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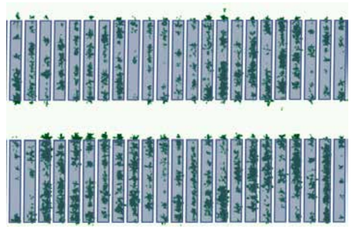
UAV-based phenotyping of Fusarium tolerance

Today's sugar beet agronomy requires breeders to combine a high financial performance with an increasing number of disease tolerances. This further intensifies the "number's game" associated with variety development and creates a requirement for large disease nursery platforms where scoring by the visual operator becomes a bottleneck. In addition, visual scores are subjective and therefore error prone. Advancements in sensor and UAV technology offer valuable opportunities to address these challenges.

In 2018 -2019 SESVanderhave developed a drone-imaging based Fusarium phenotyping methodology. This methodology was validated on proprietary breeding trial data in growing season 2019 and 2020. These data are presented here.



Discriminating beets from weeds

A major challenge was the strong weed infestation in plots with very susceptible genotypes. (Fig. 3. Left panel). This resulted in a significant overestimation of the tolerance level of susceptible genotypes. Therefore it was necessary to teach the algorithm to discriminate between sugar beet and a broad spectrum of weeds.

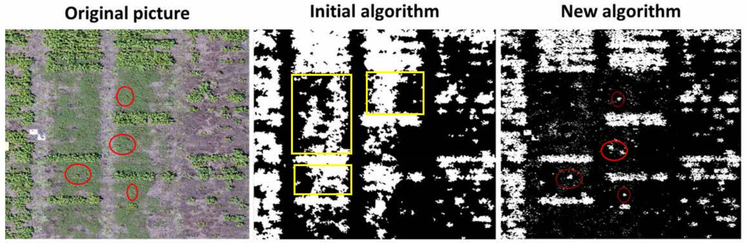


Fig. 3. Left panel: true color drone image showing how plots where severe Fusarium-mediated damping off occurs, experience strong weed infestation. Centre panel: showing how our initial algorithm treated these weed infested areas as sugar beet pixel area on which the Fusarium impact was measured (indicated by yellow rectangles). Right panel: Showing how the new algorithm is able to filter out these weed infested pixel areas, but is still able to detect single stunted beets in those areas (indicated by red circles on the left and right panels)

Strong correlation between drone estimates and visual scores

In 2 consecutive validation years stable and strong correlations between visual Fusarium scores and drone-imaging based Fusarium scores were observerd (fig 4. a&b), while seasonality and disease progression kinetics were substantially different between both seasons. This indicates that our drone-image based Fusarium phenotyping methodology had a reliable accuracy and a strong robustness over different conditions. Moreover, the drone-imaging based methodology allowed for clear differentiation between the susceptible, intermediate and tolerant checks (Fig. 5).

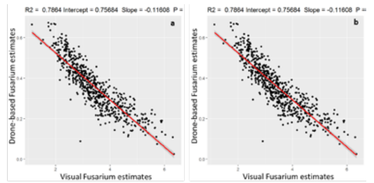


Fig. 4. Correlation between visual and drone imaging based Fusarium scores for a. 2019 trial season and b. 2020 trial season.

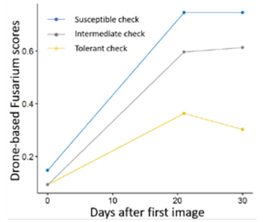


Fig. 5. Differential disease progression kinetics based on drone imaging for the susceptible, intermediate and tolerant checks

Comparison of precision

The drone-imaging based heritability's were consistently higher at all time-points, in particular in the early stage of disease progression (Table 1). In line with this, the correlation between the 2019 scores and the 2020 scores for the different genotypes (fig. 6) was stronger for the drone-imaging based scores than for the visual scores.

28 DAS		42 DAS		51 DAS	
Drone	Visual	Drone	Visual	Drone	Visual
0.63	0.29	0.78	0.65	0.77	0.69

Table 1. Comparing the heritability's of the drone-imaging based scores with the visual scores at the consecutive time-points

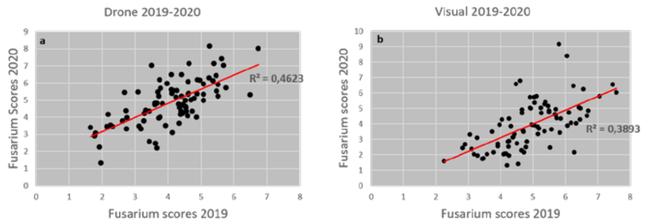


Fig. 6. Correlation between Fusarium scores obtained in 2019 and 2020 for a set of genotypes (n = 86) based on a. Drone-imaging based scores (r = 0,68) and b. visual scores (r = 0,62).

CONCLUSIONS

Automating laborious disease observations through drone-technology allows for scoring up to 5000 microplots/hour. Hence, it can potentially increase the capacity for screening new genotypes and simultaneously liberate resources for other activities.

Fusarium tolerance estimates obtained with our drone-imaging based phenotyping algorithm displayed strong correlations with the visual scores over 2 consecutive growing seasons. Moreover, heritability estimates and comparison of consistency in genotype performance between years, suggests that a higher phenotyping accuracy can be obtained through drone-imaging based phenotyping than through traditional visual scoring. Hence, this methodology allows for simultaneously achieving an efficiency increase and a data quality increase.