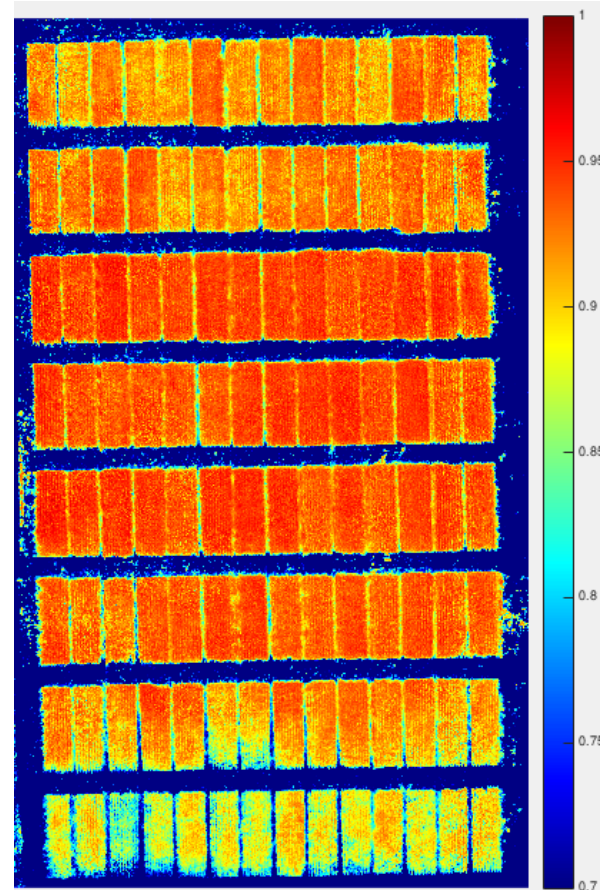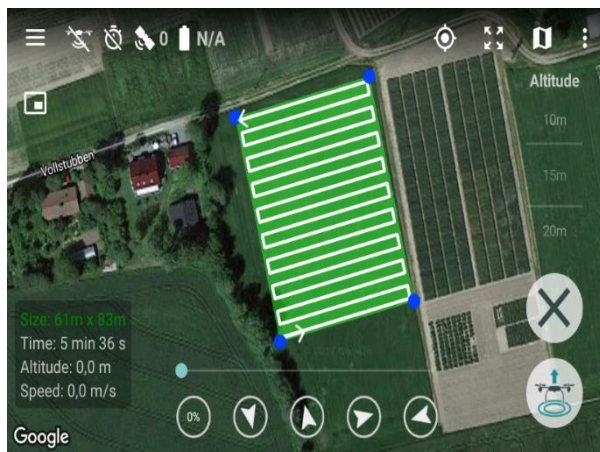# Exploring robots and UAVs as phenotyping tools in plant breeding

Be the one to take part in an exciting cross-disciplinary collaboration between Department of Plant Sciences (IPV) at BIOVIT and the robotics and imaging groups at the Faculty of Mathematical Sciences and Technology (RealTek) at NMBU.

In this MSc thesis topic the student will be comparing use of an improved version of the agricultural robot Thorvald developed at RealTek and Unmanned Aerial Vehicles (UAVs) for taking multispectral images of the crop canopy of wheat during the growing season. The new phenotyping methods will be compared with traditional measurements in order to assess the utility of these new technologies in plant breeding. The work will be done as part of the ongoing research project "Reliable and efficient high-throughput phenotyping to accelerate genetic gains in Norwegian plant breeding (virtual phenomics; vPheno)"

Supervisors:

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The physiological basis of yield increase in Norwegian spring wheat

When grown side by side it is clear that modern cultivars give higher grain yield than older cultivars, as shown in the following diagram based on three recent field trials conducted in south-eastern Norway:
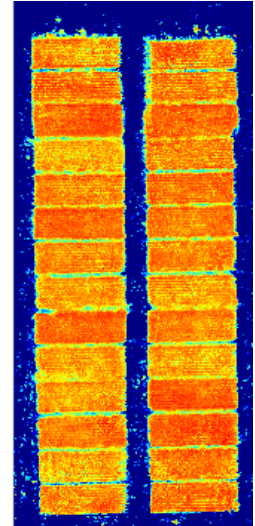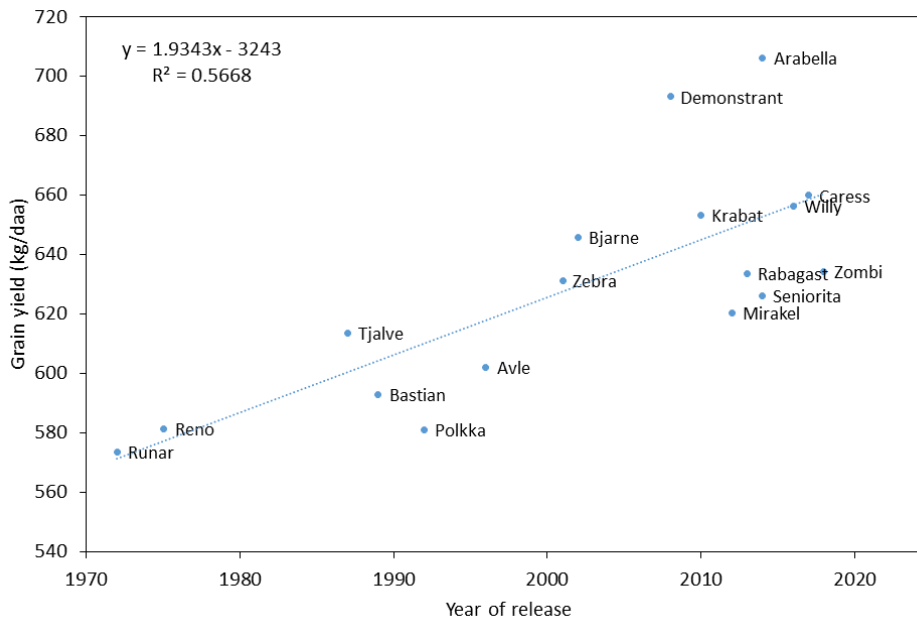
What are the reasons for higher grain yield in modern cultivars? Which developmental and plant physiological traits have changed during 40 years of breeding for higher grain yield?

If you are curious about this, and want to contribute with plant physiological measurements in field trials and investigate the genetic and physiological basis of grain yield, then this can be your master thesis topic.

The work will be done as part of the research project "Reliable and efficient high-throughput phenotyping to accelerate genetic gains in Norwegian plant breeding (virtual phenomics; vPheno)", and might in addition to traditional plant physiological measurements like light interception, leaf area index, chlorophyll content etc. also involve use of multispectral imaging from robots and drones.

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Investigations of novel host-pathogen interactions for leaf blotch resistance in wheat

Leaf blotch caused by *Parastagonospora nodorum* is a severe disease on wheat in Norway leading to grain shrivelling and reduced yield, and is a main cause of fungicide application. Necrotrophic pathogens like *P. nodorum* secrete effector molecules that are recognized by host receptors that trigger cell death in susceptible plants, providing dying tissue for infection by the pathogen.

To study host-pathogen interactions, we infiltrate leaves with purified effectors or culture filtrates of the pathogen and evaluate whether plants are sensitive or insensitive to the pathogen effectors:
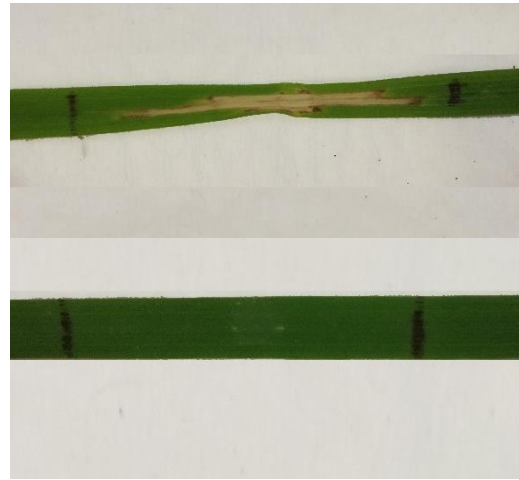
Left: Infiltration with culture filtrate with a needleless syringe. Right, top: SnToxA-insensitive leaf 5 dpi (days past inoculation). Right, bottom: Necrotic tissue developed in the infiltrated area in a SnToxA-sensitive leaf 5 dpi. Photos: Anja K. Ruud (left), Min Lin (right).

We also conduct seedling inoculations in the greenhouse and mist-irrigated field trials to evaluate seedling and adult plant resistance.

We have recently found that one of the effectors produced by *P. nodorum*, SnTox3, causes two different reaction types in Nordic spring wheats: either necrosis or chlorosis. It is currently not clear whether these two reaction types are caused by the same or different host sensitivity loci.

For this MSc thesis topic, we have developed a new mapping population segregating for the two reaction types, which needs to be screened for sensitivity to SnTox3 and evaluated for seedling and adult plant resistance. The student will also be doing SNP marker genotyping in order to map the genetic loci responsible for the different reaction types and susceptibilities to this important wheat disease.

Top: seedling tests in the greenhouse. Bottom: fied evaluation in hillplot nursery. Photos: Anja K. Ruud (top), Morten Lillemo (bottom).

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Other available topics in cereal genetics include:

Fine-mapping and functional characterization of important Fusarium head blight resistance genes in wheat, based on greenhouse and laboratory experiments with near-isogenic lines (NILs) and large fine-mapping populations using precise inoculation methods with *Fusarium graminearum*, SNP marker genotyping and candidate gene sequencing. The aim is to identify the mechanisms behind an important FHB resistance QTL on chromosome 2DLc in wheat.

Fine mapping and functional characterization of a race non-specific powdery mildew resistance gene in wheat. Recent QTL mapping studies have identified an important powdery mildew resistance QTL on chromosome 1AS in the German spring wheat cultivar Naxos. We are seeking a MSc student to be involved in the fine mapping of this race non-specific resistance locus. The work will involve field testing of a fine-mapping population, genotyping with SNP markers to narrow down the QTL interval, sequencing of candidate genes and characterization of the underlying resistance mechanisms.

Validation of important QTL for stripe rust resistance in Norwegian spring wheat. Stripe rust is one of the most yield-reducing wheat diseases globally that has recently re-emerged as an important disease in Norway. In this MSc thesis project, the student will participate in scoring of stripe rust reactions on wheat cultivars and breeding lines in field trials of spring and winter wheat, and make use of SNP marker genotyping to validate the effects of previously identified markers on new breeding lines.

Functional characterization of an important waterlogging QTL in wheat. Through genome-wide association mapping (GWAS) we have recently identified an important QTL for waterlogging tolerance on chromosome 6A in Norwegian spring wheat. Here, we are looking for a student to do follow-up waterlogging experiments with selected cultivars and breeding lines both in the field and under controlled greenhouse conditions. The work will also involve some SNP marker genotyping and sequencing of candidate genes in the QTL region.

Identification of important pre-harvest sprouting (PHS) resistance genes in Norwegian wheat.
Pre-harvest sprouting is a serious quality issue in the wheat production, and occurs when seeds of cultivars with insufficient seed dormancy starts to germinate in the heads before harvest due to rainy weather. We are seeking MSc students to be involved in field evaluation of PHS resistance in Norwegian wheat cultivars and breeding lines, conduct QTL mapping based on high-density SNP marker data and help identifying the genetic basis of this important quality trait. The work will be done as part of the ongoing research project "Expanding the technology base for Norwegian wheat breeding: genomic tools for breeding of high quality bread wheat (EXPAND)".

For further information on the above topics, please contact Morten Lillemo:
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