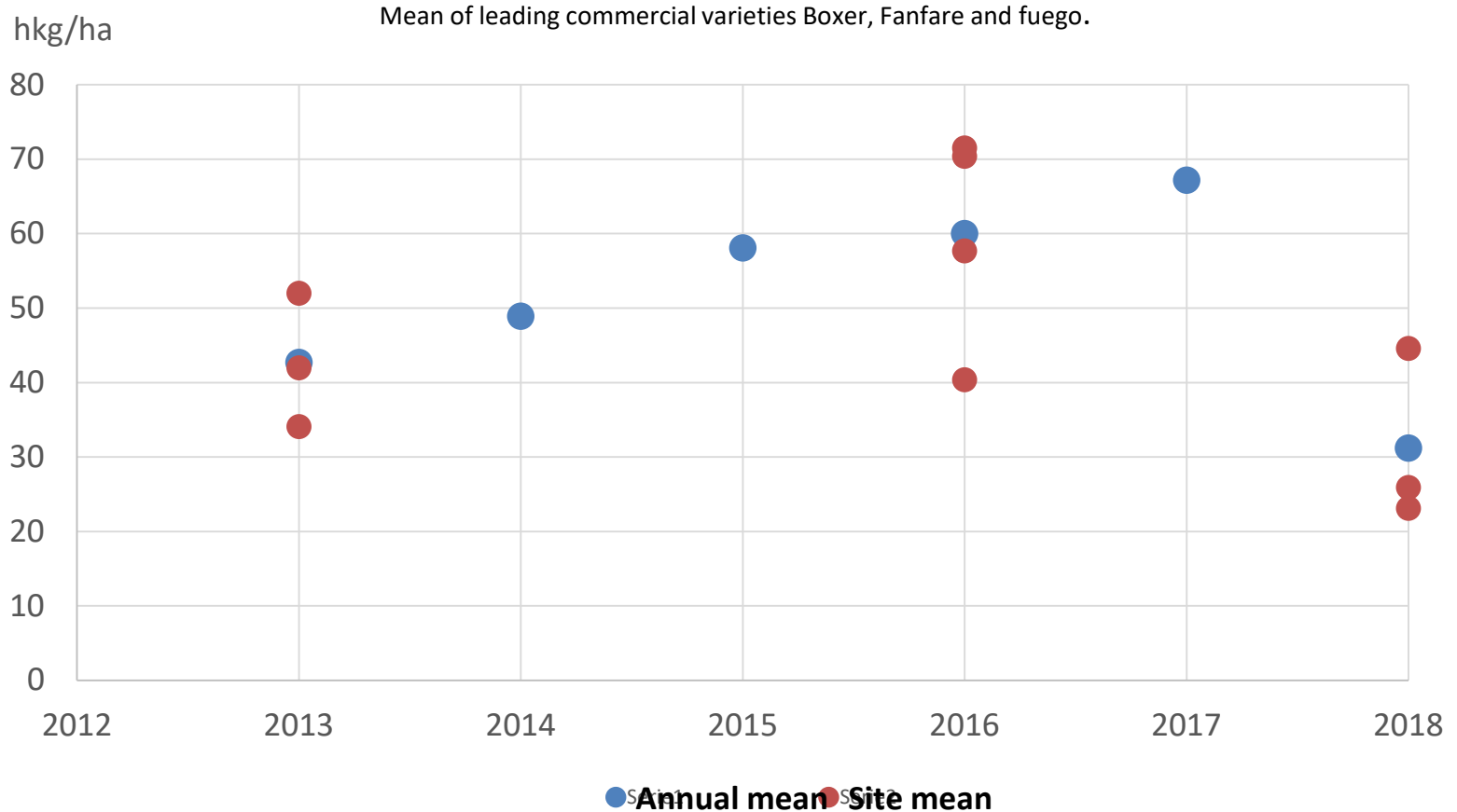


Cropsat kan optimere økonomien i gødning af vinterhvede
27. apr | 10:58 | [Konsulent](#) 



Dette er vigtigt at huske, når du sår majs
19. apr | 15:44 | [Konsulent](#) 

Yield faba bean 2013 to 2018 in farmers unions trials



Dyrkningsarealet stiger

År	Acreage	Gns hkg/ha	Fanfare hkg/ha
2010	1000		40,7
2013	2646	41,5	44,6
2014	4120	48,98	51,5
2015	7000	56,5	58,5
2016	10692,3	61,4	62,3
2017	14800	80,3	83,3
2018	24823	32	31,8



Sådan opnår du en høj
dyrkningsikkerhed i

Plantekongressen 2016 - Session J - Dyrkning af Hestebønner
Planteavlskonsulent Anders Smedemand - Musse - Sønderjysk Landboforening

Arealet udvides fordi.....

- **Forædling af nye sorter**
 - højere udbytter
 - tidligere høst
- **Ændret dyrkningspraksis**
- **Flere hjemmeblandere ser fordel i at kunne dyrke deres eget protein**
- **Fantastisk forfrugtsværdi**
 - Ukrudtssanerende (græsukrudt)
 - Sygdomssanerende
 - Mere kvælstof og liv til jorden



Future perspectives:

Protein quality f.ex higher methionine and cysteine content

Protein fractions for food

Protein for specialized food and feed

Reduced vicine and convicine content, cause favism in people with a genetically inherited glucose-6-phosphate dehydrogenase (G6PD) deficiency , app 400 mio affected.

Stig U. Andersen coordinates ERA-NET SusCrop project “ProFaba”:
Developing improved *Vicia faba* breeding practices and varieties to drive
domestic protein production in the European Union”.

ProFaba - ERA-NET SusCrop project



Nadim Tayeh & Gregoire Aubert
bruchid tolerance



Wolfgang Link
frost tolerance



Olaf Sass
breeder

GSP
Groupement des
Sélectionneurs de
Protéagineux
Francoise Labalette
breeder



Coordinator: Stig U. Andersen
rhizobium interactions
web portal for data sharing



Winnie Füchtbauer
breeder



UNIVERSITY OF HELSINKI
Fred Stoddard & Alan Schulman
acid tolerance



Ana M. Torres
disease & autofertility



Ignacio Solis
breeder



Shiela Alves
protein quality



Donal O'Sullivan
protein quality
genotyping

Fred Stoddard coordinates ERA-NET SusCrop project “Legume-Gap”:
Increasing productivity and sustainability of European protein production by closing
the grain legume yield gap



Thanks for your attention

Balance in Danish protein feed supply 2015

	total	Danish	Import
	mio. kg	pct.	
Feed consumption total	2706	60,8	39,2
Cereals	590	95,5	4,5
Protein supplements	1155	11,3	88,7
Pulses	7 0,3%	52,8	47,2
Oil cake	994	6,9	93,1