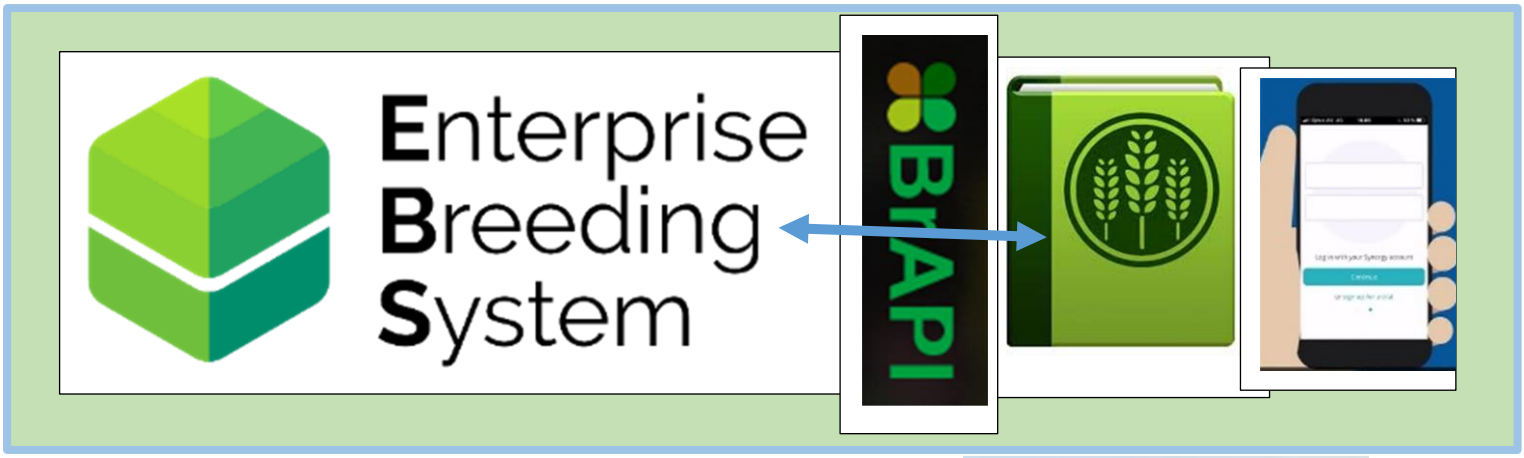
Guidelines and Best Practices

for Digital Data Collection and Management of Breeding Trials using Field Book, BrAPI and EBS.



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1. Introduction

In modern breeding programs, digital data collection plays a pivotal role in ensuring the accuracy, integrity, and timeliness of field observations. As breeding decisions become increasingly data-driven, the need for real-time, high-quality data captured through reliable tools is paramount. The FieldBook app, in conjunction with BrAPI-enabled servers and the Enterprise Breeding System (EBS), offers a robust and standardized platform for digital phenotyping and trial data management. FieldBook is an open-source Android application designed for collecting data from field research plots. By replacing traditional paper field books, it eliminates the need for manual data transcription and minimizes the risk of errors. EBS is a cloud-based breeding information management system that helps manage breeding data and activities. It provides end-to-end and easy-to-use tools to support better data-driven decisions throughout the breeding process.

 BrAPI (Breeding API) is a standardized interface that allows plant breeding tools/systems to communicate and share data efficiently, helping breeding teams avoid manual data handling and ensuring interoperability across platforms.

 Field Book, a mobile app for collecting field data, uses BrAPI to:

- Import field layouts and trait definitions from BrAPI-compatible databases.
- Export collected data back to these databases without manual file transfers.

 EBS interoperate with Field Book through BrAPI, enabling:

- Direct synchronization of fields (trial layouts), traits, and collected data.
- Streamlined workflows from data collection to analysis.
- This interoperability reduces errors, saves time, and enhances data consistency across platforms. In this context, BrAPI enables smooth and consistent data exchange between FieldBook and EBS.

2. Purpose

This guideline provides a structured framework for implementing electronic data collection using Field Book app, BrAPI, and EBS. It outlines the best practices including common troubleshooting issues and possible resolutions, needed tasks to perform at each stage of the collection and validation lifecycle. It also delineates workflows that ensure data quality, minimize errors, and facilitate seamless integration with the EBS breeding database. The goal is to equip breeders and

data managers with reliable, timely, and actionable data that supports faster and informed decision-making in crop improvement programs.

3. Scope

This document is intended for plant breeders, data officers, research supervisors and technical staff involved in field data collection. It covers the configuration, usage, and troubleshooting of Field Book common user issues, integration with BrAPI-enabled servers, and managing data flow between Field Book and EBS. The focus is on ensuring readiness for accurate data capture, streamlining field operations, and enabling data validation and reuse. These practices contribute directly to improved data quality and accelerated breeding cycles across diverse crops and environments.

4. TASKS TO PERFORM BEFORE DATA COLLECTION

4.1 Prepare and Upload Trial Design in EBS — (Data Officers/Supervisors)

- Design your trials in EBS with complete plot layout and germplasm information.
- Add all required traits to be measured in the trials by updating the trait protocols.
- Update other relevant metadata, especially planting date including fertilizer details, plot dimensions, management/treatment applied for each trial.
- Confirm the trials are accessible via Field Book by logging into BrAPI from a test device.
- Export a sample trial to the Field Book app via BrAPI server linked to your EBS instance to ensure successful connection and proper display of the trial information in the Field Book app.

4.2 Provide Technicians with Devices and Access — (Supervisors)

- Ensure all the technicians/fieldworkers have functional Android tablets or phones with FieldBook app installed.
- Confirm devices can be connected to the internet for BrAPI synchronization.

4.3 Register Users and Help Configure FieldBook — (Data Managers)

- Ensure all technicians/fieldworkers have active accounts in EBS and can log in with their institution-provided credentials or approved Gmails.
- Provide technicians/fieldworkers with soft and hardcopy scannable BrAPI settings QR codes for each EBS instance for ease of connecting to EBS via FieldBook.
- Ensure all trials with associated traits are properly created in EBS.

- Ensure the Android devices have the right FieldBook app version and settings installed.

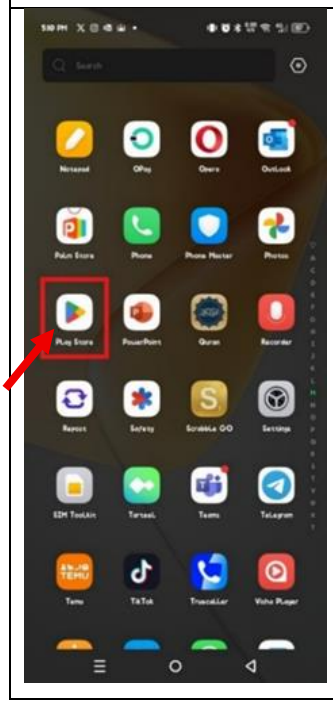
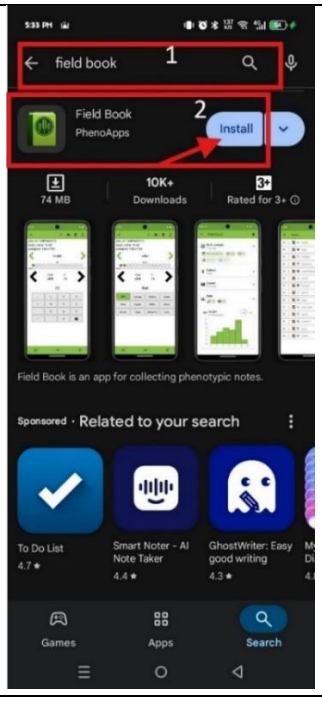
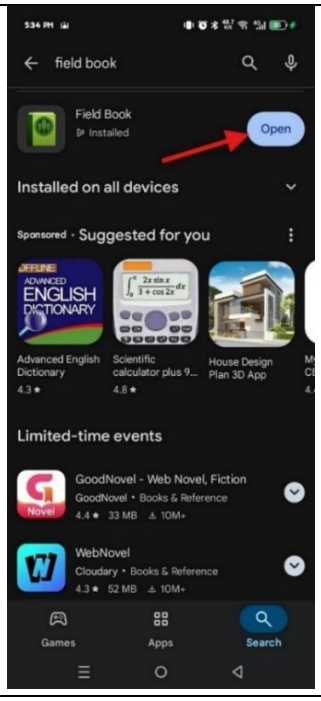
4.4 Ensure Android Device is Field-Ready — (Technicians/Fieldworkers)

- Ensure your Android device is field-ready:
  - It must be fully charged.
  - It must have the right version (version 6 and above that has BrAPI v2 setting) of the Field Book App installed on your device.
  - It must have the right field layout, and all required traits of the trial occurrence downloaded from EBS via BrAPI.
  - Ensure measuring devices/instruments are properly calibrated and well-functioning.

4.5 Download and Install Field Book — (Technicians/Fieldworkers)

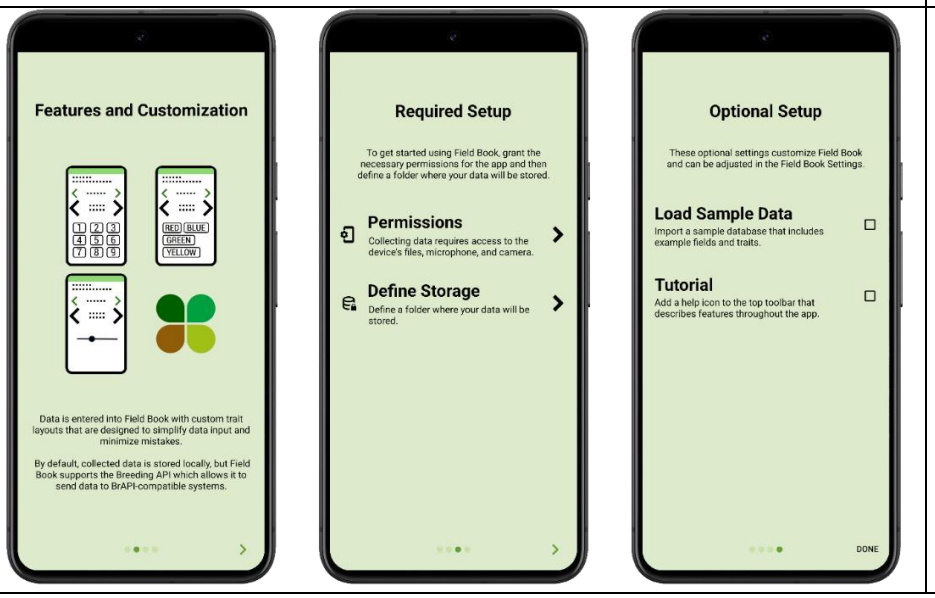
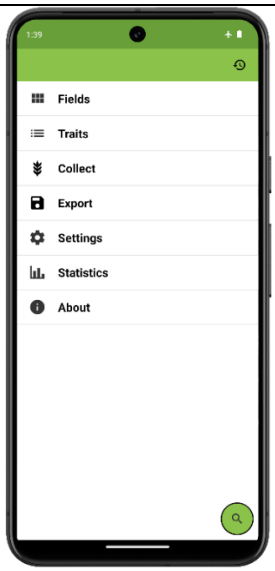
- To download the Field Book, go to the Google Play Store and search for "Field Book" to install it, if it is not already installed. You can also update your Field Book app with the current version if the one already installed is an old version via the Google Play Store.
- Install the app and grant required permissions (storage, microphone, camera).
- Open the app and complete first-time setup.

Steps to follow to download and install the Field Book App

Step1. Open "Play Store" on your android device or tablet.	**Step2. Search "Field Book" in the search bar and click install.**	**Step3. Click open to launch app after installation.**
		

4.5 Initial Setup of the Field Book after a New Installation

- When you open Field Book for the first time after a fresh installation, a brief introduction appears as shown in the sample screenshots below.
- During the setup, you must:
    - Accept/grant all the required permissions.
    - Choose or create a storage directory for the app's files.
- Optional setup steps include:
    - Enabling a tutorial.
    - Loading sample fields and sample traits.
- Tap on the DONE to complete the setup and launch the app to the home interface.

Sample screenshots for an initial Field Book setup	**Home Interface**
	

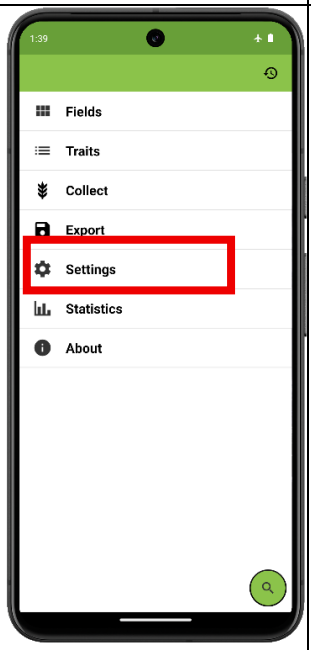
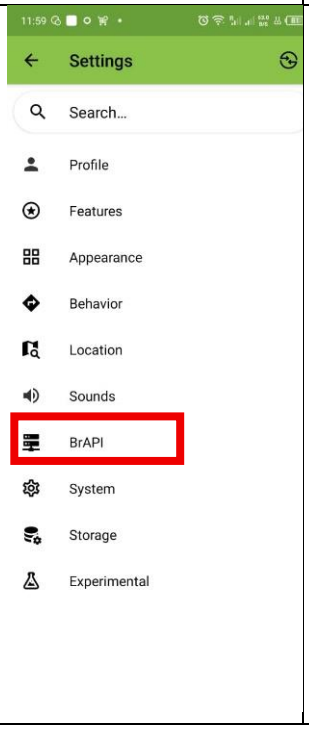
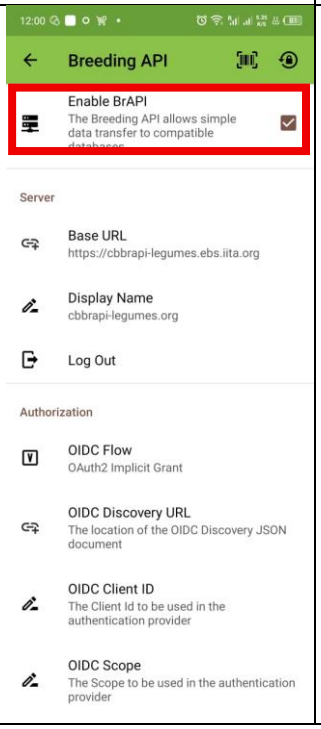
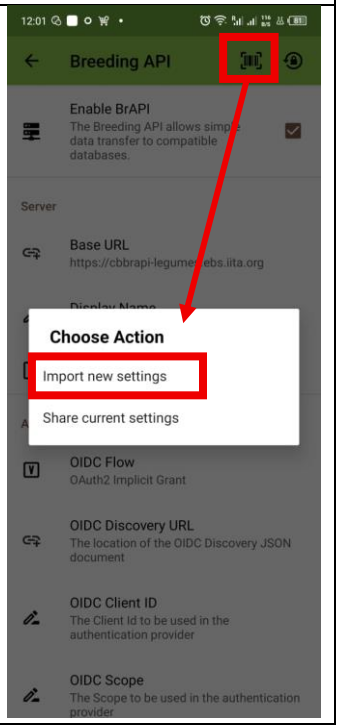
4.6 How to Configure EBS BrAPI Connection in Field Book App

Prerequisite: Ensure your device has internet connection.

Step 1: Open Field Book app to the **Home Screen** → **Step2**: Navigate to **Settings** → **Step3:** on the settings interface, tap on **BrAPI** →

Step4: on the Breeding API interface check the **Enable BrAPI** tick box→ **Step5:** Tap on the **Barcode Icon** on top of the Breeding API interface and select →

Step6: Import new nettings→ **Step7:** Scan the **BrAPI Configuration QR** code provided to you by your Data Manager or supervisor to automatically fill up the required settings. →

Home Interface	Settings	Breeding API interface	Breeding API interface
			

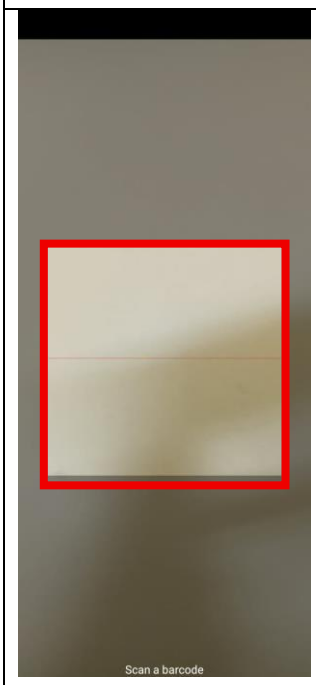
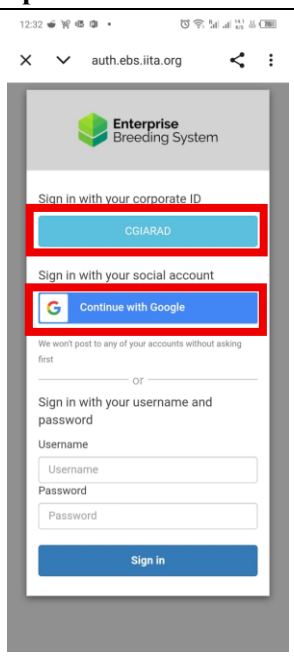
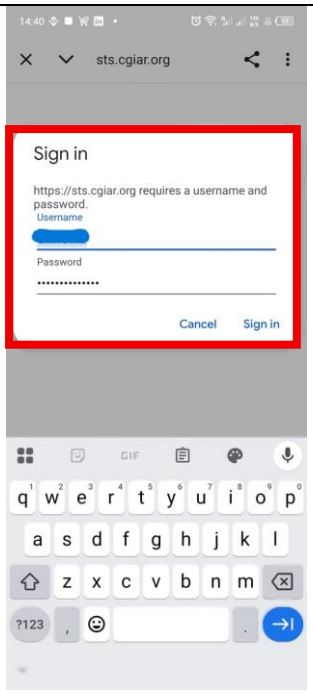
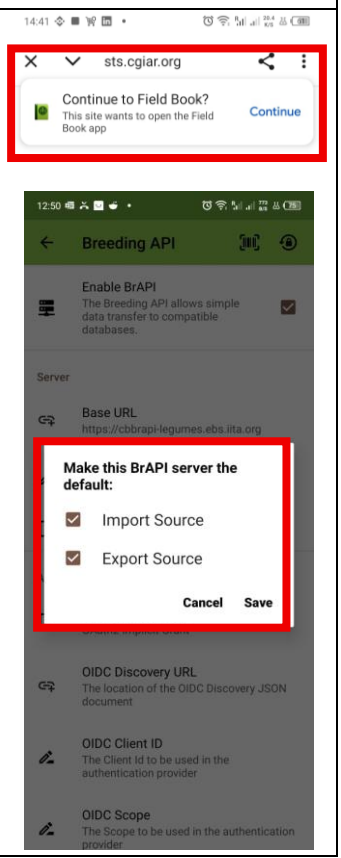
Step8: Sign in using your account registered in EBS and communicated to you by your Data Manager or Supervisor. This can be your institutional CGIAR or GMail account.

- Select →**CGIARAD** option if your CGIAR account is registered in EBS or,
- Select →**Continue with Google** option if your Gmail was the one registered in EBS.
- Enter your account login credentials username and password to authenticate and login.

Step9: Tap on the **Continue to Field Book** and you may check the **Import source and Export source** options save to make the BrAPI server your default import and export sources.

These simple steps are screenshot below for ease of reference.

EBS BrAPI Connection in Field Book App

Scan QR Code	Choose account option	Breeding API interface	Breeding API interface
 **Let your scanner camera red line pass through the middle**			

4.6 How to Import a Field (Trial Layout/Occurrence with Traits) from EBS via BrAPI into Field Book

In Field Book, experiments or trials are referred to as “fields.” These fields can be created manually, imported from a file (such as CSV or Excel), or downloaded directly from a BrAPI-enabled database like EBS. Using BrAPI simplifies the process by allowing users to fetch trials with predefined layouts and metadata directly into the app. The scope of import here is limited to the BrAPI option.

Prerequisites:

- Ensure your device has internet connection.
- Ensure that BrAPI is enabled and properly configured under the BrAPI Settings in the Field Book app as described in the previous steps.

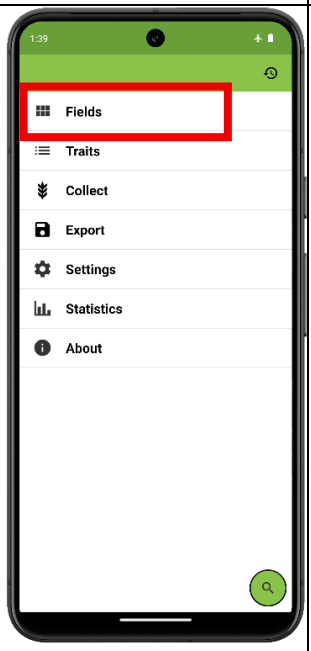
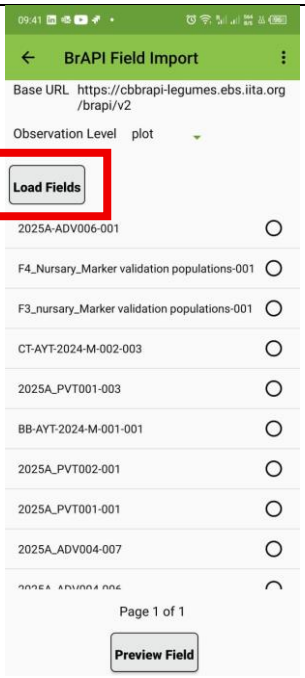
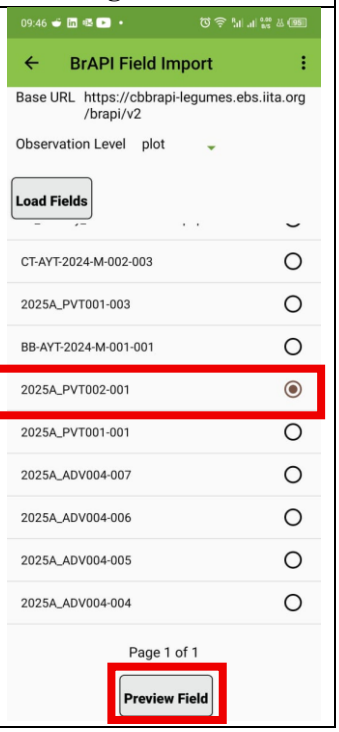
Once authenticated with the compatible BrAPI-enabled EBS database, the server will appear as an available source for field import. Users can then load trials directly from the EBS server for data collection. For more detailed instructions on field and trait import processes via BrAPI, refer to the steps below. **Note: Before importing a Field via BrAPI to the Field Book App for data collection, exported or delete all user-defined traits from your Field Book. Only traits imported with the Field via BrAPI can be exported to or sync with EBS.**

Step1: Launch the Field Book App on your device and tap on "**Fields**".

Step2: Tab on the add **"+"** button to add a new field. You may be required to re-authenticate and connect to EBS. Follow the login steps by choosing the CGIAR or Google options as stated earlier to continue to Field Book.

Step3: Tap on **load fields** to see fields from your breeding program in EBS if not already displayed.

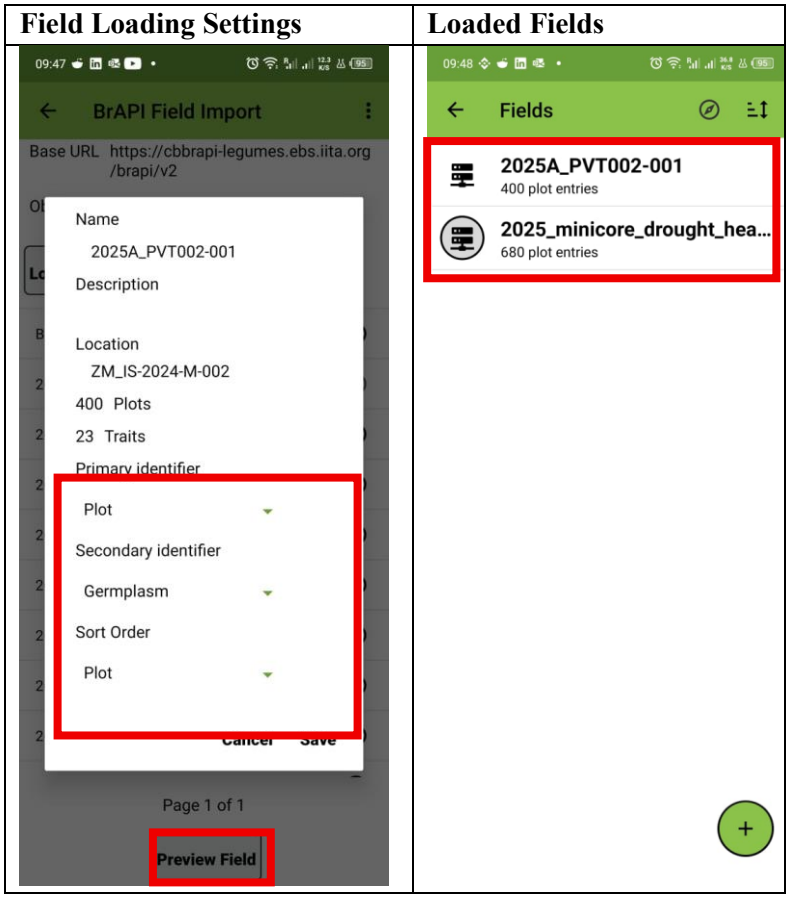
Step4: Choose the trial you wish to collect data for and tap on the tab **preview** to confirm the details

Home Interface	Settings	Breeding API interface	Breeding API interface
			

Step5: Use the following settings for the field to be loaded:

- Primary Identifier: Plot
- Secondary Identifier: Germplasm
- Sort Order: Plot

Step6: Tap on the **save** button to load the field.



4.7 How to Manage Traits

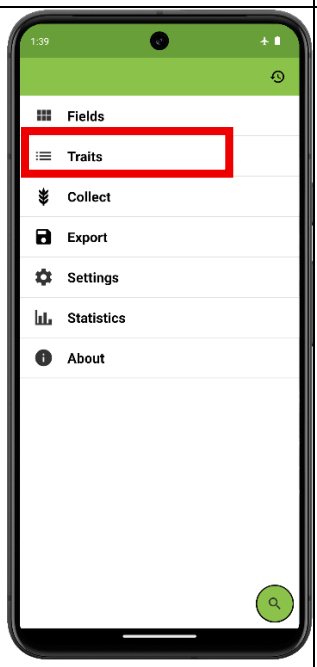
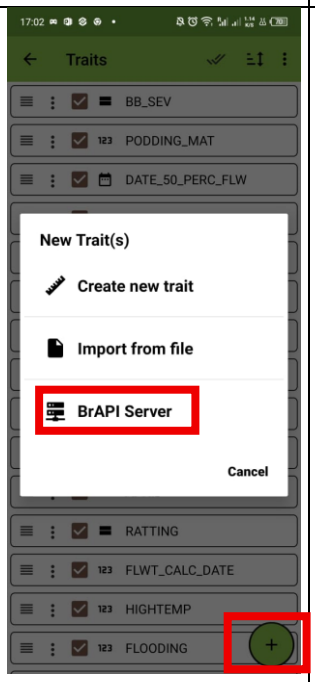
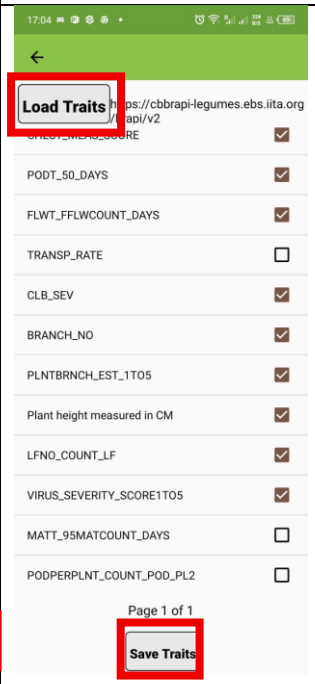
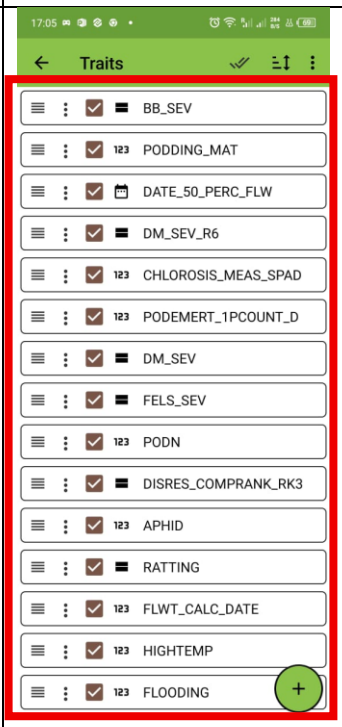
Data is collected in Field Book for each trait at a time. Each trait layout is designed to collect a specific data type. Before you collect data for a trait, ensure that the trait came from EBS along with the Field that was imported. **Note that user-defined traits cannot be exported to EBS via BrAPI. Traits can also be loaded separately by BrAPI Sync.** Existing traits can be manipulated using the following features:

- **Reorder** an individual trait by pressing and dragging the ≡ icon.
- **Copy**, **Edit**, or **Delete** an individual trait by pressing the ⋮ icon on its trait line and selecting the desired operation.
- Set an individual trait to be **Active** or **Inactive** in the **Collect** screen by checking/unchecking the checkbox on each trait line.

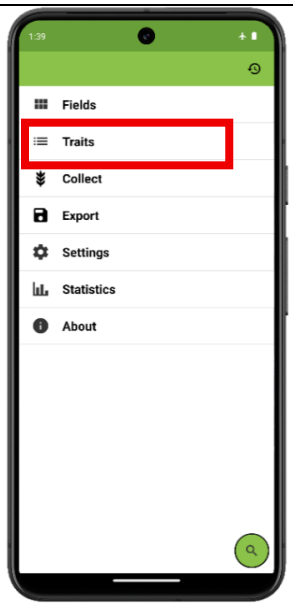
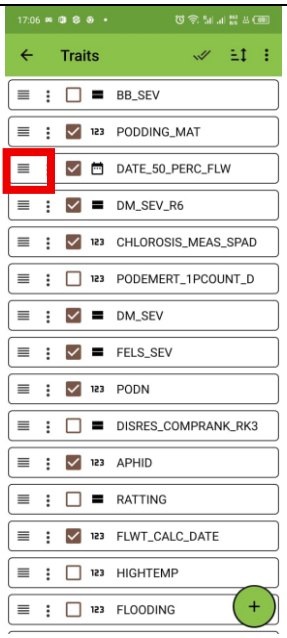
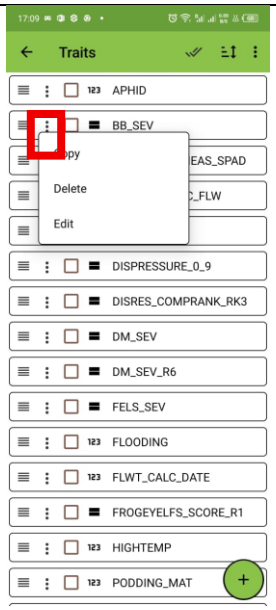
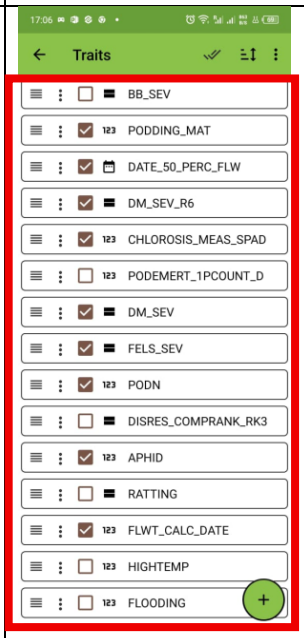
- Actions that apply to all traits can be initiated from the top toolbar.
- Make all traits **Visible** or **Invisible** by pressing the icon.
- Reorder all traits by pressing the icon in the toolbar and selecting one of the sort criteria (options include trait Name, Format, Import Order, and Visibility).
- Select **Delete all traits** from the menu to remove every trait in the list.
- Select **Import/Export** from the menu to load new traits into Field Book or to export the current traits to a file.

The screen shots below depict the trait management process.

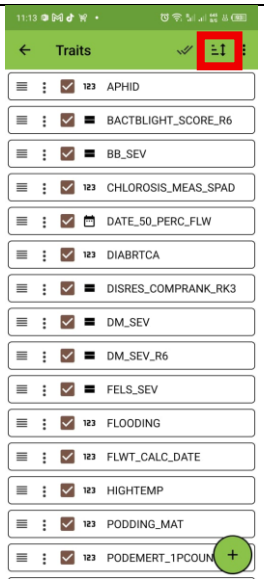
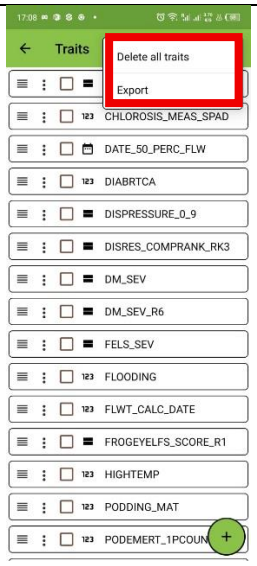
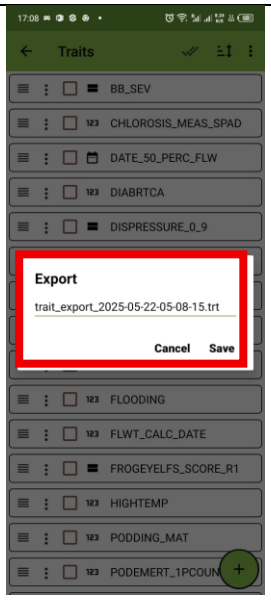
4.7.1 Loading Traits via BrAPI

Home Interface	Add Traits via BrAPI	Load, Select and Save	Loaded and active traits
			
Step 1: Select Traits in the Home Screen	**Step 2:** Tap the " +" icon and select the BrAPI option	**Step 3:** Tap Load traits, select and save traits	**Step 4** select traits to mark active at the Collect Screen

4.7.2 Single trait changes: Reorder, Copy, Edit, Delete, Activate Traits

Home Interface	Select a trait and reorder	Copy, Edit, and Delete	Activate traits
 **Step 1: Select Traits in the Home Screen**	 by pressing and dragging the ≡ icon	 **Copy**, **Edit**, or **Delete** an individual trait by pressing the ⋮ icon on its trait line and selecting the desired operation.	 Set an individual trait to be **Active** or **Inactive** in the **Collect** screen by checking/unchecking the checkbox on each trait line.

4.7.3 Multiple trait changes: Make Visible/Active, Reorder, Copy, Edit, Delete,

Make all traits Visible	Reorder all Traits	Delete/Export all Traits	Save Trait Export
 **Make all traits Visible or Invisible by pressing the ✓✓ icon.**	 Tap the ⇶ icon	 by pressing the ⋮ icon	 **Tap Save**

4.8 How to Enable the DataGrid View in Field Book App

The DataGrid displays a matrix layout of entries (plots) and traits for the active field, making it easy to spot missing values at a glance. Tapping on a specific cell in the grid will take you directly to the corresponding entry and trait for editing or review.

Step1: Lauch the Field Book app on your device and tap on **Settings**, **Step2:** Choose **Features** and check the **DataGrid, Step3:** Navigate back to **Fields** and try to **collect data, the DataGrid Icon** should now be showing on the top of Screen.

5. TASKS TO PERFORM DURING DATA COLLECTION by (Technicians/Fieldworkers)

5.1 Collect Field Data

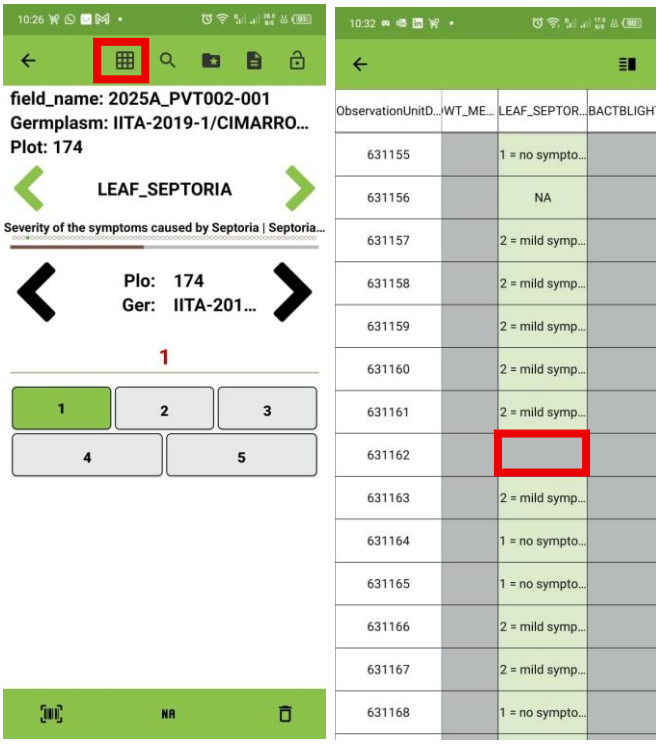
- Use Field Book App to enter data on each plot in real-time.
- Move between plots and traits using the navigation buttons.
- Scan plot or sample barcodes (if applicable) to reduce data entry error.
- Indicate NA for plots with no corresponding values because they are missing. Do not leave the plot value as 'BLANK'. If possible, go the '**Settings'** on the Field Book App, proceed to '**Behavior'**, and tap on '**Require Data to Move Entry'** and select one the options (move right or left or both) either disabled.
- When pausing for moments during the data capture, tap on the **Lock Data** feature of the Field Book App which is displayed as padlock on the Collect Screen to lock the data to avoid unintended modifications. It's opened by default, taping it will change it to locked

- Double-check the trait you selected before you begin to record data to ensure you don't enter data for a different trait other than the one you selected e.g., Ear Height (EH), Plant Height (PH) are not the same.
- Do not enter data from your memory due to delay recording which might have led to guesswork or forgotten values. Re-measure again and record the right value.
- Avoid distraction as much as possible to neglect entry errors.
- Avoid collecting data under fatigue.
- Double-check entries before saving or submitting.

- Follow your program Standard Operating Procedures (SOPs) for data collection.

5.2 Save and Review Data Regularly

- Review entries in Field Book's Data section by trait for completeness and accuracy.
- To quickly review data collected data, tap the DataGrid icon in the top toolbar of the Collect screen to spot black cells.
- Ensure there are no 'blanks' in all traits you collect data for. Blank in any trait data means it's not completely captured.



- Avoid overwriting data unless verified as incorrect.

6. TASKS TO PERFORM AFTER DATA COLLECTION

6.1 Export Data via BrAPI— (Technicians/Fieldworkers)

Once data has been collected with the Field Book app it can be exported via BrAPI by pressing Export and selecting BrAPI from the Export Data options. Note: if BrAPI is already set as your default Export mode, you won't see the options to select BrAPI again. The data will automatically be exported without asking to select an Export source.

6.2 How to Export Data via BrAPI

Prerequisites: The device should have an internet connection, and the user should be logged into EBS via the BrAPI connection before the data can be exported.

Steps to Export Data via BrAPI:

Step1: Navigate to your **Fields** page and select the Field you want to export its data from the list of displayed fields.

Step2: Double check the data. Tap on the **Data** option to view the data collection statistics for each trait and ensure that all the traits you want to export are 100% collected without blanks.

Step3: On the same screen, tap on the **Export** option, Field Book will display a summary of BrAPI Export statistics including a breakdown of the number of new, synced, and edited observations, as well as skipped observations.

The same statistics are displayed for images.

Step4: Tap on the **Export** option to submit the data to EBS.

Step5: Inform your supervisor or data officer after you have successfully exported the data to EBS.

6.3 Review and Commit Data to EBS — (Supervisors/Data Officers)

- **Log in to EBS** and navigate to the **Data Collection terminal** to confirm successful receipt of trial occurrence data for the collected traits.
- **Perform data Quality Checks**; compute calculated traits if any by selecting the right formulas.
- **View the Plot Summary** to quickly check the summary statistics (No. Obs, No. Missing data points, No. Invalid data points, Min, Max, Mean, Var) of the upload dataset.
- **Go to the plot data** detail page to check for potential outliers and invalid data points.
- **Select and suppress** any value you may find problematic; you may also replace the datapoint with valid or correct value after confirming from the technician who uploaded the data
- **Proceed to the next step to commit** the upload transaction to the EBS database if all the checks and necessary validations are done.

6.4 Perform Data Cleaning and Backup— (Supervisors/Data Officers, Data Manager)

- In very rare cases, you may export the data from EBS for additional cleaning or formatting if the uploaded dataset has many issues.
- Upload the curated data back to EBS immediately after the cleaning.
- Ensure backups are created both in EBS and locally by downloading and achiving data files.

7. Troubleshooting and Support

Below are common issues that may be encountered while using the Field Book app with EBS, along with recommended solutions and best practices. For further details, consult the Field Book Manual (https://fieldbook.phenoapps.org/#/).

Field Book not showing trials:

- Ensure that BrAPI is successfully configured.
- Confirm you are logged in with an authorized CGIAR/Google account.
- Verify that the trial(s) has been correctly exported from EBS to the BrAPI server.

Unable to export data:

- Make sure your device is connected to the internet.
- Confirm that you are authenticated on the BrAPI server.
- Re-authenticate, if necessary, by logging out and logging back in.
- Ensure trait names and formats in Field Book match those defined in EBS.

Trait mismatch:

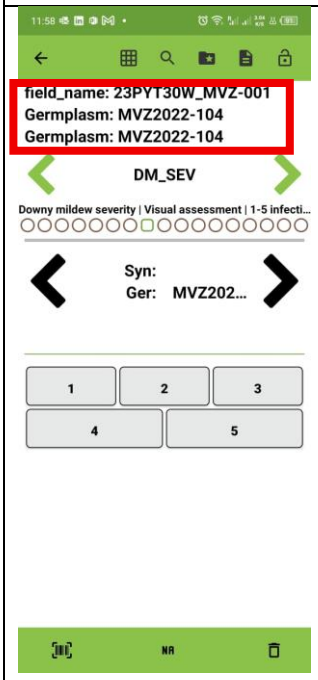
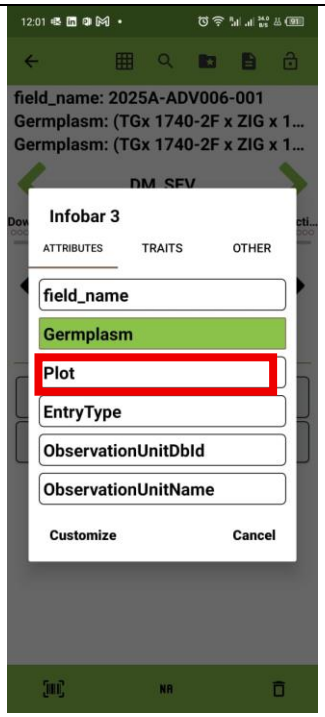
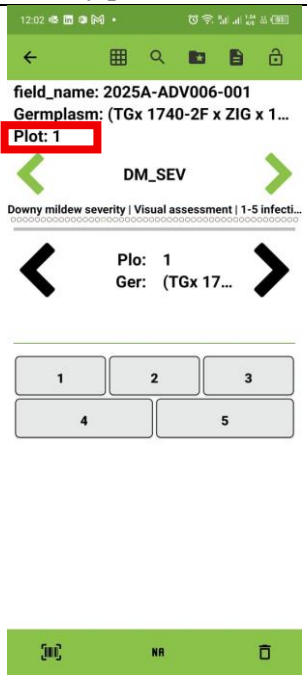
- Check that all trait names, types (e.g., numeric, categorical), and units exactly match those defined in the EBS trial setup.
- Review the imported traits under the Traits section to ensure consistency.

DataGrid not showing:

- Tap the Datagrid icon at the top of the Collect screen to access the DataGrid view.
- Ensure an active field is selected and at least one trait has been added.
- If it is still unavailable, restart the app or reinstall if the issue persists.

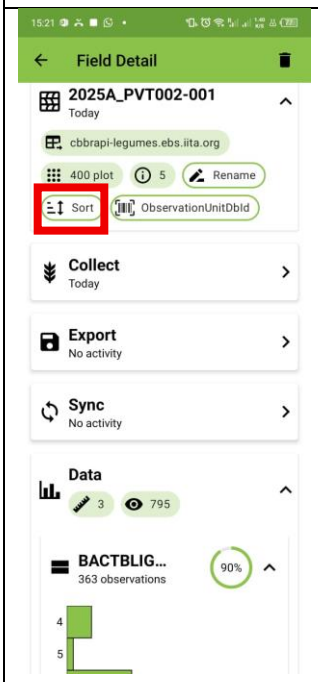
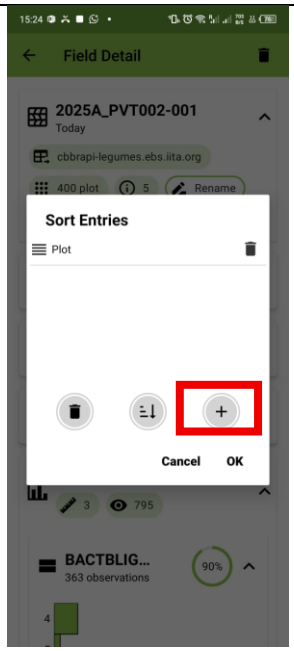
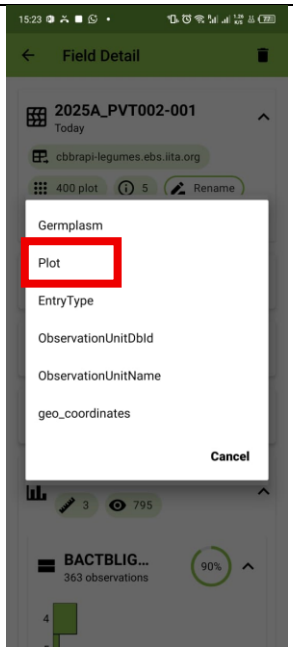
PlotNo not showing in the field data collection screen or a different attribute is showing in the place of the plot number

- Confirm the s**ettings for the field to be loaded are correctly specified:**
  - Primary Identifier: Plot
  - Secondary Identifier: Germplasm
  - Sort Order: Plot

Data Collection Screen	Data Collection Screen	Sort by plot
		
Tap on one of the repeated attributes (germplasm)	Tap on Plot to select or add it	Plot number should now be showing

Plot numbers not sorted correctly:

- Confirm that plot identifiers are numeric and formatted consistently.
- Sort manually using the Field Book 'Sort Order' setting under the field configuration.

Field Detail Screen	Fields Screen	Sort by plot
		
Tap Sort	Tap on Add "+"	Select Plot to sort by and press ok

Field not importing correctly via BrAPI:

- Make sure 'Occurrence import via BrAPI' is deselected in experimental import settings.
- Always set Plot as the primary identifier and Germplasm as the secondary.

Crashing or freezing app:

- Ensure the app has all permissions (storage, camera, microphone).
- Update to the latest version of Field Book via the Play Store.
- If problems persist, clear app cache or uninstall and reinstall the app.

Barcodes or QR code not scanning:

- Confirm camera permissions are enabled.
- Clean the camera lens and ensure the barcode is well-lit and properly printed.
- Use high-quality printed barcodes with standard dimensions. Ensure the barcode is not scratched or faded

8. Conclusion

The interoperability of Field Book App and the Enterprise Breeding System (EBS) via BrAPI represents a significant advancement in digital field data collection for plant breeding programs. By following the recommended workflows and best practices outlined in this guideline, breeding teams can ensure high-quality, consistent, and timely data captured across locations and seasons. These practices not only reduce errors and manual data handling but also accelerate the flow of data into centralized systems, enabling real-time analytics and faster decision-making. Ultimately, adopting these digital tools like Field Book BrAPI within a structured framework enhances the efficiency and responsiveness of breeding pipelines, contributing to more rapid genetic gains and improved varietal development.

9. References

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