DRIVE
Drought Resilience Improvement in Vineyard Ecosystems

LIFE19 ENV/IT/000035

Report on Monitoring tool v1.0 (release version) and related user's guide

Sub-action B1.3

Contents

Abstract

The key content of this deliverable is the final (release) version of the Monitoring Tool PocketDRIVE, which can be downloaded upon request (livia.paleari@unimi.it or roberto.confalonieri@unimi.it) from a private repository (Open Science Framework). The reason for avoiding free-access link to the download is to preserve the market potential of the technology developed, for the commercialization "after-LIFE" (see deliverable B3.4 about the exploitation plan).

The release version of PocketDRIVE is provided together with:

- the user guide, presented in the following chapter of this document;
- two videos (each available both in Italian and in English), one presenting the tool rationale and main functionalities, and one video-tutorial with a step-by-step guide to the use of the monitoring tool.

The videos are available both in the private repository cited above and on the Project's website (https://www.drive-life.it/pocketdrive-2/).

PocketDRIVE user guide

The scientific and technical documentation of the app PocketDRIVE was reported in the dedicated deliverable (B1.2). Here below, a step-by-step guide on the use of the app is provided together with explicative screen-shot figures. The chapter is organized in five sections, one for each of the PocketDRIVE main functionalities.

1. Create the vineyard register

By clincking on the top-left icon of the main screen of PocketDRIVE (Fig. 2a), it is possible to access the screen (Fig. 2b) where the user can enter the following information for each of the vinyards to be registered:

- the name to be used within the MT to identify the vineyard (please avoid blanck spaces in the name);
- the cultivar;
- the training system;
- the inter-row space (units: meter; please use the dot as decimal separator);
- how the inter-row is managed (e.g., bare soil, cover crops, etc.);
- the vineyard's GPS coordinates. This information can be provided by clicking on the blue icon at the bottom of the screen. A map tool will open (Fig. 2c). From there, it is possible to center the map on the current device position by clicking on the red gunsight icon on the bottom right. Then use the pencil icon to start highlighting the vineyard area by touching the screen clockwise on the vineyard perimeter; Fig. 2c). If you make mistakes, use the rubber icon (on the bottom left) to delete the points by simply clicking on them.

Such information needs to be entered just once during the app configuration. Nevertheless, it is always possible to delete a vineyard from the registry or modify the information associated to it (e.g., change the inter-row management system) by using the dedicated icons on the bottom of the registration screen (Fig. 2b).

Once the vineyard is registered, a text file (.csv) with all the information is automatically created and sent to the MT.

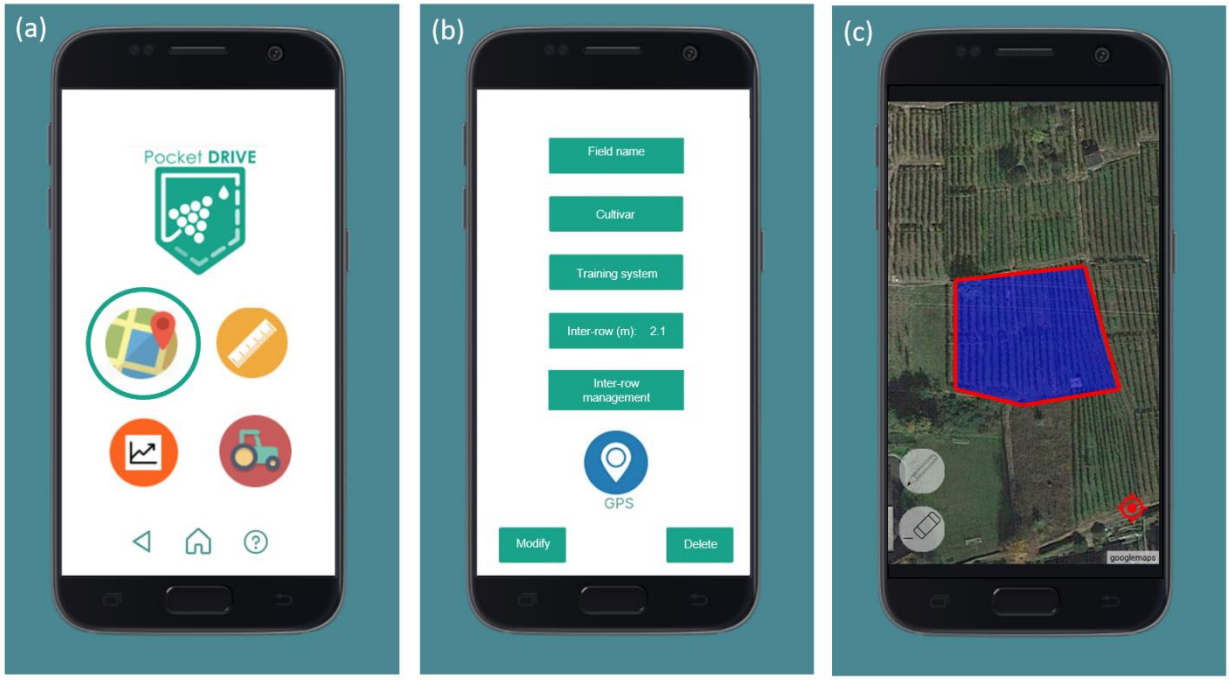

Figure 1. Screenshots showing how to create a vineyard in the app. Icon to access this functionality (a); information that needs to be specified (b); definition of the vineyard GPS position by simply drawing its borders on the map (c).

2. Estimate leaf area index

PocketDRIVE allows to easily estimate the leaf area index (LAI) of both the vineyard and of the inter-row grasses (Fig. 3b) by using the approach proposed by Confalonieri et al. (2013).

Basically, the user has to click at the center of the screen to activate the measuring mode (Fig. 3c). PocketLAI automatically takes images of the canopy at a view angle of 57.5° while the user is rotating the device along its main axis. The LAI value is then retrieved according to the light transmittance model described by Baret et al. (2010) and, in case of vertical canopies, by using also the inter-row distance (Orlando et al., 2016) that is provided by the user when the vineyard is registered (Fig. 2).

Here below a step-by step explanation of how to conduct LAI measurements:

- by clicking on the ruler icon (Fig. 3.a) it is possible to access the screen for LAI measurements. From here, select the vineyard where the measurements are being conducted;
- to conduct LAI estimates, click on the “LAI of the vineyard” button. This will automatically activate the camera (Fig. 3.c);
- hold the device at about about 40 cm from the row and about 20 cm below the lowest bound of the canopy (Fig. 4.e), in order to capture images correctly centered on the grape canopies (Fig. 4a). The phone camera should point towards the canopy (please, check that the device is not in selfie mode). Please avoid to have the sun beams directed towards the camera (better to have the sun behind the user) and any obstacle that can bias the LAI estimates (e.g., people or tractors moving in the neighboring row in front of the camera);
- click on the green circle at the center of the screen to activate the measuring mode (the circle turns red). Start rotating the device upwards along its main axis (Fig. 4.e) until it vibrates to inform the user that it has acquired the measure at the 57.5° inclination angle;
- the LAI value is shown in the bottom left corner of the screen. In case of errors, use the bin icon (on the bottom-right corner of the screen, Fig.3.c) to delete the last LAI measure;
- move about one step along the row and repeat the procedure to acquire another measure. To achieve robust LAI estimates, five readings for each measuring point within the vineyard are suggested;

- once the five readings have been completed, go back to the main screen and click on “Update measurements” to save the data on the device (the app saves the mean and the stardard deviation of the five readings) and send them to the MT on cloud. From this point it is possible to make other LAI measurements within the same vineyard (e.g., in case of marked variability in leaf development in different areas of the same field) or close the session. A dedicated message will appear to choose between these two options.

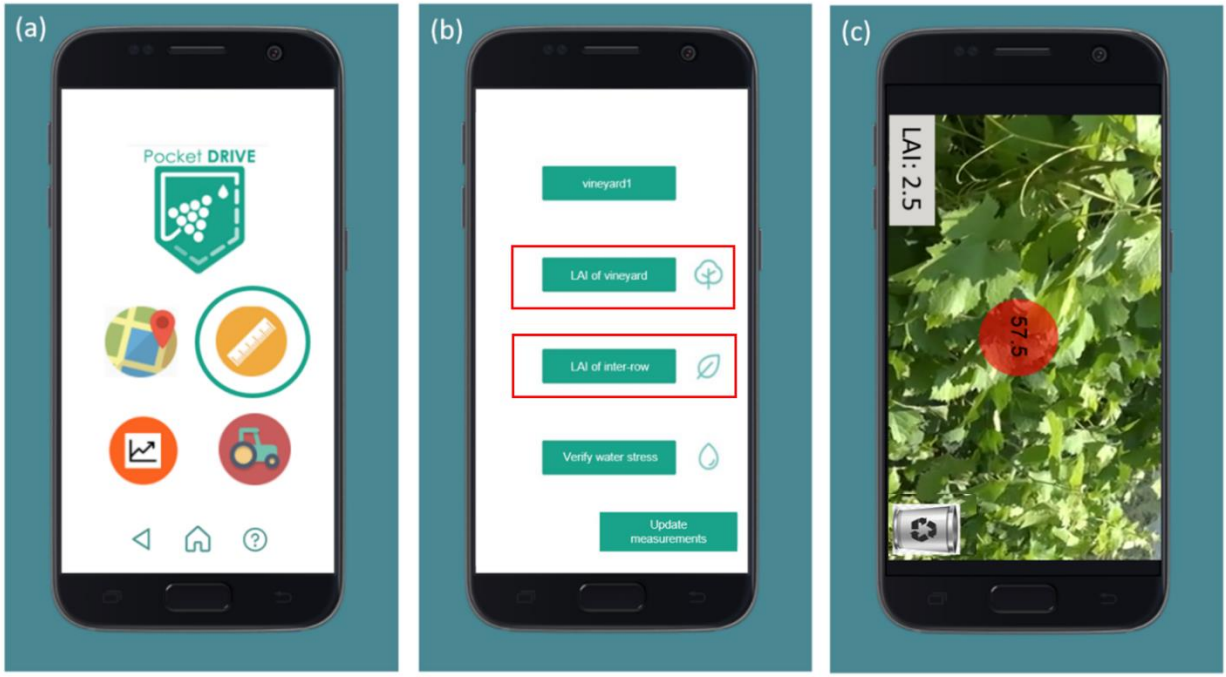

Figure 2. Screenshots of PocketDRIVE showing how to collect estimates of leaf area index (LAI) of the vineyard. Icon to access this function (a); screen where it is possible to specify the vineyard in which the measurements are being collected and the kind of measurement (i.e., LAI of the vineyard and/or LAI of the inter-row grasses) (b); measuring mode for LAI estimates (c). The inclination of the device is shown in the red circle in the middle, with the app automatically acquiring images at 57.5° while the device is rotated along its main axis.

To derive LAI estimates of the inter-row grass, once on the mainscreen (Fig. 3b), click on “LAI of inter-row” button to access the screen for activating the measuring mode (Fig. 3c). The measurement protocol is the same described above with the only difference that the device should be placed as closest as possible to the ground and ortogonal to the row direction. See also the video tutorial provided with PocketDRIVE to better understand the protocol of acquisition.

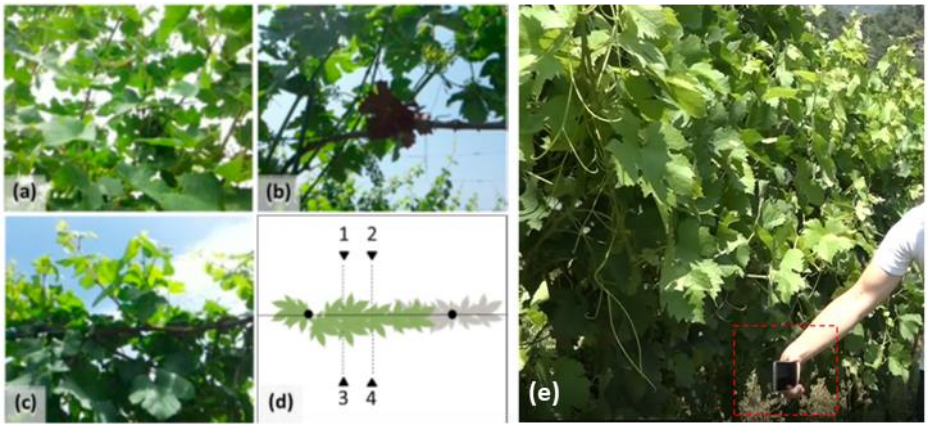

Figure 4. Example of a correct image captured with PocketLAI following the protocol (a); and wrong images that include the space below (b) or above (c) the grape canopy. The protocol for PocketLAI data acquisition in vineyard is described in (d): dark triangles and dotted lines = device orientation; black points vineyard poles; continuous line = vineyard row; green leaves = measured vine; grey leaves = adjacent vine. The correct device position is shown in (e); from that position, the device should be rotated upward until it vibrates to inform the user that it has acquired the measure at the 57.5° inclination angle. Image partly retrieved from Orlando et al. (2016).

3. Record management events

Management events that affect the amount of vegetation in the vineyard indirectly affects the water balance of the field. This includes green pruning of the grapevines, as well as management of the inter-row such as soil tillage, grass cutting, grass smashing, etc. Information about these management events ca be registered with the PocketDRIVE bottom-right icon (Fig. 5a) that opens a dedicated screen where the type of intervention and the date can be entered (Fig. 5b). The management information is automatically saved by clicking on “Done”.

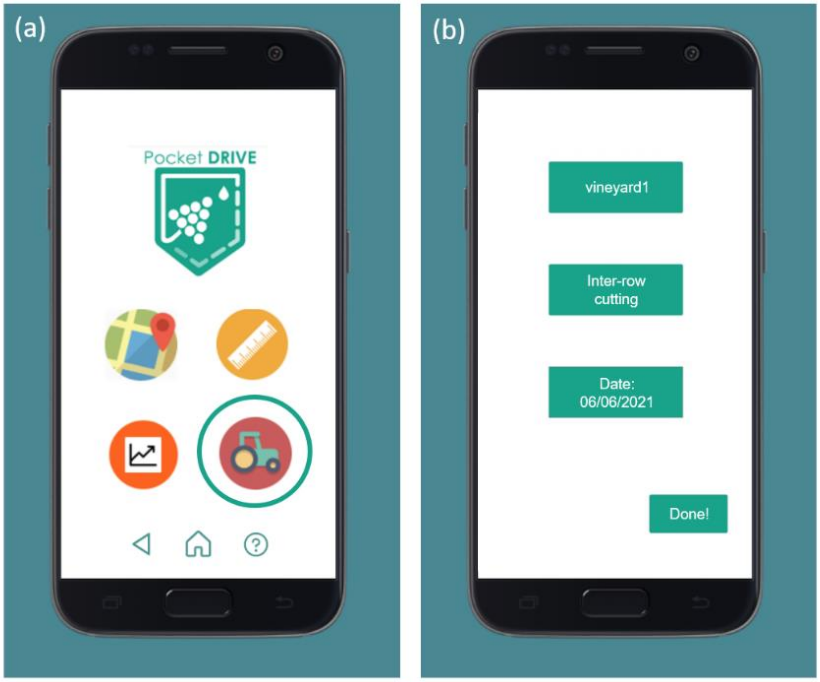

Figure 5. Incon (a) and main screen (b) to register management events.

4. Diagnose water stress

The occurrence of water stress conditions can be verified with the app by measuring variations of canopy architecture that, in turn, are related with drought occurrence. PocketDRIVE implements the app PocketPlant3D (Confalonieri et al., 2017), which uses the magnetometer and accelerometer of the device to derive the leaf orientation towards the north and the inclination of the leaf surfaces with respect to the zenith while the device is moved along the leaf lamina (Figs. 6a, 7a), thus providing the angles of leaf surfaces in a 3D Cartesian space. One measure every 200 ms is automatically acquired.

Leaf angles (θL) are then used by the app to automatically estimate two synthetic indices of canopy architecture: the parameter χ (unitless) of the Campbell's ellipsoidal leaf angle distribution (Campbell, 1990; Eq. 1) and the light extinction coefficient of solar radiation (k; Eq. 2) (Campbell, 1986).

In order to use canopy architecture estimates as a proxy of plant water status, relationships between the values of χ and k and physiological variables describing crop water status (stomatal conductance) were derived during dedicated project's field activities fully described in the deliverable B1.1.

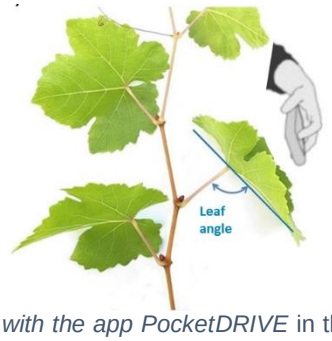

Figure 6. Example of leaf angle acquisition with the app PocketDRIVE in the case of *Vitis vinifera, for early diagnosis of water stress occurrence.*

Currently, the PocketDRIVE function to verify water stress is available for the seven grape varieties whose calibration curves have been derived during the DRIVE Project (Chardonnay, Malvasia, Pinot Blanc, Pinot Noir, Sangiovese, Montepulciano, and Croatina). Calibration curves for other varieties will be derived during the "After-LIFE" phase.

A step-by-step description of how to verify water stress occurrence with PocketDRIVE follows:

- by clicking on the icon for collecting measurements (Fig. 3a) and on that for verifying water stress (Fig. 3b), the user can easily start collecting leaf angles while keeping the device parallel to the leaf main axis (Fig. 6). To ensure high usability during leaf angles collection, the user can start and stop the recording by simply clicking at the center of the device' screen (Fig. 7c). It is also possible to remove measurements in case of errors;
- the app automatically counts the number of leaves measured (Fig. 7d). Results of field tests conducted during 2021 and 2022 suggested indeed that around ten leaves randomly selected in the middle part of the canopy (Fig. 7b) are enough to provide an accurate quantification of canopy architecture parameters. Therefore, if less than 10 leaves have been measured the app does not allow to verify water stress and shows instead a message suggesting to collect more data;
- once the angle collection on at least ten leaves is completed, the user can verify the occurrence of water stress by clicking on the dedicated button ("Verify water stress", Fig. 7c). The app automatically estimates the values of the Campbell's X, makes the comparison with the cultivar-specific threshold values indicating the onsent of water stress (details about calibrated thresholds are provided in the dedicated deliverable B1.1), and returns a quick response in terms of stress level (no/moderate/severe stress);
- after the diagnosis of water stress is completed, go back to the main screen (Fig. 3b) and click on "Update measurements" to save the data.

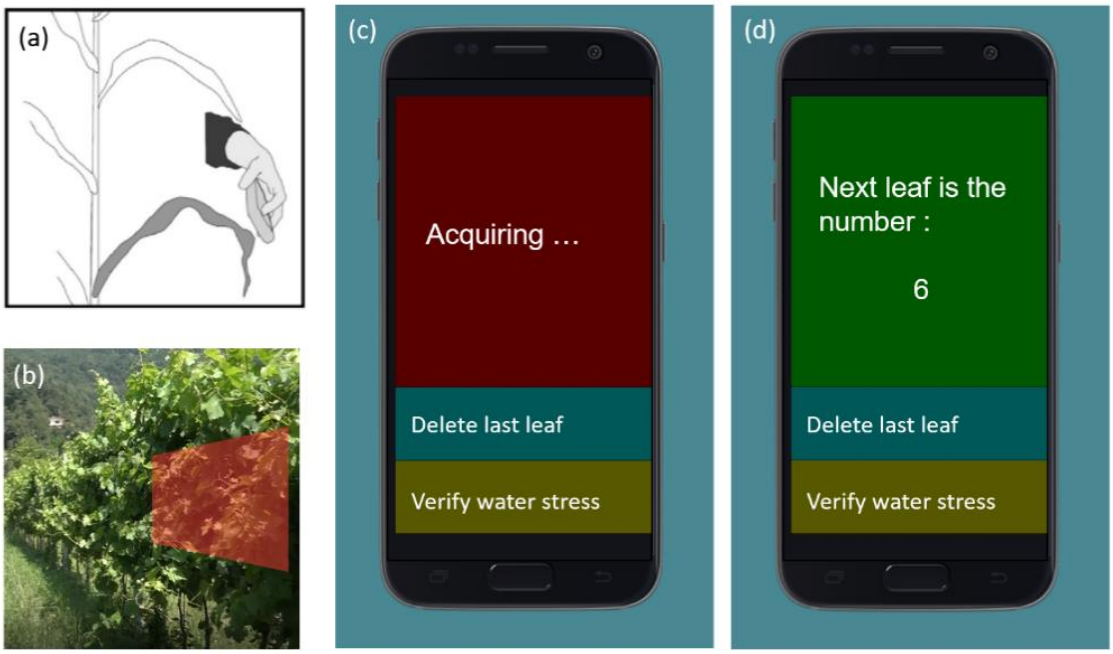

Figure 7. Collection of leaf angles to evaluate canopy architecture and verify water stress occurrence. The device should be kept parallel to the leaf main axis (a). The angle collection should involve leaves in the middle part of the canopy (b) and can be started by clicking on the red button (c). It is possible to delete measurements in case of errors. The app keeps count of the leaves measured (d) because at least 10 leaves are needed to derive reliable estimates of canopy architecture.

5. Look at the data

All the information collected with the app (LAI and canopy architecture measurements, management events) can be accessed and verified by the user through the orange bottom-left icon of the PocketDRIVEmain screen (Fig. 8) along with:

- date;
- hour of the day;
- vineyard ID;
- GPS position within the vineyard.

For LAI measurement, mean and standard deviation of the readings acquired in the same position are reported as described on the sub-chapter 3.

Figure 8. Icon to access all the data collected with the app PocketDRIVE.

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