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PLOT QUALITY RATING AS A RESULT OF INNOVATION MANAGEMENT IN THE ARTIFICIAL INTELLIGENCE SOCIETY

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Abstract

The plot quality rating of seed research industry is of great importance for most trials and experiments, trying to bring data to validate or invalidate a trait, or to see how a trait is getting variability. Still today, the plot quality is a manual assessment, requires a lot of time, and the decision based need to be taken in a short time for creating space for actions. There is a switch of plot quality rating assessment, from conventional to modern, based on imaging. Many multinational companies who business in agriculture, mostly in breeding and research and development, are now, more and more attracted by the drone use as a proof of AI (artificial intelligence). The importance of a plot quality rating is high, from the pure reason it participates in the data validation, standardization, and governance as a science decision. In this area of research, imaging can be very useful and having strong benefits for the final customers. This need provided by AI comes with the imaging concept, based on drone flights and interpretation. The drone is most of the time a commercial one, but the sensor itself is multispectral, able to deliver different layers with interest for the farm. The farm decision or the research team, evaluate the plots by using a application developed by Sentera (USA), named Field Agent. This app represents today the most advanced plot evaluation, and the use of it is quite simple, most of the time deductible for the professional agronomist. As a POC (Proof of Concept), we have used the AI to bring more reliability into the data at farm level, specifically for corn seed production, where we were able to have a stand count (for female and male), tassel identification (target is to develop it for female rows, detasseled), and yield prediction together with disease and pathogens control under the Power Distribution Board (PBD).

Key words: *plot quality rating, drone, artificial intelligence*

INTRODUCTION

Modern agriculture is consolidated by plenty of machine learning applications. Probably the most updated review is the one published by [2], where several general criteria has been identified, grouped as follow: crop and livestock management, soil and water management. The wider criteria or category, crop management is divided by five sub-categories: yield prediction, disease and weed detection, crop recognition, and crop quality.

The first used on large scale on Romanian agriculture landscape has been crop detection. Once [10] implemented geospatial checks, crop detection has become particularly popular.

On plant breeding and hybrids screening, the real importance is crop quality. This is very complex to assess as it related to soil and climate conditions, and cultivation practices.

Today, the crop quality based on machine learnings is studied for more than 80 species, the most important are (in order of number of scientific papers published in the last 10 years): maize, wheat, rice, soybean, tomato, grape, rapeseed/canola, cotton, potato and barley [14].

Corn, also known as maize, is having a high interest for the farmers [16], cultivated in all regions where people leaving, having a large variability and adaptive to different climatic conditions and technological management. Today, more and more is visible that drone use could bring a high use, large potential for the users with GIS (Geographic Information System) knowledge. Less time is invested by the agronomist to scout a field, less influenced by the size. Old methods (conventional scouting) supposed a walk in several points, empirical selected based on agronomist experience and field history, with high impact on time and safety [12, 13].

In modern plant breeding, high-throughput phenotyping trial and performance characterization analytics is a must have. Getting accurate and precise measurements to support seed production performance and outcomes is essential for today's agronomist [7]. Several outputs we are able today to assess via use of drone and algorithms, like rogue(off-type) detection, plant densities, tassel count, crop health (several scouting is needed) and yield prediction [6, 15, 5].

At present, [17] mentioned in Field Crops Research, that little is known about appropriate UAV (Unmanned Aerial Vehicle) based strategies of 'model calibration at a small site while applying these models at a large extent' for crop monitoring.

In this context, this study aims to answer the following research questions (RQs):

(1) What are the most informative UAV indicators for monitoring LAI (Large Area Imaging), LCC (Leaf Cholorophyll content), and aboveground dry matter (AGDM)?

(2) Does the suitability of indicators differ for maize jointing (BBCH= 34, [1], heading (BBCH= 51), and grain filling stages (BBCH= 71) (BBCH is the vegetative scale to identify the vegetative growth, BBCH - Biologische Bundesanstalt, Bundessortenamt and Chemical industry?

(3) Can the UAV indicators properly reflect differences in crop growth caused by distinct water and nutrient management?

(4) How well is the transfer capability of UAV remote sensing-based random forest models among distinct water and nutrient management practices?

MATERIALS AND METHODS

UAV Image Collection

Imaging data for our purpose has been collected in a corn seed production field, planting ratio 6F:2M (F-Female, M-Male)), at Astra Trifesti, in Iasi country, Romania. The aerial pictures have been collected used a commercial drone DJI brand, Phantom 3, with high resolution (12.6MP camera), equipped with a 6X sensor developed and delivered by Sentera [4] via a third-party company, with local representatives. The flights were done at 20-25m (variable in terms of field altitude which was in a slope), having 90-92% forward overlap and 88-90% sides overlap. All images have been collected during the vegetation period, starting from May up to August of 2023; On the stage V2-V4 for the plant emergence; ten days after second mechanical detasseling (first cut has been made by knifes, second cut by rolls) for the tassel count on male size, then last flight 3-4 weeks before harvest.

Image processing

One single image collected by drone were on 12.6MP, 3.5k*4k pixels, that represents a big challenge to compute all pictures associated with the right spot from the field. As every imaging software, for each image, has been created small images of lower resolution (generally 1k*1k pixels, but it happens when the field cultivation is not well done and the weeds are still present, to have 0.5k*0.5k), without any overlapping. That small sub-pictures artificially done, has been labelled and associated with the spots in the field and feed he computational learning models, which AI works.

The software used for image analysis was Field Agent, developed by Sentera (USA), special for this purpose, dedicated to seed research and seed production. The flow starting from the pictures done in the field, then pasted (offline) into Field Agent for processing. Passes has been predefined by the tool when drawing the field shape. The output is a mosaic of numbers that represent the trait captured and shows field variability(available on phone and desktop).

RESULTS AND DISCUSSIONS

Early stand count (plant densities)

Stand count is referring to plant density or plant population in a field or plot. It could be numerical or percentage values. Stand count is the first agronomic criteria that is influencing final yield. It is also having an impact on field performance from sanitation point of view, uniformity, and resources allocation. We can say that stand count is a key factor in maize seed production fields.

The advantage of using imaging and the Field Agent tool from Sentera, is that in a safer way and faster, the agronomist can scout any field and it helps to indicate and to highlight the problem-spot that requires specific agronomic management (like specific herbicide to use based on weeds, flooding areas, bird damage spots, wild animals, etc).

In seed production field and in seed research, this imaging shows indicators to claim field uniformity, helping in this case to highlight the batches with problem (like bad germination, biological impurities).

Field uniformity and the plant fulfilment per row is creating homogeneous conditions for further practices. Less care and people are used in case of a uniform field at the stage of detasseling. Also, this stand count is relatively used during inspections by the authorities for getting the final certification. Stand count topic is having a big impact on plant development, by enlarging the space for the neighboured plants with a gap in between, that means a faster development.

As said in the first part of this paper, for the stand count assessment is used a special sensor based on RGB (Red Green Blue). It is lighting bands of green, red and blue; visible for human eye. Field Agent is generating layers and maps with legends inside on what is happened in the field, plant by plant from each row (Photo 1.a and 1.b).

Photo 1.a. Spots analysis for stand count evaluation
Source: Personal photo.

The data included in the tool are vary based on the product. Specificaly for agronomy (farm management or forest management), the tool is valuable by providing the plant population for a field or a specific part of the field, and it may drive to actions for replanting, or to highlight a spot with special needs (more fertilizer, special fungicide or very common, one more herbicide application on spots), with the high impact on final yield.

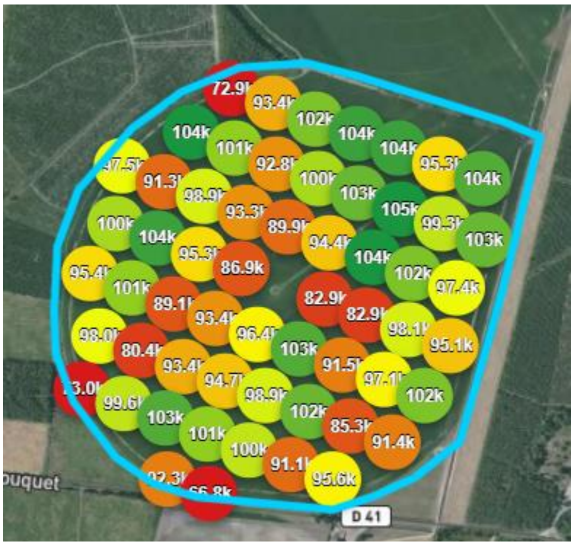

Photo 1.b. Real stand count calculation in thousands plants/ha
Source: Personal photo.

For the emergence evaluation, the Sentera company developed Stand Count tool. It takes ad-literal the number of plants/plot (not influenced by the size of the field), field uniformity, rows completeness, row gaps, plant duplicates, and other situations that influence the performance of any corn seed production field. Via this tool, Sentera is providing at the farm level, maps, analysis and high resolution pictures.

As we speak on a corn seed production field, the ratio female/male and the stand counts individually is a must have. In Field Agent, using this tool (Stand Count), we can download the maps, which based on that, agronomists can take decisions (as replanting a specific part of the field or increasing plant population for pollinator rows).

Tassel count

As said earlier, conventional way to assess tassel count in a corn seed production has been done manually, in several points related to the field uniformity and field size. For the yield determination and harvest management, agronomists were in the field, collection hundreds of samples, shipment to the farm or to the lab for yield determination, then having manual calculations for both traits.

We asses tassel count (for male: the number of total tassel per ha, which is equivalent to the plant density for male; then for female, tassel count got importance after detasseling, to know what is the number of tassel present in the field for female rows, which is not indicated to have) by used Field Agent, selecting Tassel count tool (Photo 2 a, b, and, c).

Photo 2.a. Spots analysis for tassel count evaluation
Source: Personal photo.

The detection of rogue (off-type) corn plants is currently a manual process but pose a large risk to purity within seed production. Additionally, rogues can be very difficult to differentiate from the desired genotype in some situations. The objective of this study is further to develop an image detection algorithm which can identify rogues within a field. The goal will be to detect both rogues that are of a different germplasm as well as fertile as compared to sterile versions of the same germplasm.

The map of tassel presence for female rows is a big advantage for the farmer. He knows where the tassel o remove from female rows are present in the field, and he can manage to an additional check or complete pass over the field for removing last tassels from female rows, just before the silk emergence.

FieldAgent® Tassel Count is special built to highlight the presence of tassels on female rows, as his is a mandatory task for corn seed production, to have the detasseling done before silking to avoid self pollination, which conduct to less % of genetic purity.

Photo 2.b. Field Agent map for tassel count and identification 10 days after last detasseling
Source: Personal photo.

Inside extracts from Field Agent we can easily see the number of tassels left after last detasseling. A manual check confirms it, as it visible in Figure 2.c.

The data extracted from the map via Field Agent, can be extended to entire field, and developing a variable map for nitrogen application, based on soil type and density, as well the crop sanitary situation or crop health maps based on NDVI (Normalized difference vegetation index) maps, generating for each point (GPS - Global Positioning System) on the field.

Photo 2.c. Proof of tassel presence identified by UAV (confirmed by manual check)
Source: Personal photo.

We went in the field and checked manually that irrigation wheel, a lodged female plant, touched every time when the pivot is moving in circle and not possible to be captured by detasseled machine or people in that area. You can imagine the deep of that trace is around 30-40 cm and people are more carefully on their way to go than looking for a tassel.

With the use of a combine equipped with instant yield calculation in weight and moisture, the data are included into the Field Agent Yield Prediction tool.

This is generating multiple layers, which from the farmer and the management can understand the field uniformity and the performance of that.

Based on that, it is also important that the layers are point of discussion for next crop, and the farm manager could implement corrective actions.

We are thinking here as the use of variable fertilizer rate, then for planting variable with a special planter able to do that, spraying less where no weeds or increasing the fungicide where the disease started to spot the field.

All is about information at the plot level, which Field Agent could bring to the agronomist, helping them to build economic plannings based on yield prediction and health of the crop (Photo 3) with impact on further KPIs (Key Performance Indicators).

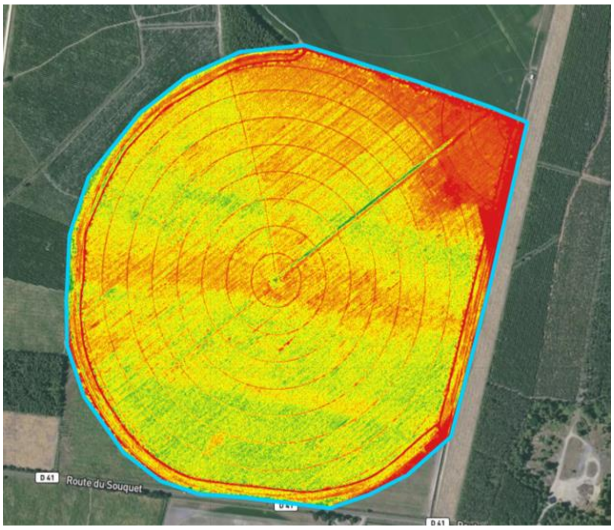

Photo 3. Crop health view at the moment of yield evaluation (3 weeks before harvest)
Note: Green means high biomass and the transition to red is correlated to the lower biomass level.
Source: Personal photo.

Yield estimation

Sentera's advanced, Double 6K sensor is fully configurable, with a multispectral variant capable of capturing five precise spectral bands: blue, green, red, red edge, and near-infrared (NIR – Near Infrared) which in the left side of the graph.

With this innovative technology, users can collect visual band imagery as well as vegetation indices based on the addition of NIR or Red Edge, including normalized difference vegetation index (NDVI) (Figure 4).

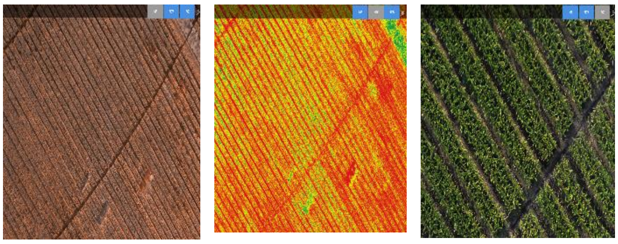

Photo. 4. Multipectralbands
Note: From left to right: NIR, Red Edge and NDVI.
Source: Personal photo.

For seed research industry and seed production industry, field selection could be done via imaging [3]. Multiple layers as results of imaging are very useful in prediction performance of the fields [8].

Photo 5. Yield monitor map as is visible in Field Agent
Source: Personal photo.

Several scientists bring the hypothesis which has been mentioned by [9], that multiple layers will create benefits for farmers in their prediction actions. Also, yield estimation layers are a way to correct the yield values on breeding programs where the field is not super uniform and the data could be fine adjusted [11].

CONCLUSIONS

AI offers today a large scale of tools with real benefits in seed production. From planning perspectives, we have an earlier visibility and increasing confidence in the field as stand count shows it. Due to high cots in winter-season, we see possible a costs reduction based on local production.

Data collection, even we speak on stand count, densities, tassel count after detasseling or crop health situation, by having drone flights and Field Agent by Sentera, shows an increase of quality, in real time processing. FieldAgent® is built to directly combat old methods of scouting, as today the agronomist can focus on research itself, data collection based on field uniformity; to assess different traits, yield prediction, moisture variation just before the harvest, with impact on the farm management being more precise and efficient.

Tassel count and identification is more attractive for off-types identification. Here the AI power is to quick support agronomists by highlighting all these plants out of same germplasm.

As for safety, we clearly improved it by having less people in the field, that means low risk, then reducing time for manual walks to rogue and manual puss tassels.

The efficiency is highlighted to a les number of trips in the field and quality data obtained. Relative ranking of yield potential based on summary statistics of NDVI.

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