Development of a high throughput plant phenotyping system for innovating durum wheat breeding in the Mediterranean

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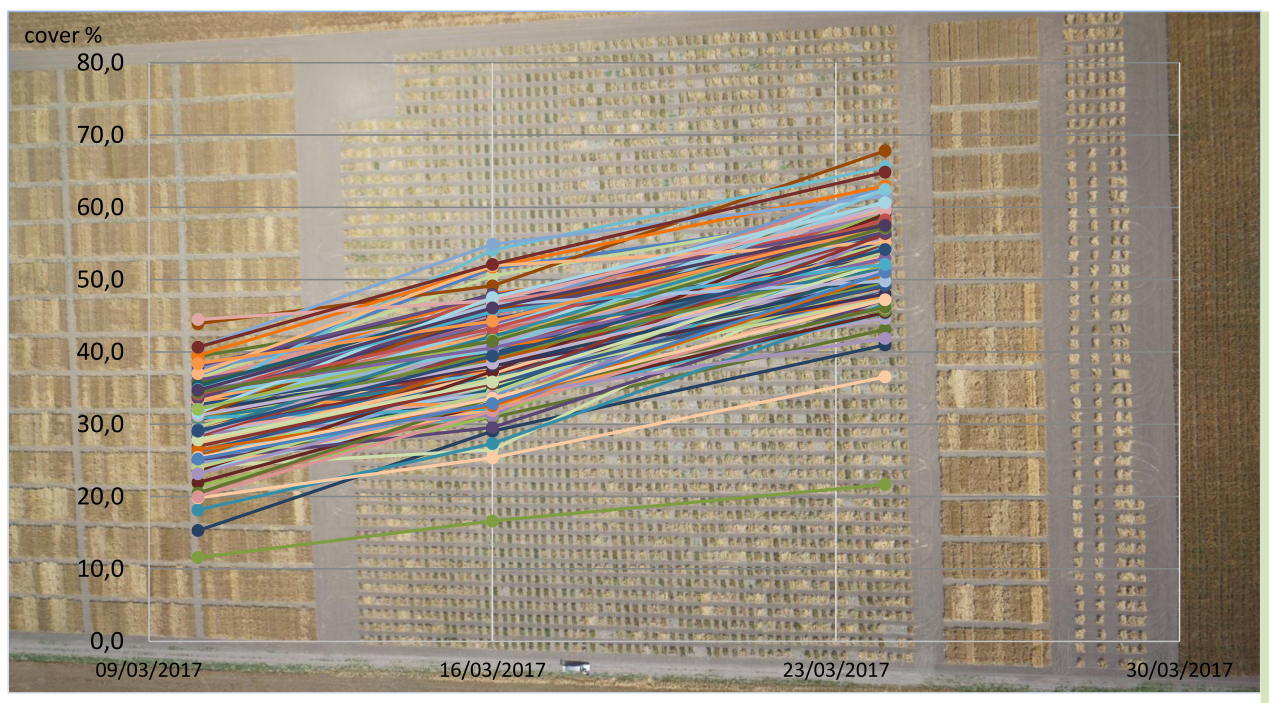
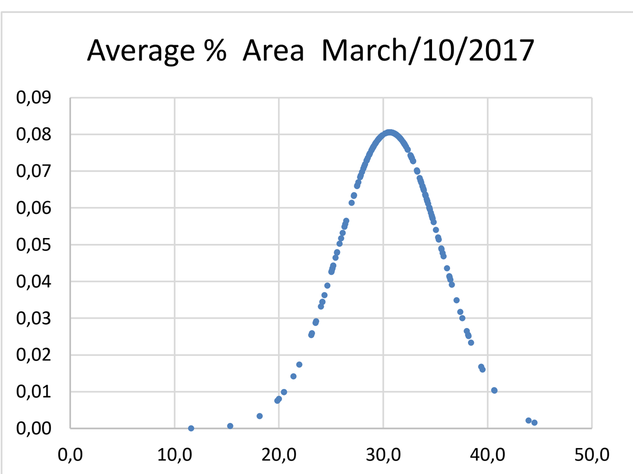
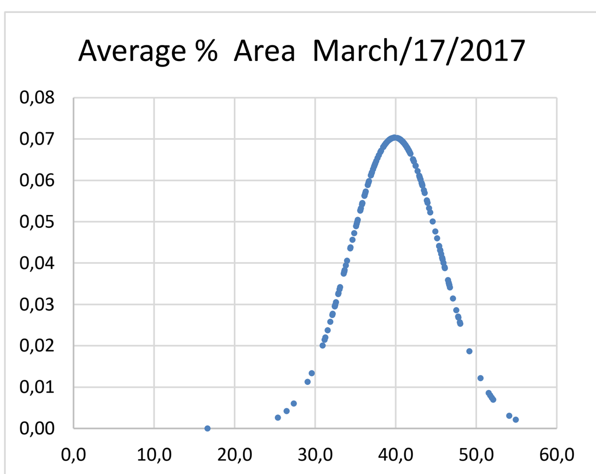
The central challenge of modern genetic analysis is to understand the biological determinants of quantitative phenotypic variation. The power of wholegenome sequencing as a unifying force in biology has motivated the development of diversity panels and large mapping populations (RIL, IL, MAGIC, NAM, …) in many crop species to facilitate trait dissection and gene discovery. More accurate and precise phenotyping strategies are necessary to empower high-resolution linkage mapping and genome-wide association studies and for training genomic selection models in plant improvement. Unfortunately, phenotyping is quickly emerging as the major operational bottleneck limiting the power of genetic analysis and genomic prediction. To solve this problem in recent years, there has been increased interest in highthroughput phenotyping platforms are fully automated facilities in greenhouses or growth chambers with robotics, precise environmental control, and remote sensing techniques to assess plant growth and performance. However, phenotyping under field environmental conditions remains a bottleneck for future breeding advances, field conditions are notoriously heterogeneous and the inability to control environmental factors makes results difficult to interpret. One of the solution is to employ Unmanned aerial vehicle (UAV) commonly known as a drone. Compared with other aerial survey methods, drones generate more precise and more frequent data about the condition of crops. The goal of the research program is to achieve a high-throughput phenotyping platforms based on the use of drone useful for obtaining detailed measurements of plant characteristics that collectively provide reliable estimates of phenotypic traits.



Grafh 1: different cover capacity of 172 soft wheat genotypes





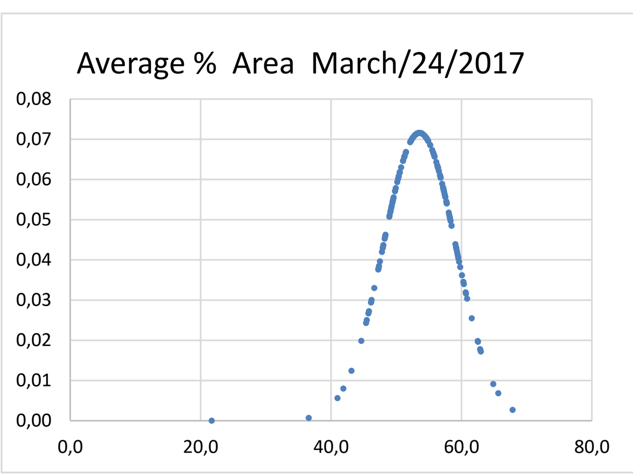
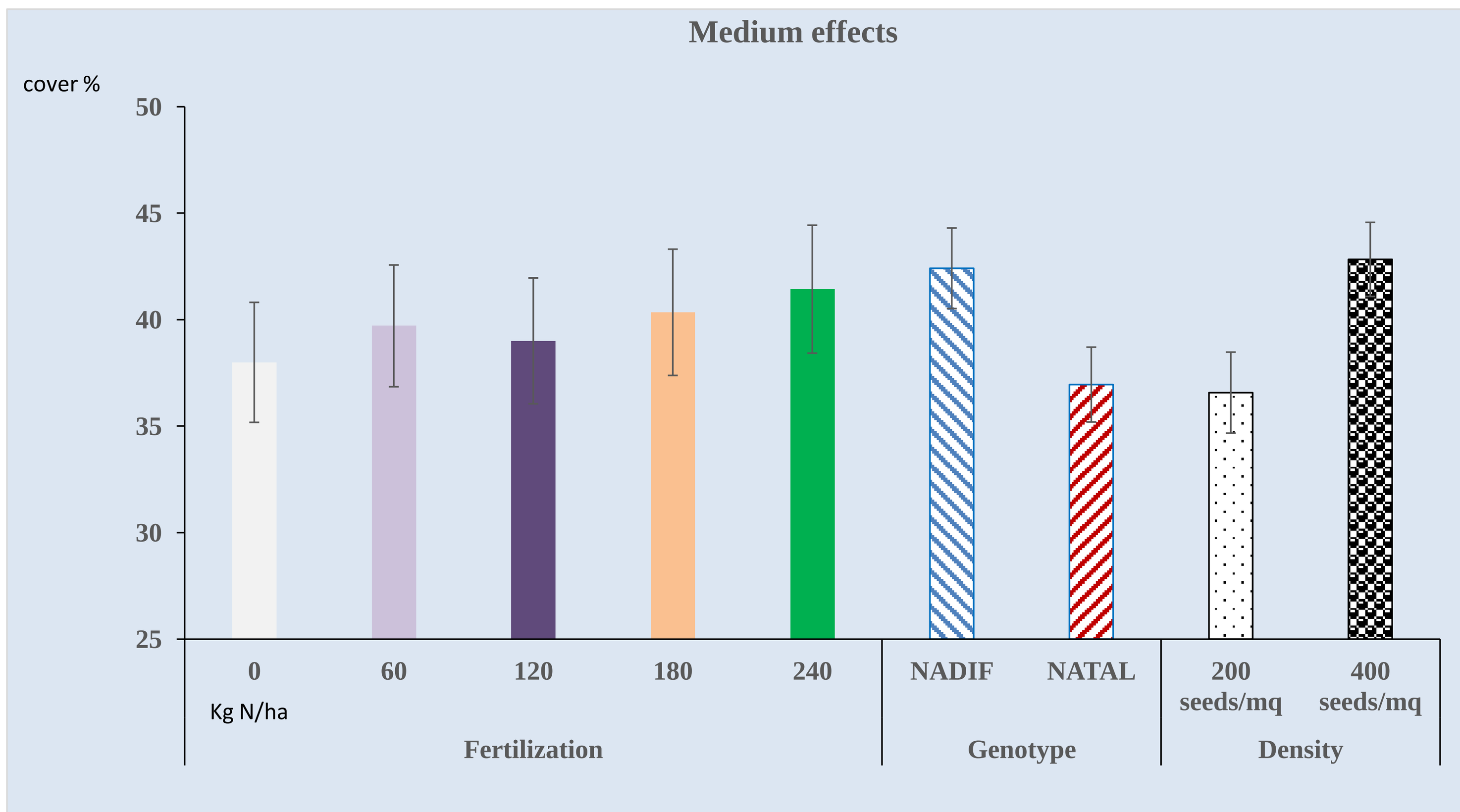


Photo 1: Trial orthophoto

The preliminary analysis of RGB images, indicative of the genotypes ability to cover the ground more or less rapidly,(graph 1) shows a high degree of variability and a good discriminatory ability of the used indices (covering capacity, green index, NDVI, etc.) between the tested genotypes.

For this kind of analysis, all photos were processed to produce georeferenced real color and near infrared orthophotos (photo 1).



The agronomic trial results, show how this kind of measurements are useful also for a precision agriculture. We notice differences, in coverage capability, not only between different genotypes but as we expected, also between different sowing densities and different fertilization level. The RGB image can be used to make a targeted fertilization.

In conclusion the first analysis seems to confirm the usefulness of automated equipment for the determination of morpho-physiological characters in order to facilitate and make the breeder's evaluation more and more objective. For the second year of activity, already scheduled, both experimental devices will be replicated.

Materials and Methods. *Agronomic trial*:The experimental device was composed by on a randomized blocks with three factors and three repetitions scheme, grown in 10.2 sq.m. plots. The factors considered were Variety (Natal and Nadif); Sowing density (200 and 400 germinable seeds per square meter) and nitrogen fertilization levels (0, 60, 120, 180 and 240 Kg N ha.). During the growing season, post-emergence chemical pest control was carried out and also a fungicide treatment for disease control. Various fertilization theses were differentiated by administering nitrogen in four different phenological stages. During the agricultural year, the following measurements were carried out: number of plants per linear meter, soil cover index, earing time, number of spikes per linear meter, multispectral and thermographic assessments by UAV system.

Variety comparison trial: 172 genotypes of soft wheat of different origin and provenance have been used. The genotypes were grown in parcels of one square meter according to a randomized block plan with 3 repetitions. The trial was sown with a seed drill on 15/12/2016, two fertilizers were made, one on sowing with (2 q.li of bi-ammonium phosphate 18-48 kg / ha and one in cover with 1.5 q.li/ha of urea in the tillering phase. During the growing season, the post-emergence chemical disinfection for weed control and fungicide treatment for disease control was performed. During the crop season, the following reliefs were taken: acquisition of RGB, multi spectral and thermographic images; morphological assessments and qualitative analyzes on grains. The UAV used for assesment is a Microdrones md4-1000 equipped with a Sony nex-7.