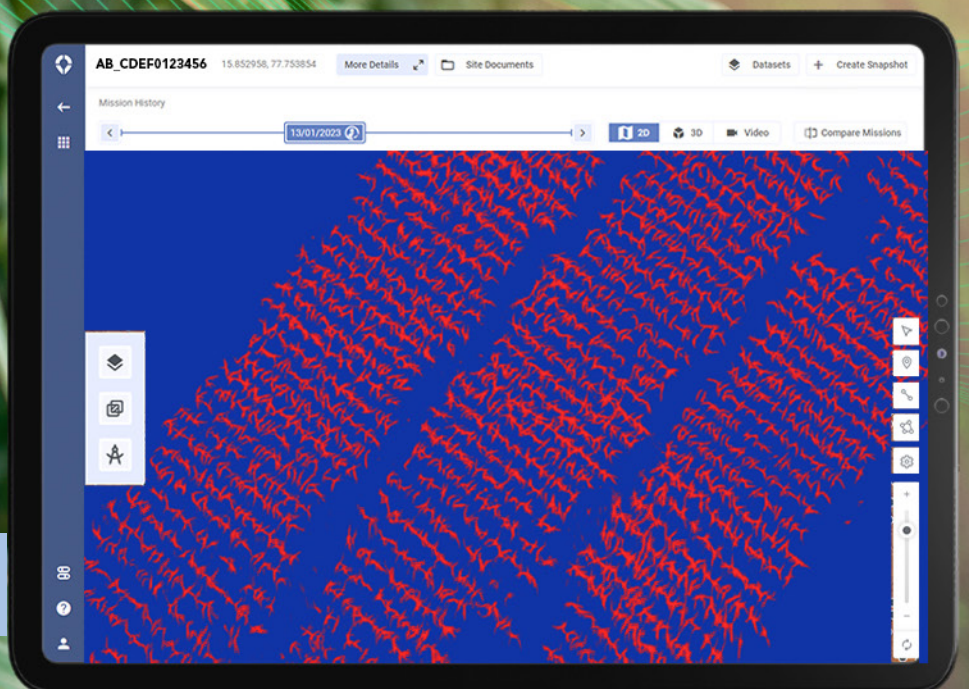


Whitepaper

Enabling smart corn breeding & seed production with end-to-end drone-based solutions

Uniformity



Introduction

The key to the ideal management of corn fields across different stages of its breeding and seed production lifecycle is regular access to large-scale phenotyping data with higher accuracy and high throughput. This data acts as the basis for producing reliable insights that can be used to validate the optimal performance and take corrective actions in case of an anomaly to address the field issues. For most of the corn seed producers across the country, this poses the biggest bottleneck that prevents the use of crop trait data in taking data driven decisions and improving crop production. At the same time, traditional methods for acquiring this data can be labor-intensive, time consuming, inaccurate, and costly.

Current challenges in corn seed production:

- Collecting large-scale, field-based plant phenotypic data with high accuracy.
- Careful planning, management, and quality control to ensure the purity, viability, vigor, uniformity, and performance of seeds.
- Selection of appropriate sites for seed production and manually monitoring the isolation distance.
- Assessing the differences in area allotted and standing area.
- Optimum plant population and plant density identification.
- Uniformity or synchronous growth monitoring.
- Contamination due to foreign pollen (Unwanted cross-pollination).
- Crop stress due to multiple biotic and abiotic factors.
- Labor shortage and skilled labor availability.
- Data Fidelity.
- Data is inaccurate, extrapolated and subjected to human errors.
- Regulatory noncompliance leading to rejection of seed production plots.
- Digitalization of seed production processes.
- Digitization of crop traits to reduce dependency on human expertise.



Traditional vs drone-based corn breeding & seed production practices

Traditionally, crop phenotypic data is collected manually by breeders or researchers assisted by labor, who scout the field and make all the estimates. This data is manually recorded and kept for reference for years. However, there are several downsides to this approach. It is not only time-consuming and inaccurate but doesn't offer reliability and detailed information on crop phenotypic traits in the field. Also, the accuracy of data captured is dependent on the level of expertise of human resources deployed. On the other hand, drones and drone analytics offer accurate data of the entire field in a fraction of the time taken by traditional methods.

Not so long ago, plant stand counts were done by sampling a very small portion of the original number of corn plants present in a field, which was then extrapolated to represent the complete field. But now, drones coupled with Asteria's proprietary deep learning artificial intelligence algorithms helps in precisely and quickly counting the number of corn plants in a field with high accuracy.

Earlier, crop uniformity was subjective and was checked

by taking random sample observations from fields and extrapolating them for the entire area. Assessing crop uniformity is a highly skilled job and demands expertise. Now, it has become much easier to assess crop uniformity with digital means. Imagery collected by drones can be fed into Asteria's proprietary deep learning AI algorithms to look for growth patterns and vegetative indices for the entire farm.

Recent innovations in image processing and drone hardware have made it possible to streamline corn breeding and seed production process and at the same time, enable faster, simpler, more accurate and regular measurement of traits, things those weren't possible earlier with traditional methods. To make the most of drone-based intelligence, it is important for seed producers and breeders to partner with a drone technology company that has proven expertise in providing industry and crop specific drone solutions. Asteria Aerospace Limited is one such company. It is a leading supplier of end-to-end drone solutions for corn breeders/researchers as well as corn seed producers.

Asteria's end-to-end drone-based solutions for corn breeding & seed production

Asteria's expertise lies in providing industry-leading drone-based tools for corn breeders and seed producers at different stages of the crop lifecycle. The objective is to help them make timely and data driven decisions as well as simplify and fast-track their digitalization journey. Asteria acts as an enabler by providing a comprehensive drone-based solution that is capable of providing corn breeding and seed production stakeholders with vital information about phenotypic traits and support in crop improvement. Asteria's drone operations and analytics platform, SkyDeck, is the perfect tool for deriving actionable insights from the data collected by drones. Asteria's end-to-end drone solutions can be used for:

Data collection: DGCA type certified drones with integrated high-end sensors –RGB & multispectral – to gather high-quality data and offer customized solutions specific to corn breeding & seed production.

Data processing, analysis & visualization: Proprietary, AI-enabled algorithms built specifically for corn seed production on SkyDeck. SkyDeck tool enables automated stand count, uniformity, missing tassel count, area measurement, isolation distancing, crop stress identification and more.

Reporting: Generate customized reports, share and download high-precision maps of fields and research plots from SkyDeck. Collaborate on the data through any simple browser, analyze problem areas, annotate and

callout issues. Generate and access reports of meaningful insights for informed decision-making.

Specific solutions for corn breeders and seed producers

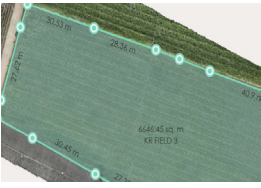

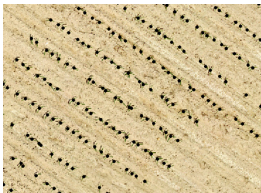
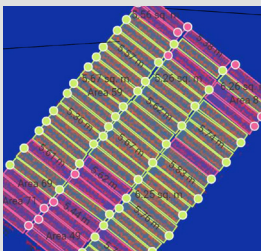

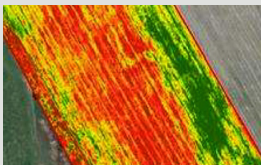
Corn Breeding:

- Build digital twins of experimental fields.
- Generate plot wise customized insights within experimental fields.
- Extract & quantify phenotyping traits & performance of different seed varieties.
- Assess & validate breeding trials remotely.

Seed Production:

- Map agricultural plots and farms quickly and reliably.
- Extract & quantify phenotyping traits & performance of different seed varieties.
- Ensure seed purity and quality
- Monitor & forecast corn seed production more accurately.
- Meet regulatory compliances of seed production farms.

Asteria can help corn breeders and seed producers have easier access to extensive phenotyping data, including but not limited to stand count, uniformity, area measurement, isolation distance, stress monitoring, and more.

Plant Trait	Challenges	Asteria's Solution	Asteria Advantage
Area measurement 	<ul style="list-style-type: none"> Laborious & hard-to-do. No alternate method of validation available. Difference in allotted area and standing area. 	Measure the area of individual target field with high accuracy.	<ul style="list-style-type: none"> Helps estimate optimum population and define seed rate. More than 98% accuracy*. Can be validated remotely. Validate the standing area to area allotted.
Isolation Distance 	<ul style="list-style-type: none"> Time-consuming & prone to human errors. It is must to maintain isolation distance to ensure seed purity. 	Measure the isolation distance with high accuracy.	<ul style="list-style-type: none"> More than 98% accuracy*. Can be validated remotely. Supports regulatory compliances.
Stand count 	<ul style="list-style-type: none"> Not possible to count each plant manually and extrapolation results are not accurate Existing methods are prone to human errors. On-ground inspection is time-consuming & labor-intensive. 	Proprietary custom built AI algorithm to perform plant stand count with high accuracy.	<ul style="list-style-type: none"> Estimate germination percentage with more than 95% accuracy. High throughput value with no extrapolation errors. Digitalization & digitization of data for easy integration with other analytics solutions and easy availability for future requirements.
Uniformity 	<ul style="list-style-type: none"> Current method of uniformity assessment is subjective & time-consuming. Dependency on skilled human resources. Results are extrapolated based on small sample sizes and don't represent exact field condition. 	Asteria uses drone mounted RGB sensors to get the vegetation map of the field to determine uniformity.	<ul style="list-style-type: none"> More than 90% accuracy High throughput value without extrapolation errors. Evaluate & store uniformity related phenotypic characteristics in digital format.
Missing tassel count 	<ul style="list-style-type: none"> The current method is labor intensive & is prone to errors. If any male tassels on female plant are missed and not found due to error, there are chances of entire fields getting rejected. 	<ul style="list-style-type: none"> Dynamic adjustment of sensitivity to balance false detection & missed detection. Ability to automatically hide the male parent line. 	<ul style="list-style-type: none"> More than 90% accuracy Reduce dependency on human error. Ensure high seed purity.
Stress identification 	The current method of identifying crop stress is inaccurate & time-consuming.	NDVI, NDRE, SAVI stress mapping gives multiple indices about crop stress due to biotic or abiotic factor.	Identify problematic areas in the field divided into multiple stress zones and take corrective crop management measures accordingly.

Benefits of Asteria's drone solutions in corn breeding & seed production



High throughput with high accuracy

Asteria's DGCA type-certified drones help in collecting large-scale, field-based plant phenotypic data with high accuracy in a short period for crop improvement.



Data-Driven decision-making & digitization

Asteria's DGCA type-certified drones help in collecting large-scale, field-based plant phenotypic data with high accuracy in a short period for crop improvement.



Improved data fidelity and scalability

Asteria's drone expertise facilitates standardization of data and analyzing methods ensuring validation of outcomes. This enables transparency and improves fidelity of data and scalability of operations.



Enhanced crop monitoring & digitalization

Asteria's DGCA type-certified drones help in collecting large-scale, field-based plant phenotypic data with high accuracy in a short period for crop improvement.



Time and labor savings

Asteria's DGCA type-certified drones help in collecting large-scale, field-based plant phenotypic data with high accuracy in a short period for crop improvement.



Safety, compliance, and risk mitigation

Asteria's drone expertise facilitates standardization of data and analyzing methods ensuring validation of outcomes. This enables transparency and improves fidelity of data and scalability of operations.



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