Field Book

Release 5.4

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ONE

FIELD BOOK

1.1 Introduction

Field Book is an open-source Android app that can be used to collect data on field research plots. When used in place of paper field books, it eliminates the need for data transcription and reduces the risk of errors. It runs on a wide range of inexpensive hardware, allowing consumer-grade technology to be used in environments where cost and inflexibility have been limiting factors. The source code for Field Book is available on GitHub.

1.2 Getting Started

Field Book can be downloaded from the Google Play Store or can be installed manually from the latest GitHub Release. After installing the app, all permissions should be accepted and sample data consisting of three fields and traits can be optionally loaded. The images in the documentation utilize the sample data.

1.3 Structure

Field Book contains a home screen with links to the major sections of the app. To use Field Book:

1. Import your ▦ *Fields*

2. Create ☰ *Traits*

3. Optionally modify any ✿ *Settings*

4. Navigate to ♨ *Collect*

5. 🖫 *Export* data to a CSV (comma separated value) file

The ⟲ Changelog can be accessed from the top toolbar to see new features and additions to the app.

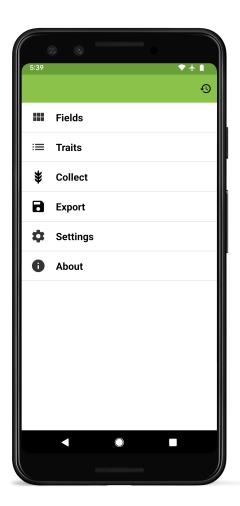Fig. 1: Primary Field Book screen

STORAGE

2.1 Storage Location Definer

After installing and opening the app, you will be asked to create a new folder and define it as the **Storage location** on the device where files will be written. In Field Book this step is required. The selected 'Storage location' can be changed in the ⚙ *General Settings*.

Fig. 1: Storage location definer layout

2.2 Subdirectories

Fieldbook will create the following subdirectories within the selected 'Storage location' directory:

- `field_import`: contains files to be imported into Field Book
- `field_export`: contains exported data files
- `plot_data`: data associated with plots (e.g., audio, photos)
- `resources`: allows the user to access photos/documents while collecting data (e.g., rating scales, field maps)
- `database`: contains automatic and manual database export files
- `trait`: contains trait files and the rust rating customizable scale
- `archive`: contains backups when exported fields are overwritten
- `geonav`: stores files created when using the geonav feature
- `updates`: stores .apk files downloaded for app updates

2.3 File transfer

To add your own files to the appropriate subdirectories you may need to manually transfer files from a computer. You can do this by connecting your Android device via a USB cable and changing its USB mode to allow file transfer. Each device manufacturer has slight variations for the appearance of this dialog.

2.4 Database

Field Book uses an internal SQLite database to store imported fields and traits, as well as all data collected with the app. The database schema is modelled after the Breeding API (BrAPI) standard, and is documented in the Field Book Wiki

The database is automatically backed up to the `database` directory at regular intervals. It can also be manually exported and imported in *Database Settings*. This feature can be used to transfer data to a new device or for recreating issues when troubleshooting.
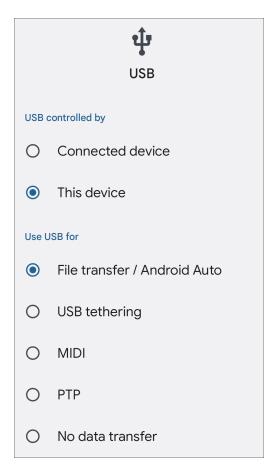
Fig. 2: Example settings for USB file transfer.

THREE

FIELDS

3.1 Overview

Experiments are represented in Field Book as *fields*. Fields are either imported from a file, from a BrAPI-enabled database, or created from scratch.

Each field has a unique name, an import date, and a set of *entries* which represent the experimental units on which data will be collected (e.g., plots, plants). Once data is collected and exported for a given field it will display the dates of last edit and export.

Fig. 1: A sample field with a name, import/edit/export dates, and number of entries

When importing from a file, each row in the file reprents an *entry*. Each *entry* within a field must have the following:

- A **unique identifier**, which is used internally by Field Book to associate data with the specific entry. It must be unique across all of your fields.

- A **primary identifier**, and a **secondary identifier**. These set the order of advancement through the field's entries, and can be whatever makes the most sense for your experiment. Most often they are numbers from the experimental design (e.g., row/plot, row/column, range/plot).

plot_id	row	plot	seed_id	seed_name	pedigree
13RPN00001	1	1	12GHT00001B	Kharkof	Kharkof
13RPN00002	1	2	12GHT00002B	Roughrider	Roughrider
13RPN00003	1	3	12GHT00003B	Nuplains	Nuplains
13RPN00004	1	4	12GHT00004B	Nekota	Nekota
13RPN00005	1	5	11ASH90002B	G980172W	SW/IKE
13RPN00006	1	6	11ASH90002B	G980723	94CGT-96HV (BULK SELECTION)
13RPN00007	1	7	11ASH90002B	G980926 W	95CGT-96WD (BULK SELECTION)
13RPN00008	1	8	11ASH90002B	NW97S412-1	KS87809-10/ARAPAHOE

Fig. 2: A sample field import file

Additional information such as variety name, pedigree, or treatments is optional, but can be included and viewed in the InfoBars or in the summary dialog on the collect screen.

Fig. 3: The Fields screen layout with sample fields loaded.

Field Book includes a set of sample field files. Samples *field_sample.csv*, *field_sample2.csv*, and *field_sample3.csv* represent typical wheat breeding fields, while *rtk_sample.csv* demonstrates the import format for entry location data (an additional **geo_coordinates** column). Imported entry coordinates can then be used with the ⚑ *GeoNav* feature.

3.2 Importing a new field

To import a new field into Field Book press the ⊕ icon in the upper right-hand corner of the toolbar in the Fields section. Then, in the resulting dialog, select whether to import from a local file, from cloud storage (Dropbox, Google Drive, etc.), or via a ▤ *BrAPI (Breeding API)* connection.

A default import source can be set in ⚙ *General Settings* to skip this dialog.

Fig. 4: Field import process.

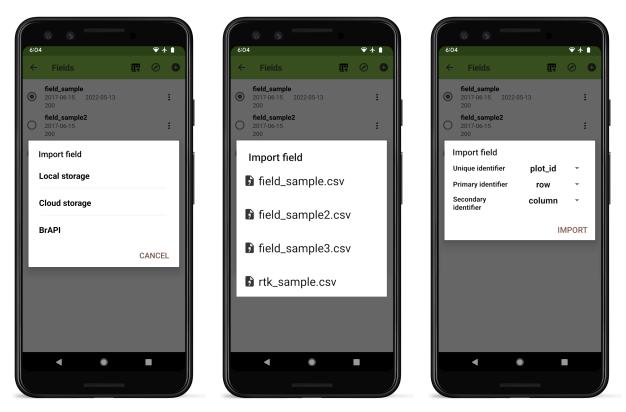Selecting local will display a list of files in the `field_import` directory. Only CSV, XLS, or XLSX files will appear in the import dialog. Filenames and column headers should exclude the following special characters:

Fig. 5: Characters that are not allowed in file and column names

Files can be added to the import folder by downloading or transferring from a computer, as described in *Storage*.

Once a file has been selected, the dropdown menus the dropdown menus allow selection of the column names that correspond to Field Book's required columns. Pressing IMPORT will finish importing the field.

3.2.1 Cloud storage

If you choose to import from cloud storage, Field Book will open the device file manager allowing navigation to the the file for import.
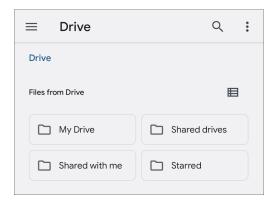

Fig. 6: Navigating to a google drive file for cloud import

3.3 Creating a field

To create a new field directly within Field Book press the ⊞+ icon on the toolbar. Set your field name and dimensions, choose which corner of the field will contain the first plot, and select zigzag or serpentine plot numbering. Unique IDs will be generated automatically.

3.4 Managing fields

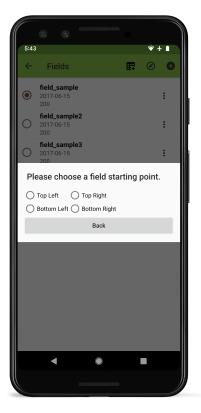To activate a field for data collection, select it from the list of fields.

Each row in the fields list displays the Date imported, Date edited, Date exported, and Number of entries.

Pressing the ⋮ icon to the right of the trial info opens a list of options:

- **Sort** provides a dialog to update the plot ordering. Populate the sort menu by pressing the ＋ icon, and selecting from the list of imported columns. Once columns have been added, change their relative priority by using the ☰ icon to drag and reorder them. Press the ⇅↓ icon to toggle the sort between ascending and descending. Press the 🗑 icon to remove a column.

- **Sync** connects to the server specified in ⎗ *BrAPI Settings*, updating the trial with new data that has been added from other sources since the last sync or import. This option will not work for trials imported from a file.

- **Delete** removes the trial and all associated data. A confirmation message will be shown first, to confirm that deletion is not triggered accidentally.
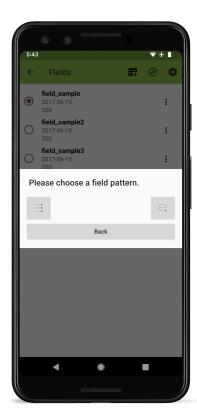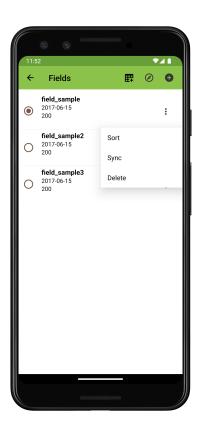
Fig. 7: Field creation process
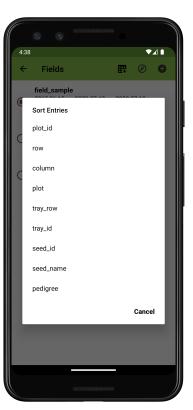
Fig. 8: Field management sorting steps

TRAITS

4.1 Overview

Data is collected in Field Book by defining different traits. Each trait layout is optimized for a specific type of data collection. The traits screen allows new traits to be defined and existing traits to be managed.
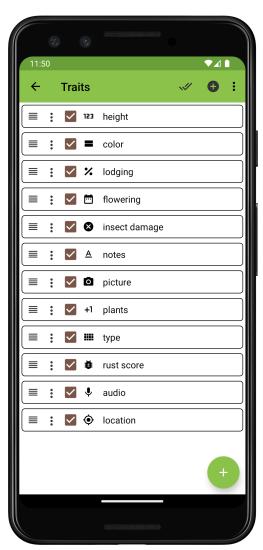
Fig. 1: The Traits screen layout with sample data loaded.

4.2 Creating a Trait

Traits can be created by pressing the large ⊕ icon at the bottom right of the screen, or the same icon in the toolbar. For each format, the creation screen adjusts to indicate which fields are required. Trait names must be unique. Each trait is created by specifying a trait `format`, a trait `name`, optional `details`, and format-dependent fields such as `min`, `max`, and `default`.
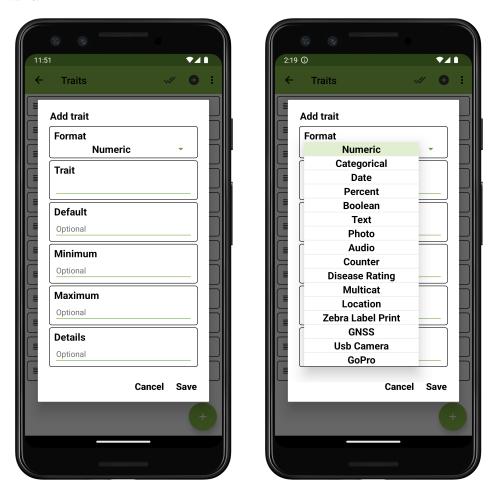
Fig. 2: Trait creation for a *numeric* trait, and other format options.

4.3 Managing Traits

Once created, traits can be manipulated using the following features:

4.3.1 Single trait changes

- Reorder an individual trait by pressing and dragging the ☰ icon on the far left of its trait line.

- Copy, edit, or delete an individual trait by pressing the ⋮ icon on its trait line, then selecting the desired operation from a list.

- Hide or unhide an individual trait from the 🌾 *Collect* screen by checking/unchecking the checkbox on each trait line.
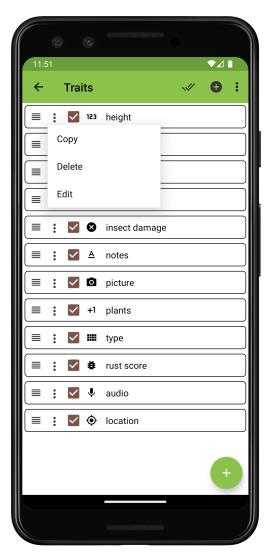
Fig. 3: Single trait management menu.

4.3.2 All trait changes

To make all traits active or hidden, press the ✔ double check icon in the toolbar.

Other changes affecting the whole trait list can be made by accessing the trait menu using the ⋮ icon on right side of the toolbar
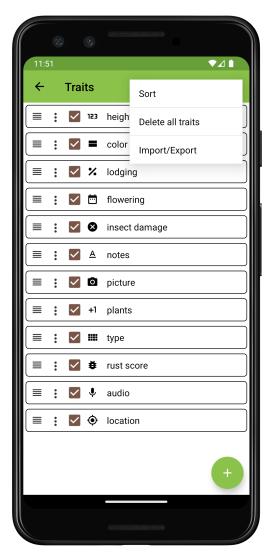
Fig. 4: All traits mangement menu.

- Reorder all traits by selecting **Sort**, then chosing your sort criterion (options include trait *Name*, *Format*, or *Checked* status)
- Remove all traits by selecting **Delete all traits**, then confirming the operation.
- Transfer traits in and out by selecting the **Import/Export** option.

Trait imports and exports are similar to field imports/exports in that they rely on files stored in a dedicated folder, or on communication with a designated server using a *BrAPI (Breeding API)* connection.

When using local storage, trait lists are stored as `.trt` files in the `trait` folder. Internally, `.trt` files store their data in a CSV format, but it is not recommended to manually edit these files.

COLLECT

5.1 Overview

Field Book aims to increase the rate at which data can be collected by tailoring the input screen to fit the exact task. Only a single entry and trait are visible at a time during collection. This reduces the risk of error and allows trait-specific layouts to be used for data input.

The small green arrows are used to navigate between traits. The large black arrows are used to navigate between entries. Data is entered in the bottom area of the screen using a layout determined by the current trait. Data is saved to an internal database as it is collected.
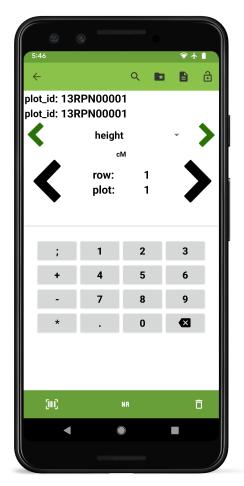

Fig. 1: Data collection screen

5.2 Collect Screen Details

5.2.1 Top toolbar

By default there are four buttons at the top of the screen (in addtion to the back navigation arrow).

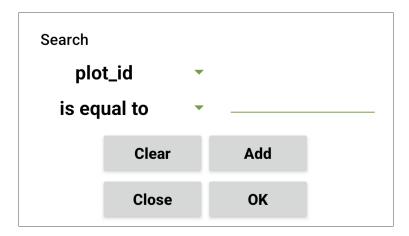- $\mathbf{Q}$ Search opens a dialog to search for a specific entry.

Fig. 2: The collect screen search tool

The search dialog provides a flexible interface for finding a specific entry within the current field. Select which imported data field to search by, what strategy to use to find a match, and enter a search string. Press Add to construct a complex search with an additional field and search string, or press OK to execute the search.

- Resources opens the `resources` directory and can be used to load reference images.

- Summary opens a dialog that displays all info for the current entry.

Summary shows detailed information for the current entry. Arrows at the bottom navigate forwards or backwards to other entries. By default the summary shows all of the imported data fields from the field file, but none of the collected trait values. Pressing the edit icon in the top toolbar opens a dialog to customize which data fields and traits are shown. Selecting a trait from the summary screen navigates to that trait.

- Locking adds restrictions about data input section to prevent accidental changes. Pressing this icon multiple times will cycle through three states:

  - Unlocked is the default, unfrozen state that allows trait values to be entered, edited, or deleted.

  - freezes the collect input so no values can be entered, modified, or deleted.

  - freezes existing data but allows entry of new values.

More features and tools can be added to the toolbar in the *General Settings*. Default icons can be removed from the toolbar in the *Appearance Settings*.

Fig. 3: The collect screen summary tool

Select summary labels

- ☑ plot_id
- ☑ row
- ☑ column
- ☑ plot
- ☑ tray_row
- ☑ tray_id
- ☑ seed_id
- ☑ seed_name
- ☑ pedigree
- ☐ height
- ☐ color
- ☐ lodging
- ☐ flowering

Toggle All **Cancel** **OK**
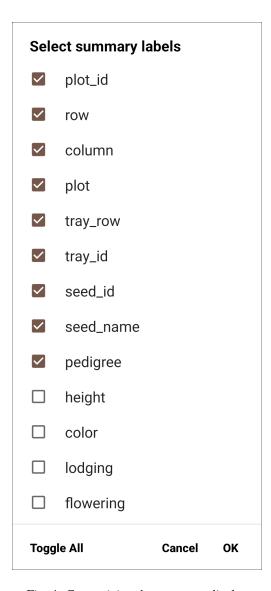
Fig. 4: Customizing the summary display

5.2.2 InfoBars

plot_id: 13RPN00001
plot_id: 13RPN00001

Fig. 5: The collect screen InfoBar section

InfoBars display information about the current plot. InfoBar prefixes can be pressed to adjust which data field is displayed.
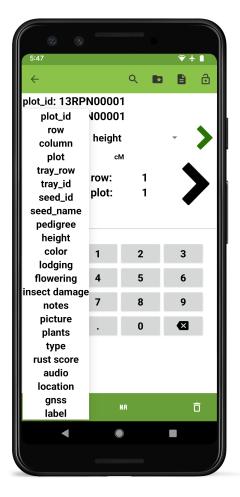

Fig. 6: Selecting which data field is shown in the InfoBars

5.2.3 Trait navigation

Fig. 7: The collect screen trait navigation section

The small, green arrows are used to move between the different traits that are currently active. Pressing the current trait will show a dropdown of all currently active traits.

Fig. 8: Pressing the active trait to see the trait dropdown

5.2.4 Entry navigation
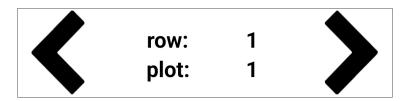
Fig. 9: The collect screen entry navigation section

The large, black arrows navigate between different entries. Pressing and holding these arrows will continuously scroll. The longer the arrows are pressed, the faster the scrolling becomes.

5.2.5 Data input

The bottom half of the screen is used to input data. The elements and layout of this area change based on the trait that is currently active. Information for each specific trait format can be found in the Trait Formats pages.

5.2.6 Bottom toolbar

The bottom toolbar contains three buttons for data input:
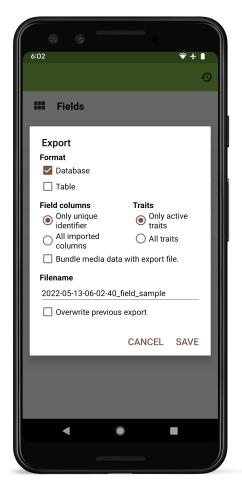
- ▯ enters data by scanning a barcode.

- **NA** enters NA for when a phenotype is not available.

- 🗑 deletes the entered data.

SIX

EXPORT

6.1 Overview

Collected data is exported to CSV files. The Export dialog allows the user to customize how collected data is exported.

6.2 Options

6.2.1 File Format

At least one format must be selected to export data. If both formats are selected, Field Book exports a single zipped file containing the files.

Table format exports each entry as a row and each trait as a column, creating a matrix of observed values. Metadata such as person and timestamp are excluded. If repeated measures have been collected, only the first value will be exported when using the table format.

plot_id	height	color	lodging
13RPN00001	75	Blue	27
13RPN00002	45	Yellow	51
13RPN00003	63	Yellow	75
13RPN00004	14	Purple	57
13RPN00005	15	Black	27

plot_id	trait	value	timestamp	person	location	number
13RPN00001	height	75	2023-05-22 11:25:57.304-04:00	Trevor Rife	35.9750949;-78.9786926	1
13RPN00001	color	Blue	2023-05-22 11:26:04.936-04:00	Trevor Rife	35.9750949;-78.9786926	1
13RPN00001	lodging	27	2023-05-22 11:26:11.278-04:00	Trevor Rife	35.9750949;-78.9786926	1
13RPN00002	height	45	2023-05-22 11:26:18.414-04:00	Trevor Rife	35.9739981;-78.9765391	1
13RPN00002	color	Yellow	2023-05-22 11:26:21.666-04:00	Trevor Rife	35.9739981;-78.9765391	1

Fig. 1: Sample data exported in both formats

Database format exports each individual observation as a spreadsheet row, and includes columns for collected metadata such as the name of the person who collected the data and the timestamp of when the observation was collected.

6.2.2 Included Columns

The exported file can include only the unique identifier or all field columns that were imported.

The exported file can contain traits that are currently active or all traits that have been created.

6.2.3 Save Details

The default filename is automatically generated based on the current date and the name of the field.

After clicking save, you will see Field Book app citation information and an option to share the exported file with other apps or email. The exported file is stored in the `field_export` directory.

6.2.4 Other Customizations

Bundle media data produces a zipped file that contains the exported data along with images and audio files that have also been collected.

Overwrite previous export moves old files to `archive` directory.

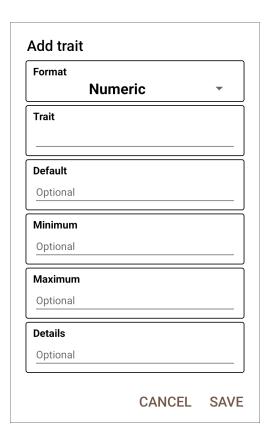The default export location can be modified in ⚙ *General Settings*.

¹²³ NUMERIC TRAIT

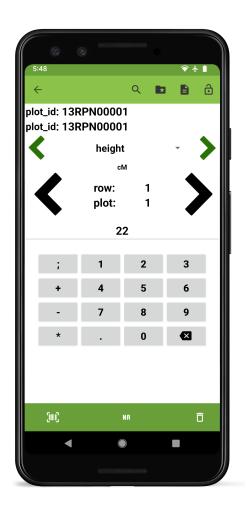## 7.1 Overview

The numeric trait format is used for quantitative traits like yield and height. Value minimum and maximums help reduce erros during collection. Details text is displayed under the trait name on the collect page.

7.2 Creation

Add trait

Format
Numeric ▾

Trait

Default
Optional

Minimum
Optional

Maximum
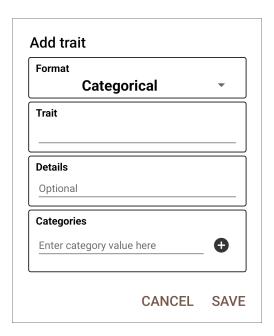Optional

Details
Optional

CANCEL   SAVE

7.3 Collect layout
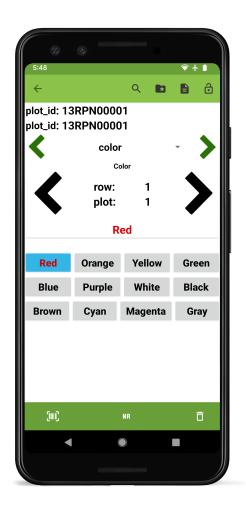
▬ CATEGORICAL TRAIT

8.1 Overview

The categorical trait format is used when trait values fall into a set of discrete categories. Categories are invidiually added in the `Categories` section of the create screen. Details text is displayed under the trait name on the collect page.

Defined categories are displayed as buttons on the collect screen; a single category can be selected per entry.

8.2 Creation

Add trait

Format
Categorical ▾

Trait

Details
Optional

Categories

Enter category value here ➕
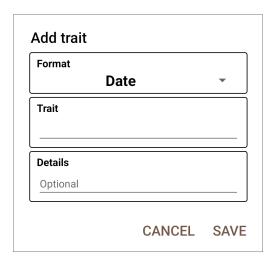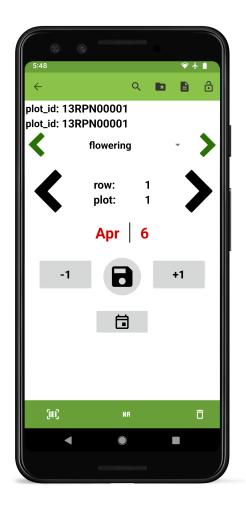
CANCEL   SAVE

8.3 Collect layout

📅 DATE TRAIT

9.1 Overview

The date trait format is used to record dates. Details text is displayed under the trait name on the collect page.

On the collect screen, the current date is displayed by default and can be incremented forwards or backwards in single day intervals. A calendar date picker allows selection of a specific date.
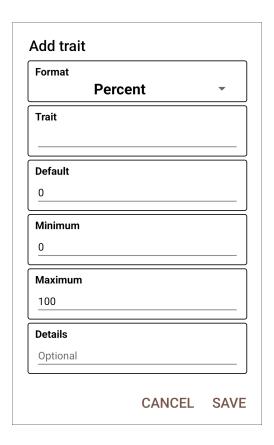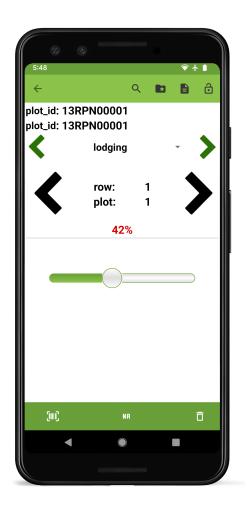
9.2 Creation

Add trait

Format
Date   ▾

Trait

Details

Optional

CANCEL   SAVE

9.3 Collect layout

TEN

✂ PERCENT TRAIT

10.1 Overview

The percent trait format is used to collect percentage-based phenotypes. In addition to the required trait name the default value, minimum, and maximum values can be adjusted. Details text is displayed under the trait name on the collect page.

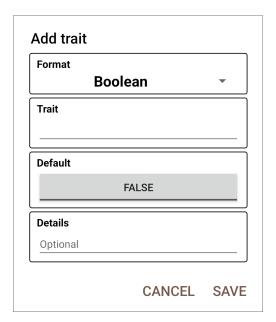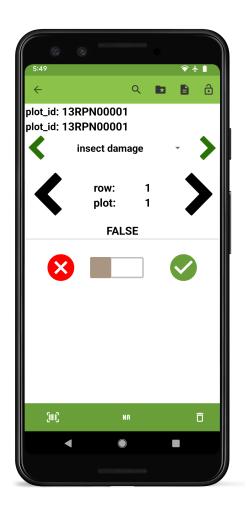On the collect page, percent values are recorded by adjusting the percent slider.

10.2 Creation

Add trait

Format

Percent ▾

Trait

_____

Default

0

Minimum

0

Maximum

100

Details

Optional

CANCEL   SAVE

10.3 Collect layout

✖ BOOLEAN TRAIT

11.1 Overview

The Boolean trait format is used to record TRUE/FALSE values. It is created with a trait name, default value, and optional details. On the collect page you can toggle between TRUE and FALSE as needed. Details text is displayed under the trait name on the collect page.
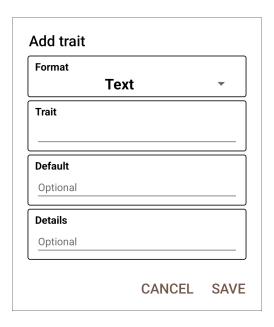
11.2 Creation

```
Add trait

  Format
            Boolean              ▾

  Trait
  _____

  Default
            FALSE

  Details
  Optional
  _____

                    CANCEL   SAVE
```

11.3 Collect layout
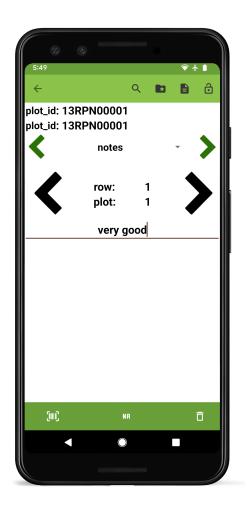
ᴀ TEXT TRAIT

12.1 Overview

The text trait format is used to record open-ended text. It is created with a trait name, optional default value, and trait details.

On the collect screen, text can be typed or dictated using the system keyboard.

12.2 Creation

Add trait

Format

Text ▾

Trait
_____

Default

Optional
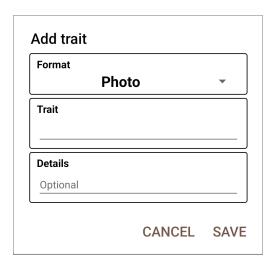
Details

Optional
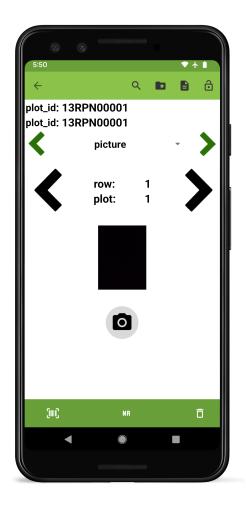
CANCEL   SAVE

12.3 Collect layout

📷 PHOTO TRAIT

13.1 Overview

The photo trait format is used to capture images. It is created with a trait name and optional details.

On the collect page, the camera icon opens the device camera to capture images. Multiple photos can be captured for each entry. Photo files are named with the entry's **unique_id**, the trait name, the photo number, and a timestamp. They are stored as .jpg files in a field-specific subdirectory (`plot_data/FIELD_NAME/picture/PHOTO_FILE_NAME.jpg`).

13.2 Creation

Add trait

Format

Photo ▾

Trait

Details

Optional

CANCEL   SAVE

13.3 Collect layout

🎤 AUDIO TRAIT

14.1 Overview

The audio trait format is used to record audio. It is created with a trait name and optional details.

On the collect page, press the 🎤 button to begin recording audio. Press the ■ button to stop recording. Press the ▶ button to play back the audio that has been recorded.

Recorded audio files are named with the entry's unique_id and a timestamp. They are stored as `.mp3` files in a field-specific subdirectory (`plot_data/FIELD_NAME/audio/AUDIO_FILE_NAME.mp3`).

14.2 Creation

Add trait

Format
Audio ▾

Trait
_____

Details
Optional
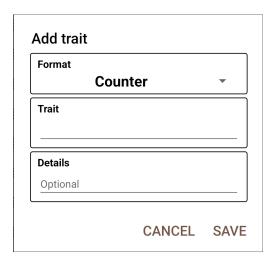_____

CANCEL   SAVE
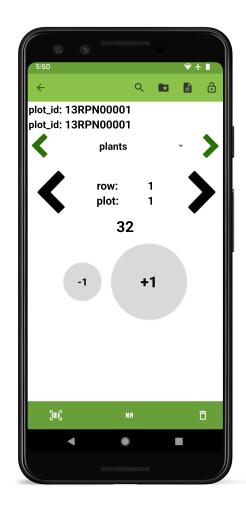
14.3 Collect layout

⁺¹ COUNTER TRAIT

15.1 Overview

The counter trait format is used to count numeric integer data, starting from zero. It is created with a trait name and optional details.

On the collect screen, the counter starts at zero and can be incremented or decremented via the **+1** and **-1** buttons.

15.2 Creation

Add trait

Format

Counter ▾

Trait
_____

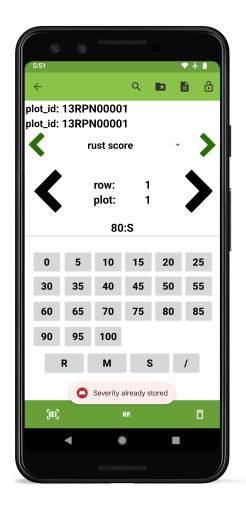Details

Optional
_____

CANCEL   SAVE

15.3 Collect layout

🐛 DISEASE TRAIT

16.1 Overview

The disease trait format is used for collecting ratings of both disease incidence and severity. It is created with a trait name and optional details. The incidence scale can be adjusted by editing the `disease_severity.txt` file in the `traits` directory.

On the collect screen, buttons showing numbers between 0-100 in 5 digit increments are used to record incidence, and **R**, **M**, and **S** are used to record severity. For each measurement, only a single incidence can be recorded while severity types can be combined. The **/** button allows varying incidence rates to be recorded (e.g., heterogenous response within a plot).
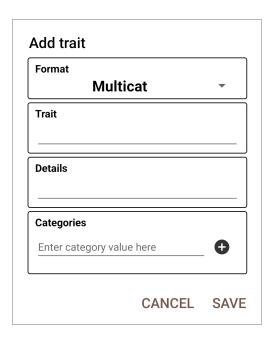
16.2 Creation

Add trait

Format
Disease Rating   ▾
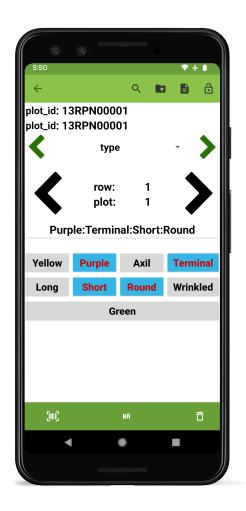
Trait

Details

Optional

CANCEL   SAVE

16.3 Collect layout

⣿ MULTICAT TRAIT

17.1 Overview

The categorical trait format is used when trait values fall into a set of discrete categories. Categories are invidiually added in the `Categories` section of the create scren. Categories within a multicat trait must be unique. Details text is displayed under the trait name on the collect screen.

Defined categories will be displayed as buttons on the collect screen. Multiple categories can be selected per entry.

17.2 Creation

Add trait

Format

Multicat ▾

Trait

_____

Details

_____

Categories

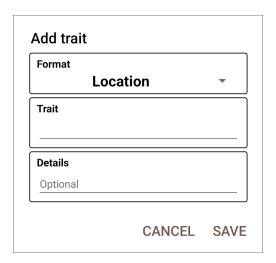Enter category value here   ➕

CANCEL   SAVE

17.3 Collect layout

⊚ LOCATION TRAIT

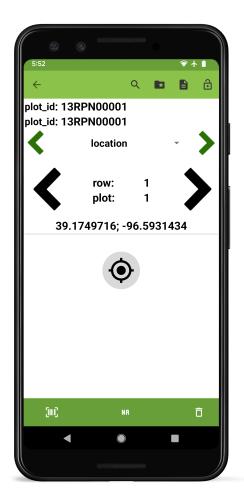### 18.1 Overview

The location trait is used to record the GPS coordinates of the device. It is created with a trait name and optional details.

On the collect page, pressing the ⊚ button will record the current latitude and longitude. If the device is connected to an external location source, the coordinates from this source will be used instead of the device's internal GPS.

18.2 Creation

Add trait

Format	
Location	▼

Trait

_____

Details

Optional
_____

CANCEL   SAVE

18.3 Collect layout

🖶 ZEBRA LABEL PRINT TRAIT

19.1 Overview

The Zebra Label print trait format is used to print labels from an external printer. The trait is designed to work with Zebra's ZQ500 Series of ruggedized, mobile printers. It is created with a trait name and optional details.

To use this trait, the Zebra printer must first be paired via Bluetooth. Label size, barcode, specific data, and number of copies are selected and are saved as defaults. Pressing the print button will print the desired number of labels, each containing a barcode and ID for the specific entry, along with any additional selected data.
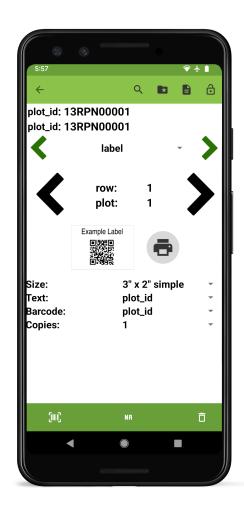
19.2 Creation

Add trait

Format
Zebra Label Print ▾

Trait
_____

Details
Optional
_____

CANCEL   SAVE

19.3 Collect layout

19.4 Troubleshooting

Issues with label printing are often caused by incompatible Zebra mobile printer configurations. To troubleshoot, install the [Zebra Printer Setup Utility](https://play.google.com/store/apps/details?id=com.zebra.printersetup) and try the following steps:

1. Download the latest firmware for the mobile printer model from the [Zebra support page](https://www.zebra.com/us/en/support-downloads/printers.html), unzip it, and send the unzipped *.zpl* file to the printer using the **Available Files** option in the Zebra Printer Setup Utility.

2. With the firmware updated, ensure the media type settings in **Media Settings** is correct for the type of label being used (usually *MARK*).

If the above steps don't fix the problem, printing a configuration label using **Printer Actions** in the Zebra Printer Setup Utility can help with further troubleshooting.
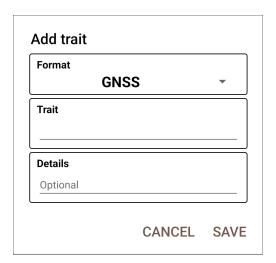
🛰 GNSS TRAIT

20.1 Overview

The GNSS trait format is used to acquire high-accuracy GPS coordinates from an external, Bluetooth-connected device. While other traits only capture phenotypic or observational data, the GNSS trait is intended to be used to capture metadata about the plot itself. This metadata can be used in conjunction with the 🚩 *GeoNav* feature to automatically navigate through the field.

20.2 Creation

20.3 Collect layout

20.4 Details

When first navigating to a GNSS trait, the collect screen will show a 🛰 button that will show a list of devices that can be accessed to provide a location for this trait.

Once a device is selected the screen will populate with a series of values from the GNSS reciever output including high-accuracy latitude and longitude coordinates, current Coordinated Universal Time (UCT), the Horizontal Dilution
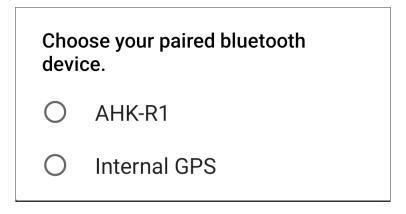
Fig. 1: GNSS device select

of Precision (HDOP, a measure of the suitability of satellite positioning in the sky, ideally 1 or below), the number of available satellites, the altitude, and accuracy.
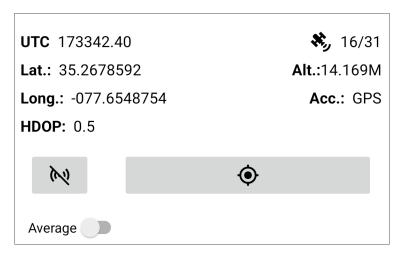

Fig. 2: GNSS reciever output

Pressing will record an instantaneous GPS reading. Toggling the average option will record an average of incoming location data for 5s, 10s, or manually (whereby all manually collected location points are averaged to create a representative value).
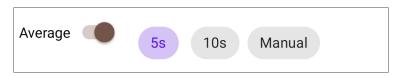

Fig. 3: GNSS average options

When recording data for an entry with existing coordinates, a warning message will be displayed to confirm that the existing coordinates will be updated.
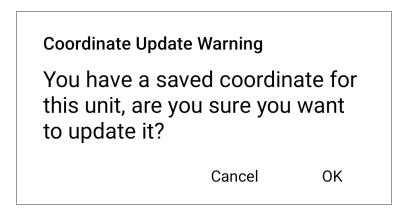

Fig. 4: GNSS update warning

If errors occur while collecting gnss data (e.g., socket cannot be established), users may have to manually disconnect/reconnect to the external device.
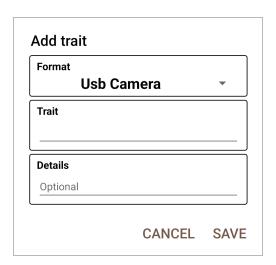
⊙ USB CAMERA TRAIT
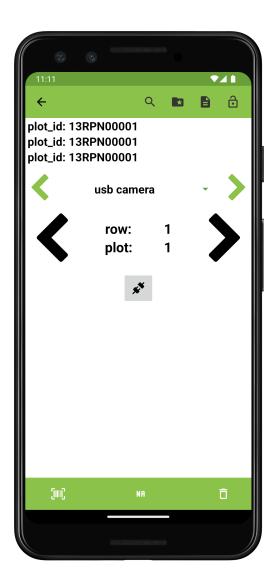
21.1 Overview

The USB camera trait format is used to capture images with an external camera. It is created with a trait name and optional details.

On the collect screen, once a camera is connected via USB, it can be opened using ⚟ . Once connected, press the ⊙ icon to access it and capture images. Multiple photos can be captured for each entry.

Photo files are named with the entry's unique identifier, the trait name, the photo number, and a timestamp. They are stored as .jpg files in a field-specific subdirectory (`plot_data/FIELD_NAME/usb-camera/PHOTO_FILE_NAME.jpg`).

21.2 Creation

Add trait

Format
Usb Camera ▾

Trait
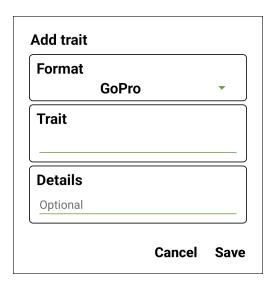_____

Details
Optional
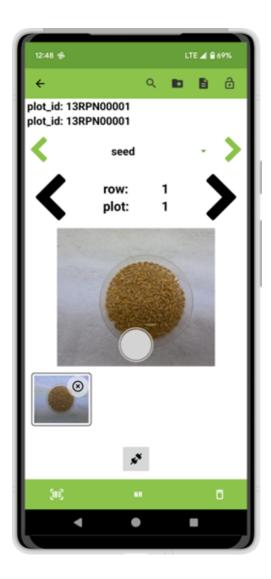
CANCEL   SAVE

21.3 Collect layout

◙ GOPRO TRAIT

22.1 Overview

The GoPro trait format is used to capture images with an external, Bluetooth-connected GoPro camera. It is created with a trait name and optional details.

On the collect screen, once a GoPro is connected via Bluetooth, it can be opened using the ✦ button. Once connected, press the ◙ icon to access it and capture images. Multiple photos can be captured for each entry.

Photo files are named with the entry's unique identifier, the trait name, the photo number, and a timestamp. They are stored as .jpg files in a field-specific subdirectory (`plot_data/FIELD_NAME/gopro/PHOTO_FILE_NAME.jpg`).

22.2 Creation

Add trait

Format
    GoPro   ▾

Trait
_____

Details
Optional
_____

                Cancel   Save

22.3 Collect layout
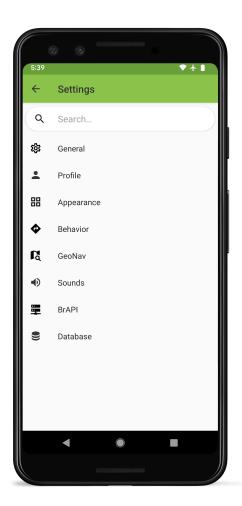
TWENTYTHREE

SETTINGS

Fig. 1: Settings screen layout

Field Book settings are grouped into eight subcategories:

- ⚙ *General Settings* allow modification of system defaults and optional collection tools

- 👤 *Profile Settings* set the identity of the person collecting data.

- ⊞ *Appearance Settings* change language, app colors, icons, or layouts.

- ◆ *Behavior Settings* change default collecting and file sharing actions.

- *GeoNav Settings* allow a positioning device to be paired and used for field navigation.

- *Sound Settings* toggle sound notifications for collection activities.

- *BrAPI Settings* connect to an external data source using the Breeding API (BrAPI).

- *Database Settings* allow the database to be imported, exported, or reset.

 at the top of the screen can be used to quickly find and navigate to a specific setting.

Fig. 2: Searching for a specific setting

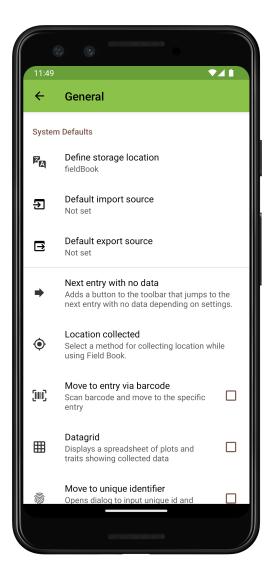# TWENTYFOUR

GENERAL SETTINGS

Fig. 1: General settings screen layout

24.1 System Defaults

24.1.1 ▊ Define storage location

Opens the *Storage* dialog to define or update the 'Storage location' on the device.

24.1.2 ↴ Default import source

Set the default field and trait import source to one of the provided options so the app doesn't ask each time.

<div align="center">

Default import source

○   Always ask

○   Local storage
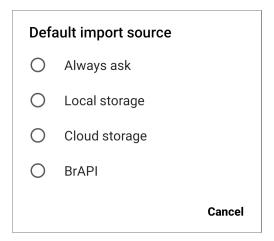
○   Cloud storage

○   BrAPI

Cancel

</div>

Fig. 2: Default import options

24.1.3 ↳ Default export source

Sets the default export location to one of the provided options so the app doesn't ask each time.

<div align="center">

Default export source

○   Always ask

○   Local storage
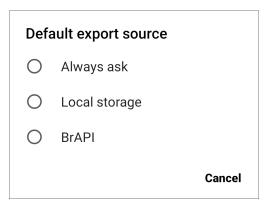
○   BrAPI

Cancel

</div>

Fig. 3: Default export options

24.2 Optional Collect Tools

24.2.1 ➡ Next entry with no data

Adds a button to the Collect top toolbar thats skips to the next entry without data.

24.2.2 ⊕ Location collected

Set the method for collecting location while using Field Book. Can be at the level of the field, the plot, or the individual observation.
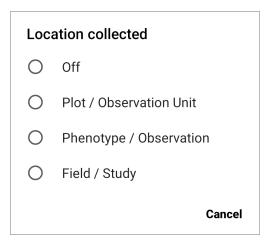

Fig. 4: Location collect options

24.2.3 ▥ Move to entry via barcode

Adds a ▥ icon to the Collect top toolbar. When pressed, it opens the device camera to move to an entry by scanning a barcode. The barcode must match a unique ID within the active trial.

24.2.4 ▦ Datagrid

Adds a ▦ icon to the Collect top toolbar. When pressed, it displays a grid of all the recorded values for each entry and trait. See more details in the ▦ *Datagrid* section.

24.2.5 ⦿ Move to unique identifier

Adds a ▥ icon to the Collect toolbar. When pressed, it opens a text entry dialog. Move to a specific entry by typing or scanning its unique id into the text field.
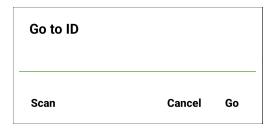
Go to ID

_____

Scan   **Cancel**   **Go**

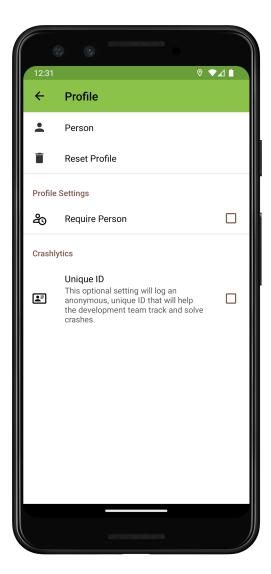Fig. 5: The move to unique identifier dialog

PROFILE SETTINGS

Fig. 1: Profile settings screen layout

25.1 Profile

25.1.1 ⚇ Person

Sets the first and last name of the person operating Field Book. This information is stored with each collected measurement as metadata and is included in the database 💾 *Export* format.
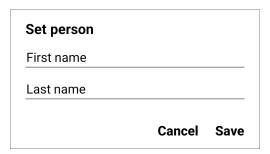

Fig. 2: Set person dialog

25.1.2 🗑 Reset Profile

Unsets the first and last name of the person operating Field Book.

25.1.3 ⏱ Require Person

If enabled, prevents using Field Book unless Person is set. And adds a ⏲ time between verification setting, which can be set to one of three intervals.
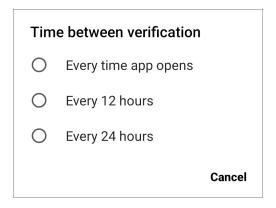

Fig. 3: Choice of profile verification intervals

25.2 Crashlytics

25.2.1 ⊞ Unique ID

Creates a unique ID for use in generating more specific crash logs. This helps the development team when troubleshooting and improving Field Book
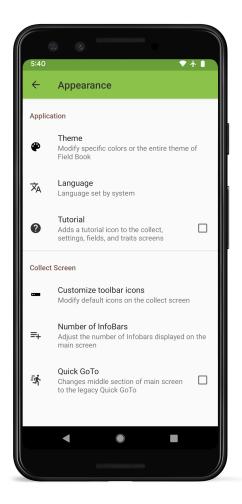
APPEARANCE SETTINGS

Fig. 1: Appearance settings screen layout

26.1 Application

26.1.1 🎨 Theme

Allows users to modify specific colors or the entire theme of Field Book.
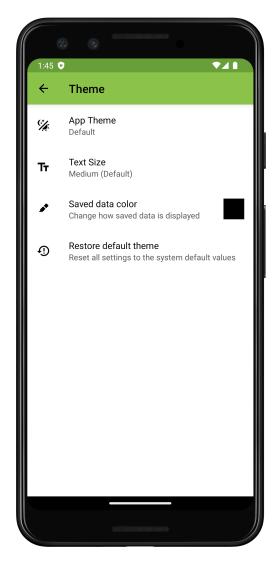

Fig. 2: Theme options within appearance settings

26.1.2 🗛 Language

Allows the user to change the Field Book language to one of 14 different options.

Fig. 3: Language options

26.1.3 ❓ Tutorial

Adds a ❓ icon to the toolbar that enables the tutorial. The tutorial provides contextual information throughout the app.

26.2 Collect Screen

26.2.1 ▭ Customize toolbar icons

Allows the user to change which default toolbar buttons are displayed on the Collect screen.
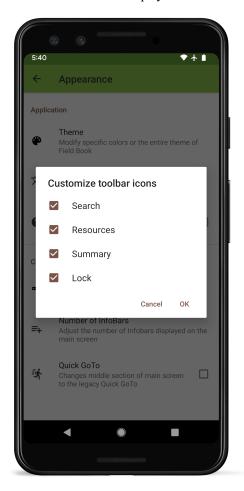
Fig. 4: Turn default toolbar options on/off

26.2.2 ≡+ Number of Infobars

Allows the user to change the number of Infobars that are displayed on the Collect screen.
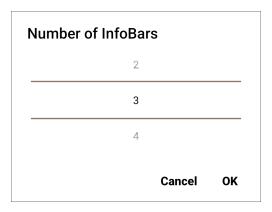
Number of InfoBars

2

3

4

Cancel   OK

Fig. 5: Choice of number of Infobars

26.2.3 🏃 Quick GoTo

Changes the read-only primary/secondary order on the Collect screen to edit texts that can search and move to specific entries.
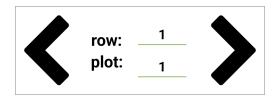
row: 1
plot: 1

Fig. 6: Collect screen editable primary/secondary order when using Quick Goto

BEHAVIOR SETTINGS
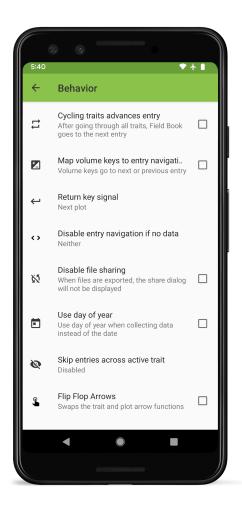
27.1 Behavior

Fig. 1: Behavior settings screen layout

27.1.1 ⇄ Cycling traits advances entry

When enabled, once all active traits have been cycled, the app automatically advances to the next entry.

27.1.2 ◪ Map volume keys to entry navigation

Allows volume keys to be used to move to next/previous entry. Note that this disables the volume buttons being able to change the device volume when Collect is open.

27.1.3 ↩ Return key signal

Allows the user to choose the behavior of the return key signal that can be included when scanning barcodes: next plot, next trait, or do nothing.

Return key signal

◉ Next plot

○ Next trait

○ Do nothing

Cancel

Fig. 2: Choice of return key signal behavior

27.1.4 ‹› Disable left/right entry arrow

Disables the left, right, or both entry arrows unless data has been collected to ensure an entry isn't skipped during data collection.

Disable entry navigation if no data

◉ Neither

○ Left

○ Right

○ Both

Cancel

Fig. 3: Choice of direction disabled

27.1.5 ⋈ Disable file sharing

Turns off the share dialog that opens by default when data is exported.

27.1.6 ▢ Use day of year

Changes the date trait format to record date values as numbers counting up from Jan 1, rather than traditional dates. For example *96* instead of *2023-04-06*.

27.1.7 ⬨ Skip entries across active trait

When advancing entries, skips either entries that already have data for the active trait, or entries that already have data for all traits.
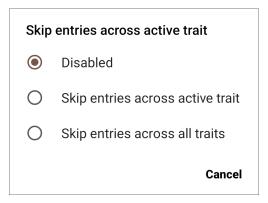
Skip entries across active trait

⊙ Disabled

◯ Skip entries across active trait

◯ Skip entries across all traits

Cancel

Fig. 4: Choice of skip behavior

27.1.8 ☝ Flip Flop Arrows

Switches the collect screen arrows so that the small green arrows advance entries and the large black arrows advance traits.

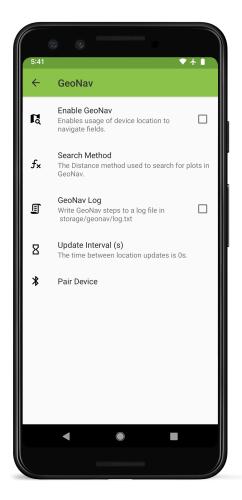# TWENTYEIGHT

GEONAV SETTINGS

Fig. 1: GeoNav settings screen layout

28.1 📇 Enable Geonav

Enables the device to move between entires based on GPS data. Requires entries to have GNSS data.

28.2 𝑓× Search Method

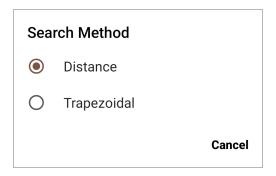The method used to match GPS location to entry. Defaults to the distance method.

Search Method

⦿ Distance

◯ Trapezoidal

Cancel

Fig. 2: GeoNav search method options

28.3 📑 GeoNav Log

Turns on GeoNav logging to a logfile stored in `/storage/geonav/log.txt`

28.4 ⧗ Update Interval

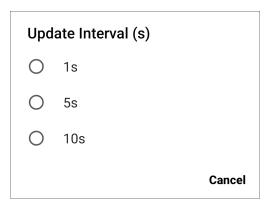Changes the time between GeoNav location updates. Can be set to 1s (default), 5s, or 10s

Update Interval (s)

◯ 1s

◯ 5s

◯ 10s

Cancel

Fig. 3: Geonav interval options

28.5 ⌖ Pair Device

Opens Bluetooth interface to pair to an external GPS device
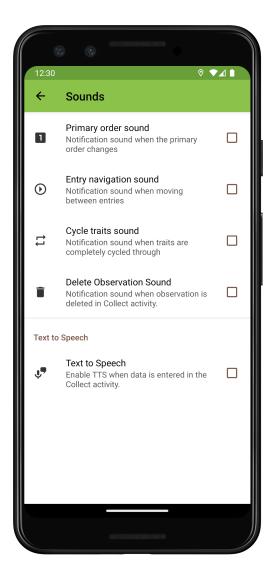
SOUND SETTINGS

Fig. 1: Sound settings screen layout

29.1 Sounds

29.1.1 ◼ Primary order sound

Makes a sound when the primary order changes. Useful for knowing when to move to the next field row.

29.1.2 ⊙ Entry navigation sound

Makes a sound when the entry changes on the Collect screen. Can alert to accidental entry advancement.

29.1.3 ⇄ Cycle traits sound

Makes a sound when all the active traits have been cycled through. Useful for knowing when to move to the next entry.

29.1.4 🗑 Delete Observation Sound

Makes a sound when a recorded value is deleted in the Collect screen.

29.2 Speech

29.2.1 🎤 Text to Speech

Enables text to speech. When enabled, choose one of the five availalbe languages. The device will read data as it is entered in the Collect screen.

Fig. 2: Text to speech language options

BRAPI SETTINGS

30.1 Configuration

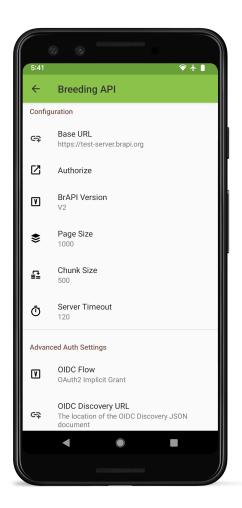Fig. 1: BrAPI Configuration Settings

30.1.1 ⊞ BrAPI Base URL

Set the server URL when importing via BrAPI.

Base URL

https://test-server.brapi.org
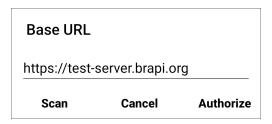
| Scan | Cancel | Authorize |

Fig. 2: BrAPI Base URL setting

30.1.2 ↗ Authorize BrAPI

Open the authorization page to login to the BrAPI server and allow Field Book to communicate with it.

30.1.3 Ⅴ BrAPI Version

Set the version of the BrAPI specification that will be used to communicate with the server. Defaults to V2.
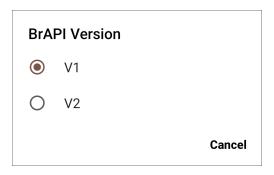
BrAPI Version

◉ V1

◯ V2

Cancel

Fig. 3: BrAPI version setting

30.1.4 ≶ Page Size

Set the page size for BrAPI server responses. Defaults to 1000.

Page Size

50

Cancel **OK**

Fig. 4: BrAPI page size setting

30.1.5 ⬒ Chunk Size

Set the chunk size. Defaults to 500.

Fig. 5: BrAPI chunk size setting

30.1.6 ⏱ Server Timeout

Set the time limit in seconds to wait for a repsonse from the server before timing out. Defaults to 2 minutes.
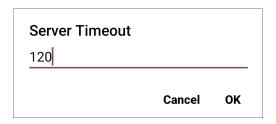

Fig. 6: BrAPI server timeout setting

30.2 Advanced Auth Settings

30.2.1 Ⓥ OIDC Flow

BrAPI server authentication version. Defaults to OAuth2 Implicit Grant.

30.2.2 ⇱ OIDC Discovery URL

The location of the OIDC discovery JSON document.

30.3 BrAPI Variables

30.3.1 ⊞ Value vs Label Display

Sets desired field for display when using a categorical trait the comes from a BrAPI Variable.
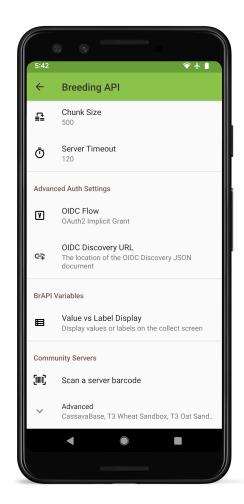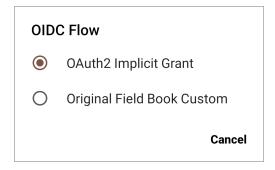
Fig. 7: BrAPI Advanced Auth Settings

Fig. 8: BrAPI OIDC flow setting

Fig. 9: BrAPI OIDC url setting

Fig. 10: BrAPI Value vs Label setting

30.4 Community Servers

30.4.1 ⬚ Scan a server barcode

Add a BrAPI server by scanning a URL barcode.

30.4.2 Advanced

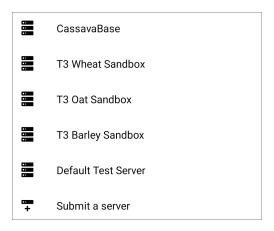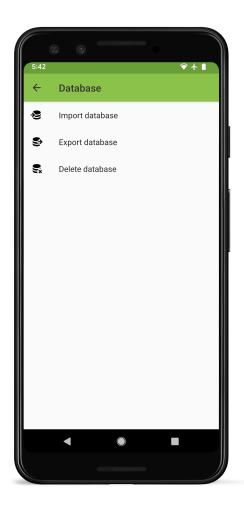Access servers from the BrAPI community.

Fig. 11: BrAPI database whitelist

DATABASE SETTINGS

31.1 ♋ Import database

Imports a database from an exported database file. This replaces the current data in the app.

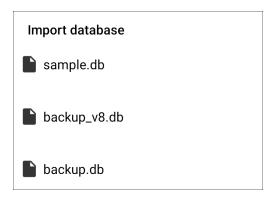**Import database**

📄 sample.db

📄 backup_v8.db

📄 backup.db

Fig. 1: Database import dialog

31.2 ♋ Export database

Exports the internal database. Contact the development team if you need data recovered or are having issues and send the file that is exported.

Database

2023-05-31-02-00-12_systemdb9

Cancel   Save

Fig. 2: Database export dialog

31.3 ♋ Delete database

Wipes all data from the app.

Warning

All data will be deleted. Are you sure you want to reset the database?

No   Yes
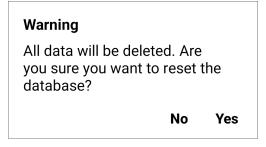
Fig. 3: Database delete confirmation

BETA SETTINGS

Fig. 1: Beta settings screen layout

32.1 ⚗ Repeated Measures

Turns on repeated measures. When turned on, a green plus symbol appears next to the trait value entry box on the collect screen.
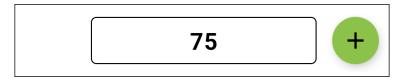

Fig. 2: Collect screen value entry with repeated measurements enabled

When pressed it creates a new entry field for collecting an additional observation on the same plot for the same trait.

To export data that includes repeated measures make sure to chose the **Database** format or to use BrAPI. These formats allow repeated measures to be differentiated by timestamp. If exporting in **Table** format then only the latest measurement will be included.

BARCODES

To improve data entry, Field Book includes built-in barcode scanning features that use the device camera to collect data or move to a specific entry.

Most Android devices are also compatible with external barcode scanners that connect via USB or Bluetooth and act as a hardware keyboard. They can be used to directly capture data from barcodes into any input field that uses the device keyboard, including many traits.

33.1 Examples

33.1.1 Plant height

Barcoded height sticks can be used to rapidly capture plot height values. Attaching the Android device to the stick makes it possible to accurately capture height without having to hold both the height stick and the device.

Fig. 1: Plant height measurement via barcoded height stick

33.1.2 Leaf length

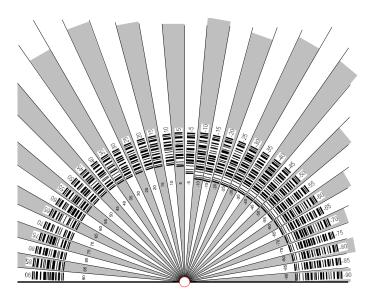Fig. 2: Example leaf length collection via length barcodes

33.1.3 Leaf angle

Fig. 3: Example leaf angle barcodes

33.2 Resources

The three types of barcodes described above are available for download on GitHub as printable files.

BRAPI (BREEDING API)

34.1 Overview

BrAPI is an application programming interface for plant breeding. It allows Field Book to directly communicate with compatible databases to import fields and traits and export collected data. This eliminates the need to manually transfer files and enables Field Book to offer more sophisticated features including field and trait metadata and data syncing.

34.2 Setup

BrAPI can be set up in the *BrAPI Settings*. To use BrAPI, set the base URL to the URL of a valid BrAPI server and authorize it. Once authorized, Field Book will be able to communicate with the server to import fields and traits and export data.
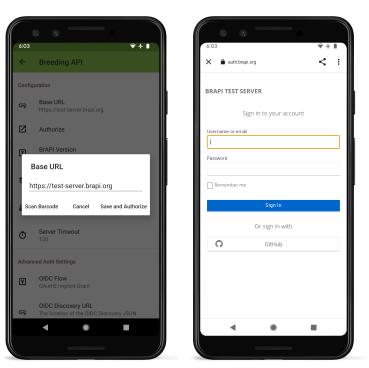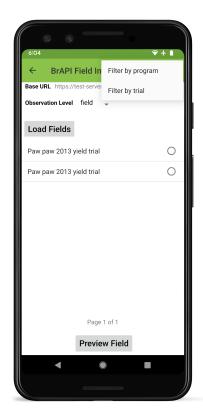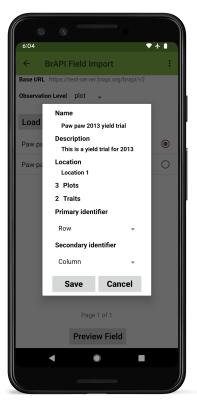

Fig. 1: Example BrAPI URL authorization.
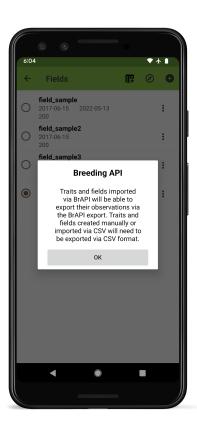
34.3 Import fields

Fig. 2: The BrAPI field import process.

To import a field using BrAPI, press ⊕ in the top toolbar, select BrAPI as the source, and press the 'Load Fields' button

Field Book will import a list of possible fields (known as *studies* in the BrAPI standard) from the BrAPI Base URL set in the ≣ *BrAPI Settings*.

Available fields can be filtered by program and trial using the menu options in the top toolbar. The list can be filtered by `Observation Level` using the dropdown below the server URL.

If the returned list of fields contains more than a single page, the 'Next' button will advance to the next page. Once a field has been selected, the field structure can be previewed by pressing the 'Preview Field' button

Previewed fields are imported by pressing the 'Save' button. **Only fields that have been imported via BrAPI can be exported to BrAPI servers.**

34.4 Import traits

Depending on the BrAPI server, fields may have linked traits that are imported with the field. Additional traits can be imported via BrAPI by selecting import from the Traits menu, then selecting BrAPI.
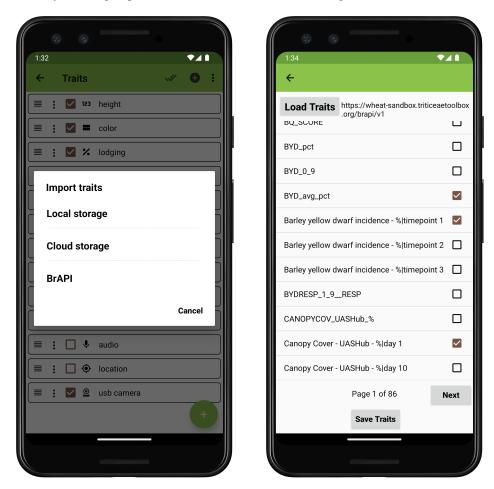

Fig. 3: The BrAPI trait import process.

Field Book will import a list of possible traits (known as *observationVariables* in the BrAPI standard) from the BrAPI Base URL set in the ![icon] *BrAPI Settings*.

Traits are selected and then imported by pressing the **Save Traits** button. Traits can be imported individually or in groups.

Field Book will report *Selected traits saved successfully*, and return to the traits screen with the imported traits selected.

34.5 Export data

Once data has been collected it can be exported via BrAPI by pressing Export and selecting BrAPI from the Export Data options.

Before the export is finalized, Field Book will display a summary of BrAPI Export statistics. These include a breakdown of the number of new vs synced(imported) vs edited observations, as well as skipped observations. The same statistics are displayed for images.
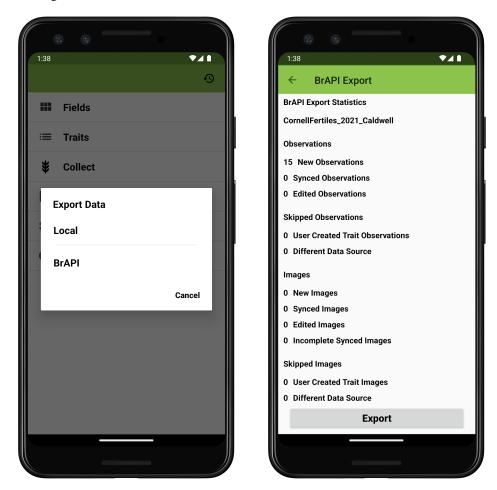

Fig. 4: The BrAPI data export process.

Pressing the 'Export' uploads the observations to the external BrAPI database.

DATAGRID

35.1 Overview

DataGrid is accessed by pressing the ⊞ icon in the toolbar. DataGrid displays a matrix of entries and traits in the active field. This view allows rapid identification of missing values. Pressing an individual cell moves the collect screen directly to the corresponding entry and trait.

35.2 Settings

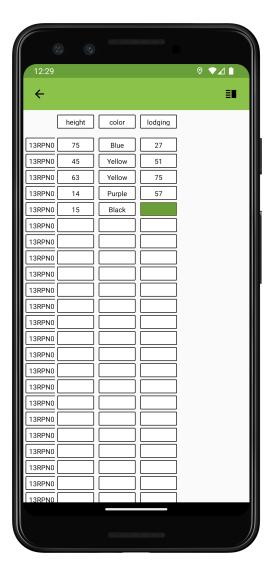The column used for the row header can be changed by pressing the ☰ icon in the toolbar.

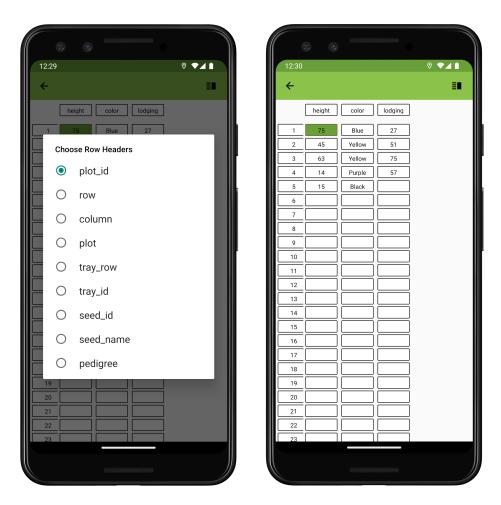Fig. 1: The Datagrid tool, showing a grid of entries, traits, and collected values.

Fig. 2: The Datagrid tool, showing a grid of entries, traits, and colleced values.

GEONAV

36.1 Overview

GeoNav is used to automatically navigate between entries in the field based on the location of a high precision GNSS device. This feature requires field entries to have high-precision location data collected via the 🛰 *GNSS Trait* or included in the field import file. Imported coordinates must be in `Lat;Long` format in a single *geo_coordinates* column. Refer to the `rtk_sample.csv` file in the `field_import` directory as an example.

To use GeoNav, navigate to the 📖 *GeoNav Settings* and enable GeoNav. Turn on Bluetooth, and pair your external reciever. Navigate to the Collect screen and look for a confirmation message that says 'Rover communications estabished'

Fig. 1: The Collect screen GeoNav confirmation message

Once the rover is connected, Field Book will automatically display the nearest plot in the bottom toolbar. Press the ➤ icon on the right to jump to the plot.

Fig. 2: The Collect screen bottom toolbar showing the nearest plot for manual geonavigation

To enable automatic geonavigation, press the ⊗ icon that appears on the right in the top toolbar. It will change to a 🧭 icon indicating that automatic geonavigation is enabled. Field Book will automatically switch to the nearest entry as the device moves around the field, displaying the following message on each switch.
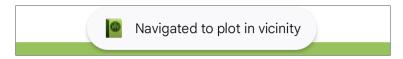

Fig. 3: The Collect screen message when the entry changes during automatic geonavigation

36.2 Example

Fig. 4: GeoNav automatic navigation demonstration.

36.3 Recommendations

This section provides the original hardware recommendations from when the Geonav feature was first developed in conjunction with the Breeding Insight OnRamp project. It also includes instructions for deploying the suggested devices to use the GeoNav feature in the field.

While not covered in the original recommendations, Emlid's new Reach RX device is also suitable for Geonav, and comes with a simplified setup process. Devices from other manufacturers should also work with the Geonav feature, as long as they broadcast using the NMEA protocol.

36.3.1 Supplies

- Survey tripod
- Survey post (optional depending on rover case)
- Tablet
- RTK Hardware (Base): * Emlid RS2
- RTK Hardware (Rover) * Emlid RS2 OR * Emlid M2 + Antenna + cable + LoRa radio + microUSB cable + battery

36.3.2 Instructions (field use)

1. Turn on BASE and ROVER, wait for both to broadcast WIFI hotspots
2. In TABLET settings, join ROVER WIFI.
3. In Reach3 app, navigate to ROVER WIFI settings. Connect ROVER to BASE WIFI.
4. Go back to TABLET settings, now connect TABLET to BASE WIFI
5. In Reach3 app, connect to BASE. Navigate to Base Settings. Wait until the BASE collects enough data to report a "single" position in the left hand corner and click apply.
6. In Reach3 app, connect to ROVER. Navigate to BT settings and turn on ROVER BT. Turn off and on again if you've forgotten the BT password (currently it is 1111).
7. Go back to TABLET BT settings. Turn on TABLET BT. Select ROVER from list of available devices and input password when prompted.
8. Finally, navigate to FIELDBOOK. Start collecting data. When prompted for GNSS trait, select ROVER.

Emlid's own documentation for the RS2 and M2 can be found here (RS2 docs) and here (M2 docs)

36.3.3 Kits and Cases

Complete kits and matching 3D Cases for M2 hardware are available for purchase online:

- https://e38surveysolutions.com/products/reach-m2-with-gnss-antenna
- https://cults3d.com/en/3d-model/tool/emlid-reach-m2-case-estuche-gnss-gps-rtk

TRAINING RESOURCES

In addition to this documentation, we have created training materials that can be used to introduce Field Book to breeders and technicians. These materials are also useful for bringing existing users up-to-speed with new features. This training presentation introduces Field Book's core features and key settings with accompanying excercises.

The exercises in the the training slides are based on the *training_sample.csv* field file which is copied into the field_import directory on install and is imported as part training.
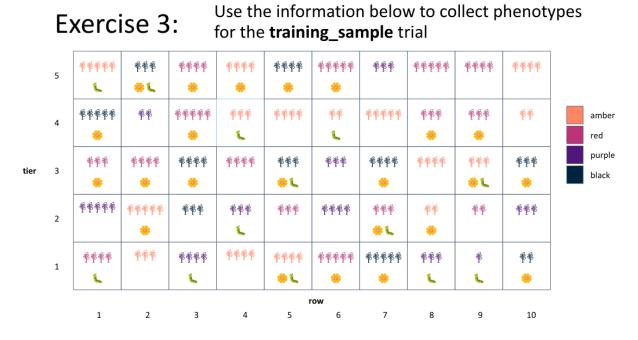

Fig. 1: The training sample field in exercise 3
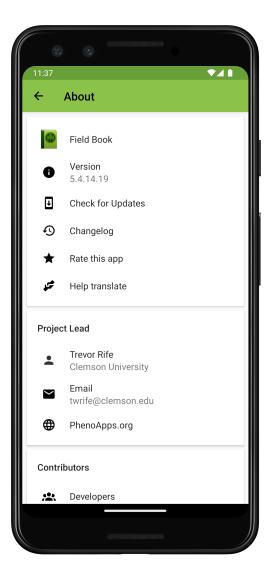
THIRTYEIGHT

ABOUT

Fig. 1: About screen

The About screen provides helpful information about Field Book including the version number and changelog. It also includes an update tool to check the availability of newer versions.

THIRTYNINE

FUNDING

Note: This project is under active development.

39.1 Current

USAID No. 7200AA-19LE-00005

USDA NIFA SCRI No. 2022-51181-38449

USDA NIFA AG2PI No. 2022-70412-38454

39.2 Previous

McKnight Foundation

NSF No. 1543958

USDA NIFA FACT No. 2019-67021-29931