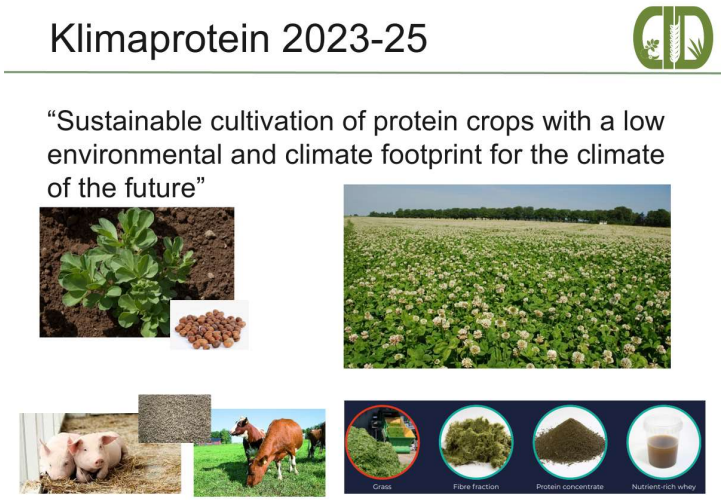
6. Status on Promilleafgiftsfonden projects - 25 & 26

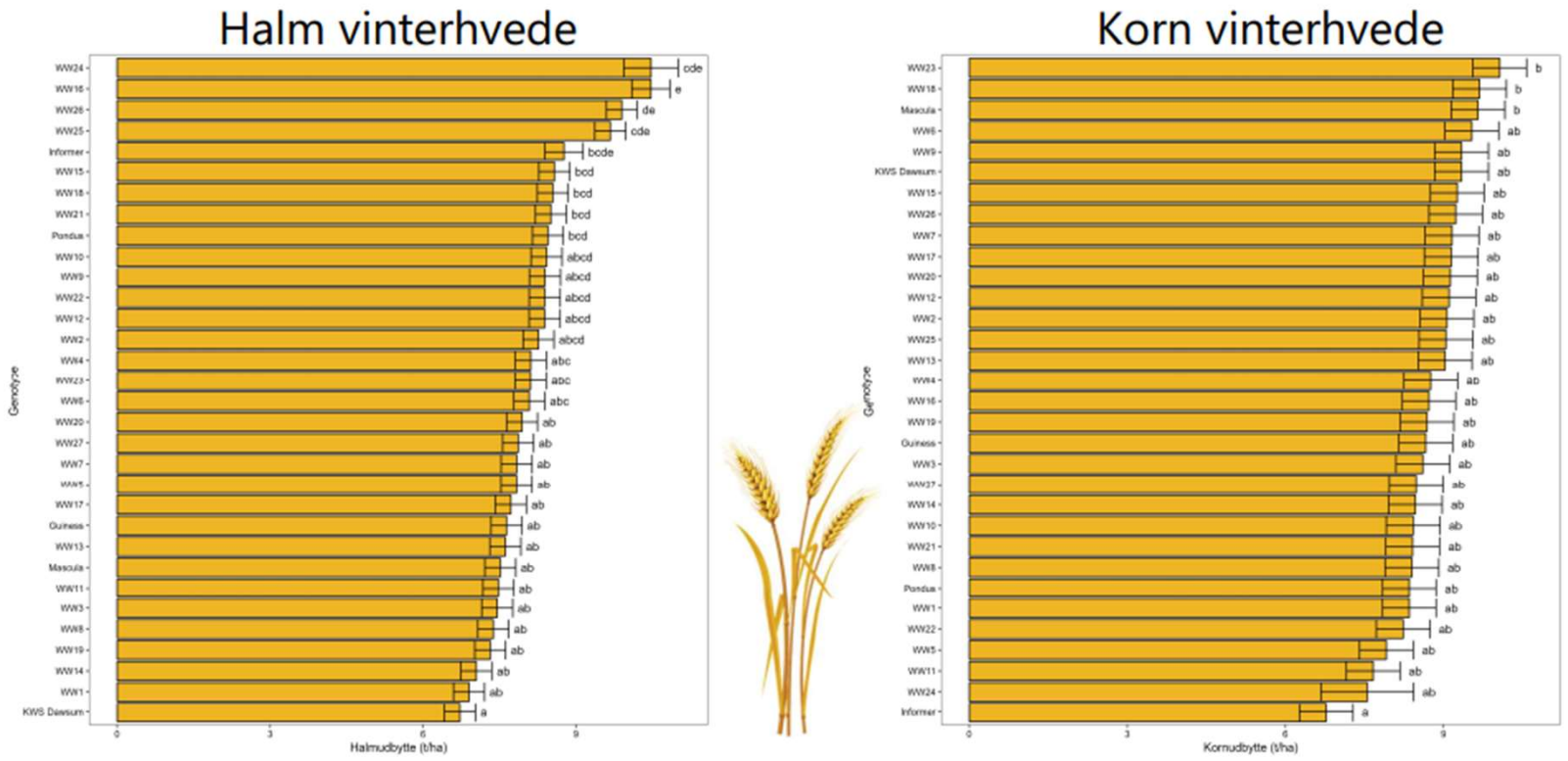
- 2023-2025
  - ❖Halm til det hele (Straw yield + Protein Wheat)
  - ❖KlimaProtein (Drought/roots Faba bean + Clovers)



HTDH: HalmTilDetHele – background/potentials

HTDH: Large variation in straw yield, also in high yielding varieties.

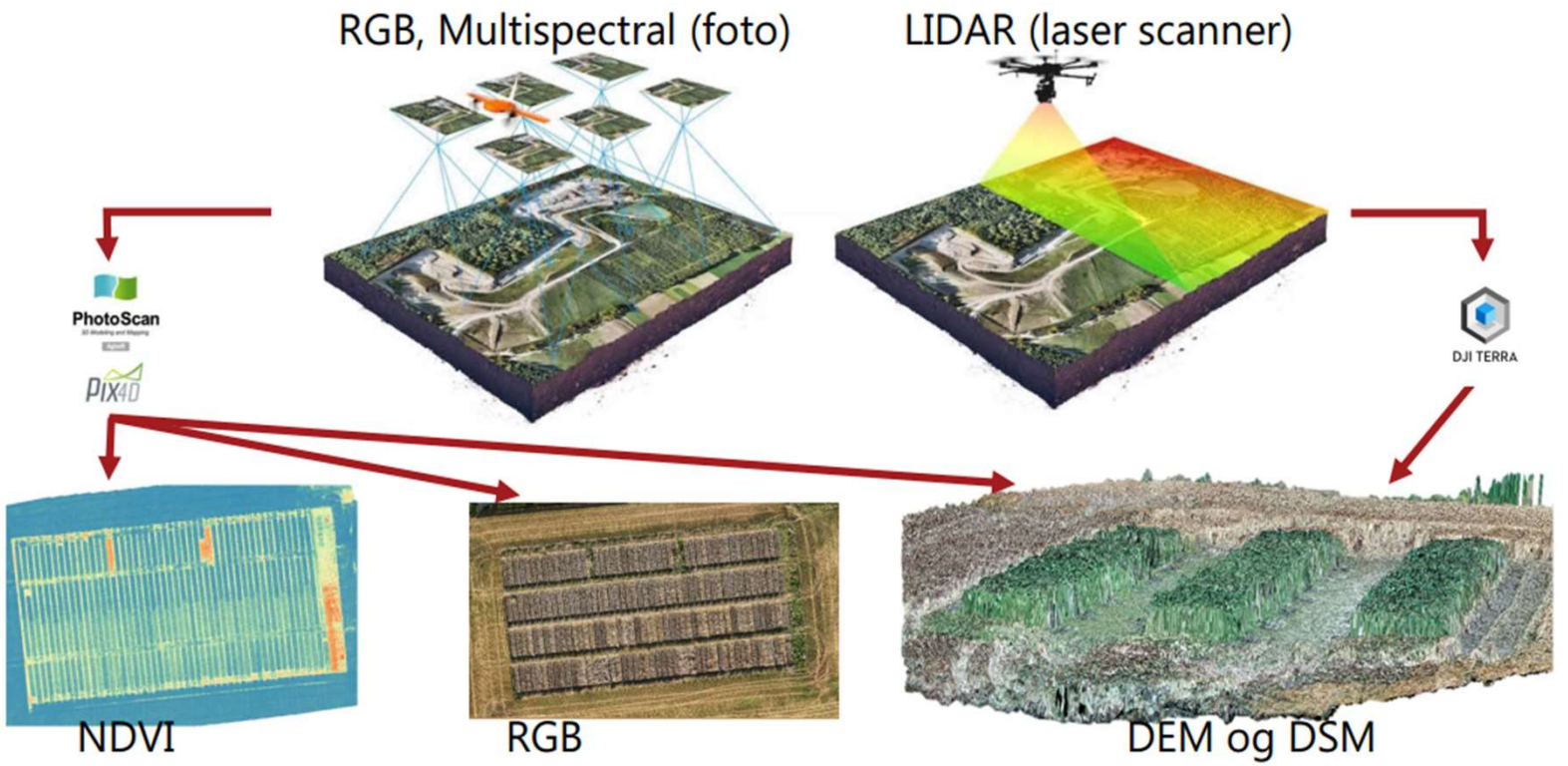
Variation i udbyttet



HTDH: Potentialer for brug af droner til biomasse bestemmelse

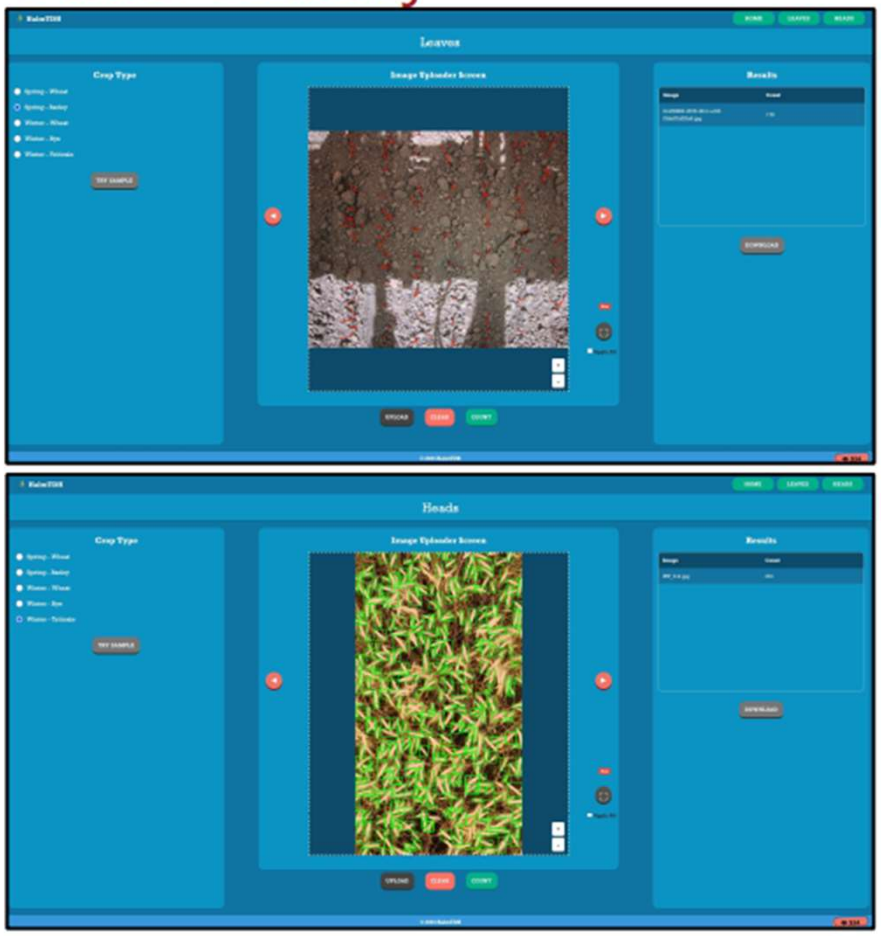
Måling af digitale højder og biomasse dække

https://www.mosaic51.com/technology/lidar-vs-photogrammetry-which-is-better-for-point-cloud-creation/



HTDH - Digitale modeller baseret på dronedata til brug hos forædlerne

Online værktøj

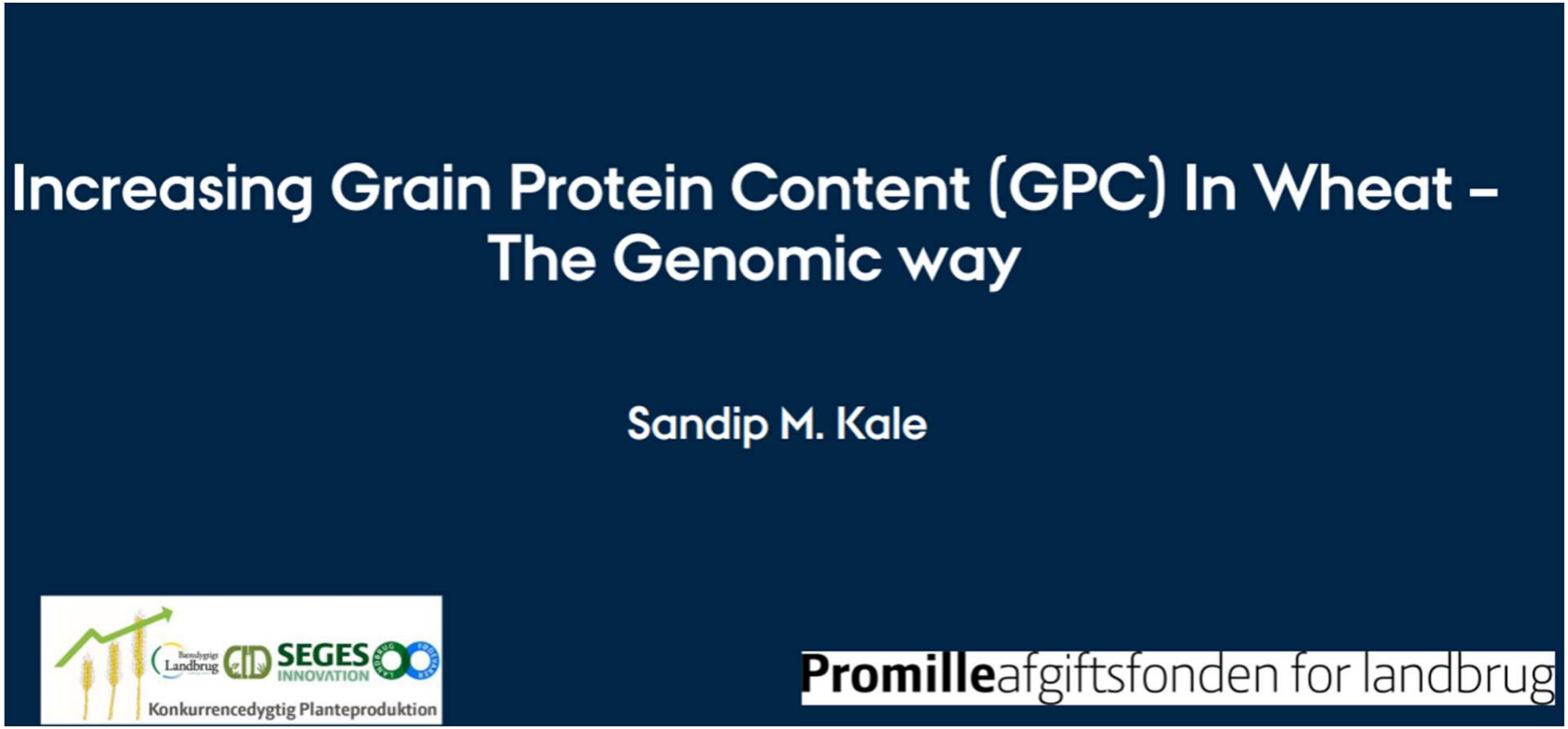


https://halmtdh.atkhan.info/

- Fri tilgængelig website
- Afgrøde-specifikke modeller
- Plantetælling
- Asktælling

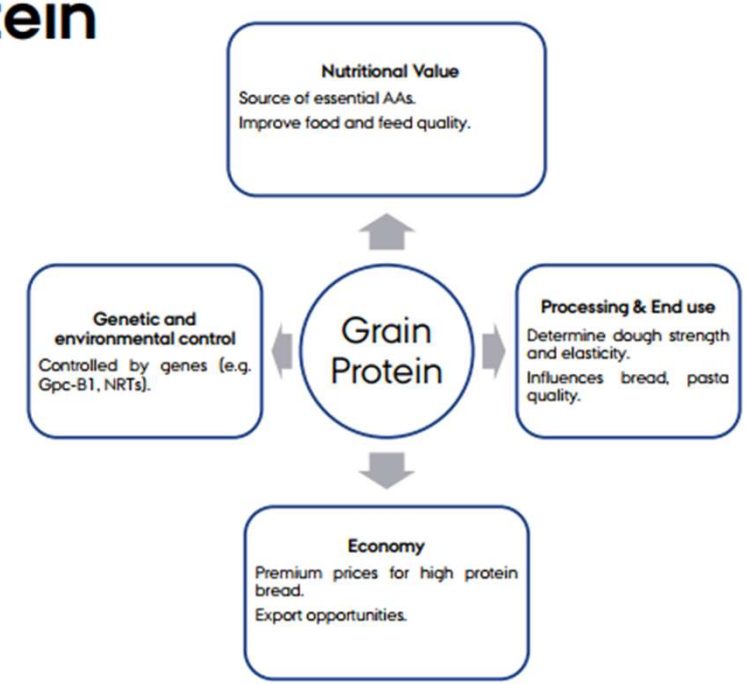
Billige metoder til at kvantificere
flere udbytte komponenter I marken,
Der kan bruges aktivt I forædlingen af
Mere højtydende sorter.

HTDH: Protein winterwheat



HTDH: Increasing the gran protein content (GPC) in wheat – the genomic way.

Wheat Grain Protein

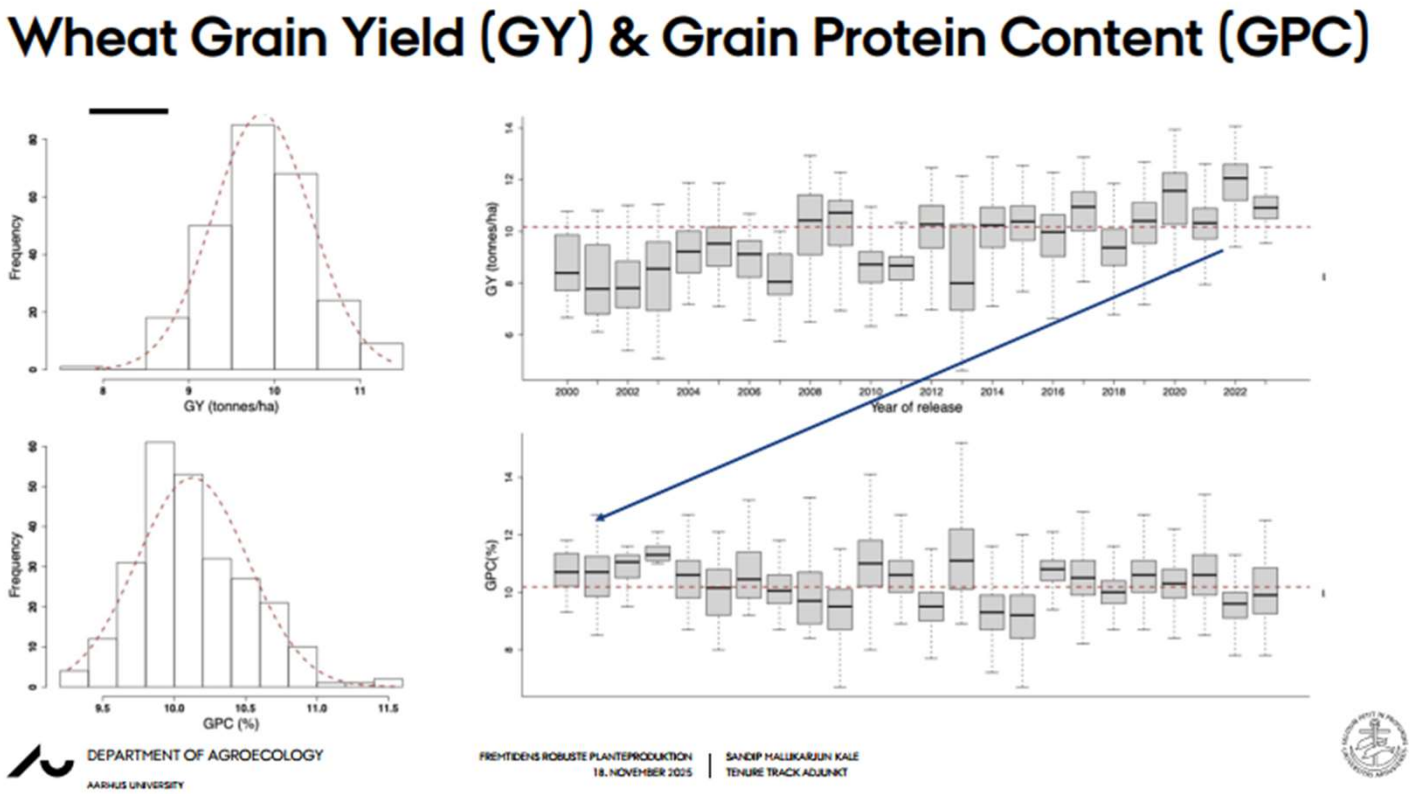


DEPARTMENT OF AGROECOLOGY
AARHUS UNIVERSITY

FREMTIDENS ROBUSTE PLANTEPRODUKTION
18. NOVEMBER 2025 | SANDIP MALLIKARJUN KALE
TENURE TRACK ADJUNKT

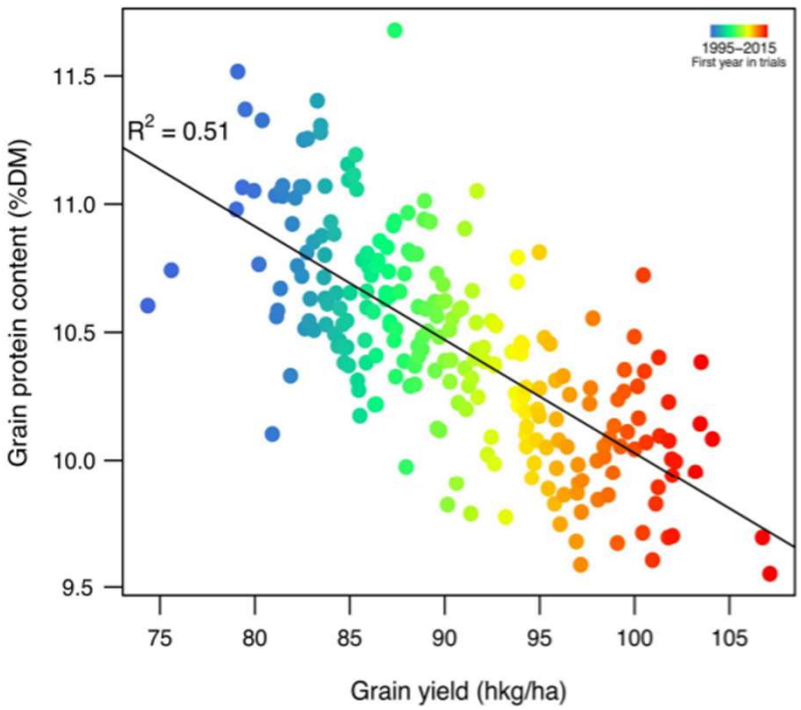
DLF Nordic Seed AARHUS UNIVERSITY Sejet planteforædling DANESPO KØBENHAVNS UNIVERSITET LANDBRUG FØDEVARER

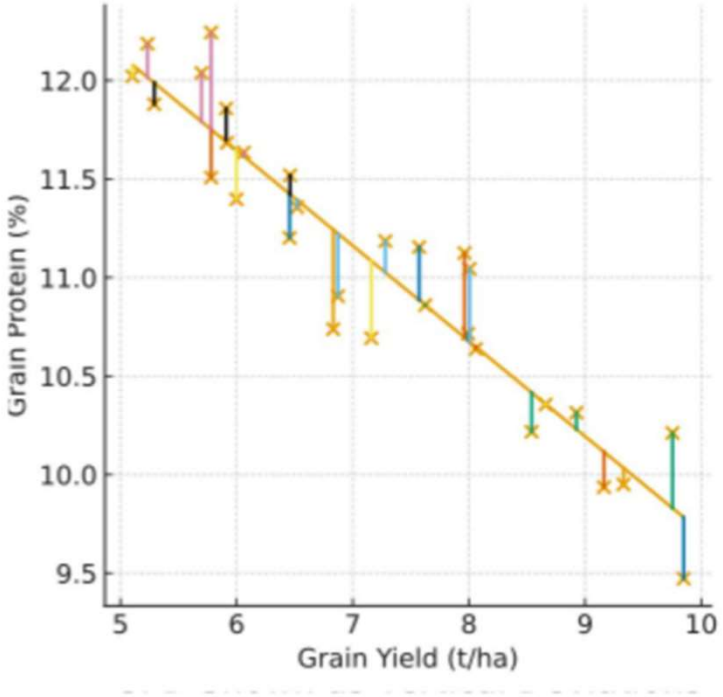
HTDH – Increasing the gran protein content (GPC) in wheat – the genomic way.



Invers correlation between yield and proteincontent– the project focused on the decoupling of the two

Tackling negative relation in GPC & GY





Summary & Future Prospective

- We identified a region on chr2B explaining 11.5% and 14.45% of the variation in GPC and GPD, respectively.
- It corresponds to a 0.5% increase in GPC.
- The region also harbor *Pm6* locus and negative effect on GPC.
- Breaking the linkage between *Pm6* and GPC is needed.
- New Breeding Techniques (NBTs) like mutation breeding, CRISPR-Cas9 can be used
- GWAS fixing the introgression

HTDH – Increasing the gran protein content (GPC) in wheat – the genomic way.

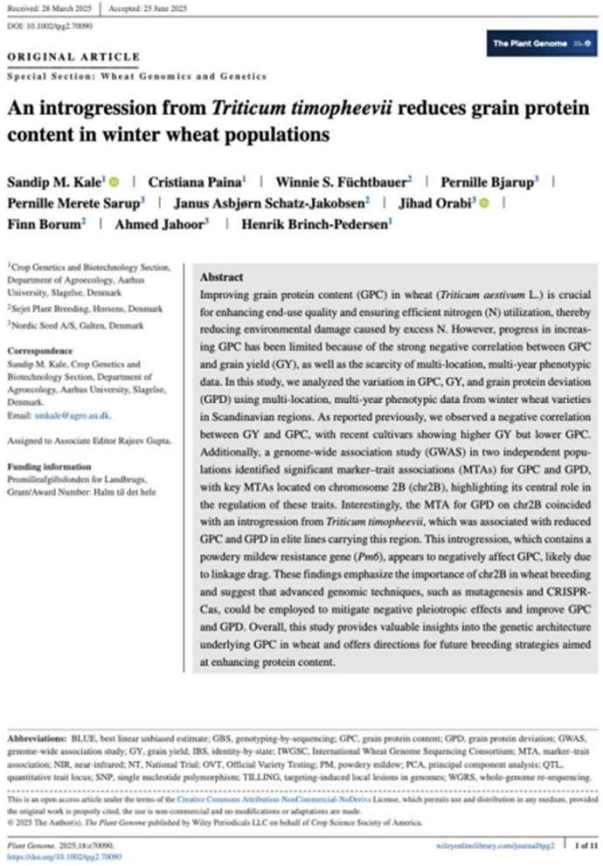
Screening of genetic and phenotypic data from different populations of winterwheat varieties from Scandinavia and Europe.

A specific region is responsible for lower protein grain content

The gene is couple with a resistance trait for mildew, but via CRISPR or similar methods, they can be decoupled

Successful decoupling can increase the grain protein content with 0.5%

It would contribute significantly to the Danish protein balance and the quality of Danish winterwheat



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DOI: 10.1002/tpg2.70090

The Plant Genome

ORIGINAL ARTICLE
Special Section: Wheat Genomics and Genetics

An introgression from *Triticum timopheevii* reduces grain protein content in winter wheat populations

Sandip M. Kale[1] | Cristiana Paina[1] | Winnie S. Füchtbauer[2] | Pernille Bjarup[3] | Pernille Merete Sarup[3] | Janus Asbjørn Schatz-Jakobsen[2] | Jihad Orabi[3] | Finn Borum[2] | Ahmed Jahoor[3] | Henrik Brinch-Pedersen[1]

[1]Crop Genetics and Biotechnology Section, Department of Agroecology, Aarhus University, Slagelse, Denmark
[2]Sejet Plant Breeding, Horsens, Denmark
[3]Nordic Seed A/S, Gulten, Denmark

Correspondence
Sandip M. Kale, Crop Genetics and Biotechnology Section, Department of Agroecology, Aarhus University, Slagelse, Denmark.
Email: smkale@agro.au.dk.

Assigned to Associate Editor Rajeev Gupta.

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Promilleafgiftsfonden for Landbrugs, Grant/Award Number: Halm til det hele

Abstract

Improving grain protein content (GPC) in wheat (*Triticum aestivum* L.) is crucial for enhancing end-use quality and ensuring efficient nitrogen (N) utilization, thereby reducing environmental damage caused by excess N. However, progress in increasing GPC has been limited because of the strong negative correlation between GPC and grain yield (GY), as well as the scarcity of multi-location, multi-year phenotypic data. In this study, we analyzed the variation in GPC, GY, and grain protein deviation (GPD) using multi-location, multi-year phenotypic data from winter wheat varieties in Scandinavian regions. As reported previously, we observed a negative correlation between GY and GPC, with recent cultivars showing higher GY but lower GPC. Additionally, a genome-wide association study (GWAS) in two independent populations identified significant marker–trait associations (MTAs) for GPC and GPD, with key MTAs located on chromosome 2B (chr2B), highlighting its central role in the regulation of these traits. Interestingly, the MTA for GPD on chr2B coincided with an introgression from *Triticum timopheevii*, which was associated with reduced GPC and GPD in elite lines carrying this region. This introgression, which contains a powdery mildew resistance gene (*Pm6*), appears to negatively affect GPC, likely due to linkage drag. These findings emphasize the importance of chr2B in wheat breeding and suggest that advanced genomic techniques, such as mutagenesis and CRISPR-Cas, could be employed to mitigate negative pleiotropic effects and improve GPC and GPD. Overall, this study provides valuable insights into the genetic architecture underlying GPC in wheat and offers directions for future breeding strategies aimed at enhancing protein content.

Abbreviations: BLUE, best linear unbiased estimate; GBS, genotyping-by-sequencing; GPC, grain protein content; GPD, grain protein deviation; GWAS, genome-wide association study; GY, grain yield; IBS, identity-by-state; IWGSC, International Wheat Genome Sequencing Consortium; MTA, marker–trait association; NIR, near-infrared; NT, National Trial; OVT, Official Variety Testing; PM, powdery mildew; PCA, principal component analysis; QTL, quantitative trait locus; SNP, single nucleotide polymorphism; TILLING, targeting-induced local lesions in genomes; WGRS, whole-genome re-sequencing.

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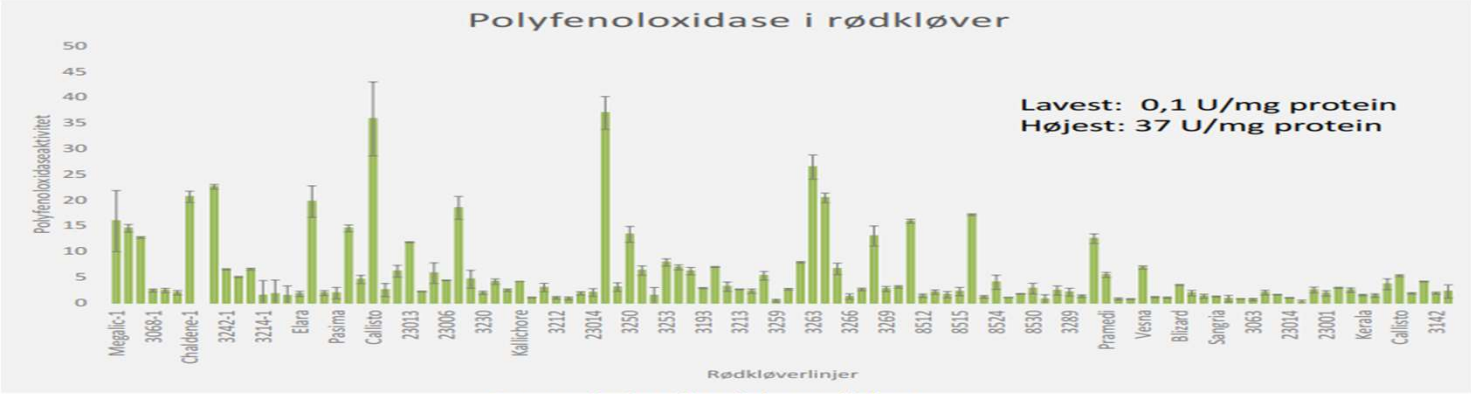
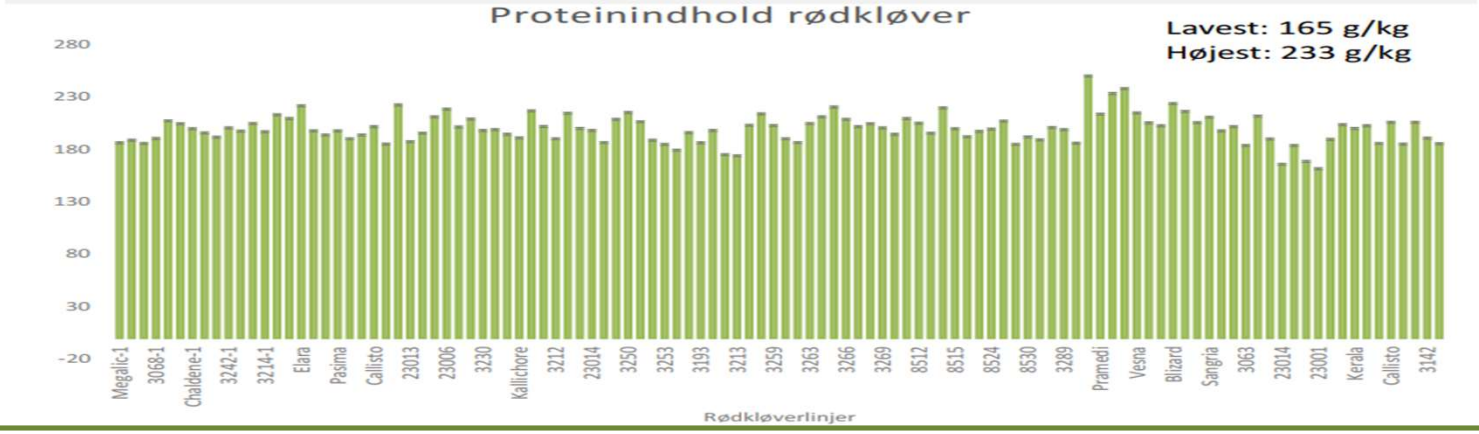
Klimaprotein – Focus on fava bean, red/white clovers

Klimaprotein – forædling efter højere polyphenoloxidaseaktivitet og proteinindhold i rødkløver

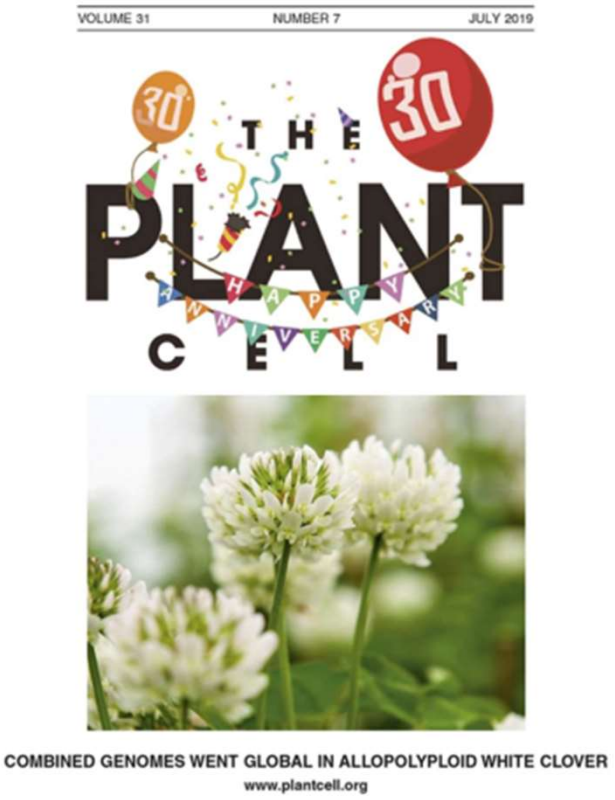
Der er tilstrækkelig variation I bade råprotein og polyphenoloxidase aktivitet I rødkløversorter.
Udfordring at rødkløver er populationssorter

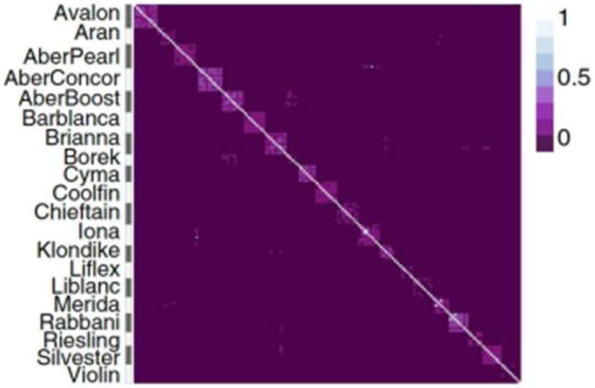


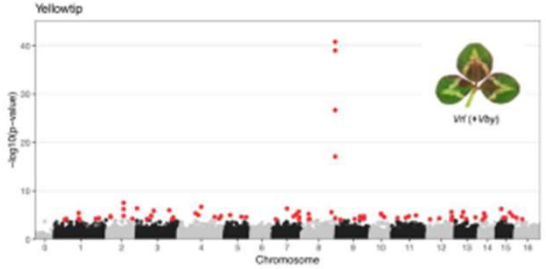


09-12-2025

Klimaprotein – muligheden for at bruge bladaftegninger i forædlingen af nye kløversorter







Klimaprotein – Hestebønne, koblingen mellem tidlig rodudvikling og udbytte

Article

The giant diploid faba genome unlocks variation in a global protein crop

https://doi.org/10.1038/s41586-023-05791-5
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Murukarthick Jayakodi[1,26], Agnieszka A. Golicz[2,26], Jonathan Kreplak[3,26], Lavinia I. Fechete[4], Deepti Angra[5], Petr Bednář[6], Elesandro Bornhofen[7], Hailin Zhang[1], Raphaël Boussageon[3], Sukhjiwan Kaur[8], Kwok Cheung[5], Jana Čížková[9], Heidrun Gundlach[10], Asis Hallab[11,12], Baptiste Imbert[3], Gabriel Keeble-Gagnère[8], Andrea Koblížková[13], Lucie Kobrlová[14], Petra Krejčí[6], Troels W. Mouritzen[4], Pavel Neumann[13], Marcin Nadzieja[4], Linda Kærgaard Nielsen[15], Petr Novák[13], Jihad Orabi[16], Sudharsan Padmarasu[1], Tom Robertson-Shersby-Harvie[5], Laura Ávila Robledillo[13], Andrea Schiemann[16], Jaakko Tanskanen[17], Petri Törönen[18], Ahmed O. Warsame[5], Alexander H. J. Wittenberg[19], Axel Himmelbach[1], Grégoire Aubert[3], Pierre-Emmanuel Courty[3], Jaroslav Doležel[9], Liisa U. Holm[18], Luc L. Janss[7], Hamid Khazaei[17], Jiří Macas[13], Martin Mascher[1,20], Petr Smýkal[14], Rod J. Snowdon[2], Nils Stein[1,21], Frederick L. Stoddard[22,23], Jens Stougaard[4], Nadim Tayeh[3], Ana M. Torres[24], Björn Usadel[11,25], Ingo Schubert[1], Donal Martin O'Sullivan[5] ✉, Alan H. Schulman[17,18,23] ✉ & Stig Uggerhøj Andersen[4] ✉

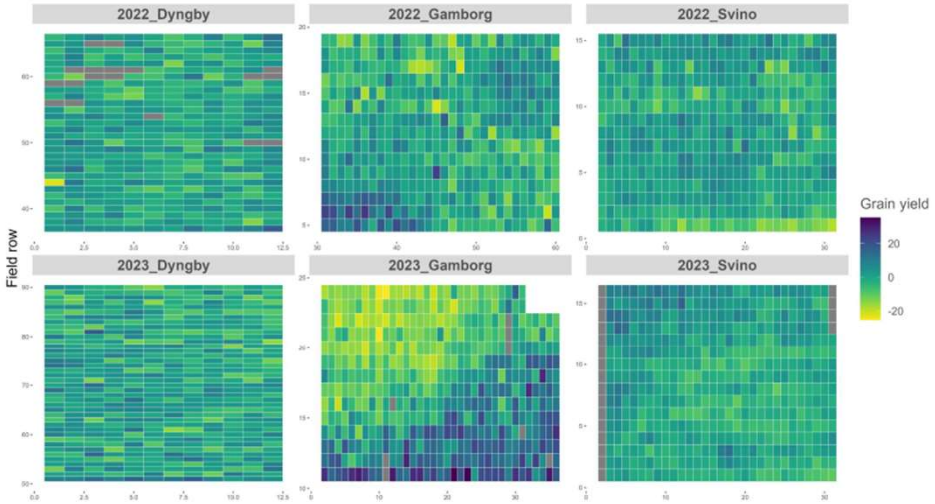
Hestebønnegenomsekvens og genetiske markører
Der skabes løbende mere viden om hestebønner, som kan hjælpe I forædlingsindsatsen

IMFABA MEETING
30 JAN, 2024

ELESANDRO BORNHOFEN
POSTDOC

Klimaprotein - Hestebønne, koblingen mellem tidlig rodudvikling og udbytte

- There was a positive correlation between early root growth and yield, although large variation.
- This knowledge should be implemented with breeders, for the early screenings



De første danskforædlede hestebønnesorter kommer snart!