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CRACK SENSE

D3.6: Data for SDSS I

Author(s)/Organisation(s)	Georgia Nikolakopoulou, Sofia Mouseti (AUA); Tarin Paz-Kagn (BGU)
Contributor(s)	Victor Alchanati, Idit Ginzberg, Uri Hochberg, Amnon Lichter, Avi Sadka (ARO); Kantari Katerina (AUA); Vladislav Dubinin (BGU); Laurent Julhia, José Quero Garcia (INRAe); Manuela Zude-Sasse (ATB); Andreas Winkler (LVGA); Sonata Grabusovė (BetaVia).
Work Package	WP3
Delivery Date (DoA)	M36
Actual Delivery Date	30.01.2026

Document Revision History			
Date	**Version**	**Author/Contributor/ Reviewer**	**Summary of main changes**

Dissemination Level		
PU	Public, fully open, e.g. web	**X**
SEN	Sensitive, limited under the conditions of the Grant Agreement	
Classified R-UE/EU-R	EU RESTRICTED under the Commission Decision No2015/444	
Classified C-UE/EU-C	EU CONFIDENTIAL under the Commission Decision No2015/444	
Classified S-UE/EU-S	EU SECRET under the Commission Decision No2015/444	

CrackSense			
Participant Number	**Participant organization name**	**Short name**	**Country**
1	THE AGRICULTURAL RESEARCH ORGANISATION OF ISRAEL - THE VOLCANI CENTRE	ARO	IL
2	LEIBNIZ-INSTITUT FUR AGRARTECHNIK UND BIOOKONOMIE EV	ATB	DE
3	GEOPONIKO PANEPISTIMION ATHINON	AUA	EL
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10	LACHISH WORKER'S MOSHAV FOR COOPERATIVE AGRICULTURAL SETTLEMENT LTD	Tali grapes	IL
11	KIBBUTZ TSOR A	KT	IL
12	AGROTIKOS SYNETAIRISMOS POLISEOS XIRON KAI NOPON STAFYLION KIATOY KORINTHIAS PIGASOS	PEGASUS	EL
13	CENTRE TECHNIQUE INTERPROFESSIONNEL DES FRUITS ET LEGUMES	CTIFL	FR
14	EVENFLOW	EVENFLOW	BE
15	LEHR-UND VERSUCHSANSTALT FURGARTENBAU UND ARBORISTIK EV (LVGA)	LVGA	DE
16	BEN-GURION UNIVERSITY OF THE NEGEV	BGU	IL
17	MEHADRIN TNUPORT EXPORT LIMITED PARTNERSHIP	MTEX	IL
18	UDRUZENJE ZA PREDUZETNISTVO I INOVACIJE FOODSCALE HUB	FSH-RS	RS

Title:

High throughput real-time monitoring and prediction of fruit cracking by utilising and upscaling sensing and digital data technologies

Type of action: HORIZON Research and Innovation Actions

Topic: HORIZON-CL6-2022-GOVERNANCE-01-11

Start date of project: 01 January 2023 ● Duration: 48 months

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List of abbreviations

Abbreviation	Definition
AI	Artificial Intelligence
BBCH	Biologische Bundesanstalt, Bundessortenamt und CHemische Industrie (phenological scale)
CWSI	Crop Water Stress Index
DEM	Digital Elevation Model
ET_0	Evapotranspiration
EU	European Union
FDS	Fruit Daily Shrinkage
GNDI	Greenness Normalized Difference Index
GNDVI	Green Normalized Difference Vegetation Index
IPVI	Infrared Percentage Vegetation Index
LAI	Leaf Area Index
LIDAR	Light Detection and Ranging
MDS	Maximum Daily Shrinkage
ML	Machine Learning
MSAVI	Modified Soil-Adjusted Vegetation Index

NDRE	Normalized Difference Red Edge Index
NDVI	Normalized Difference Vegetation Index
NPK	Nitrogen Phosphorus Potassium
OSAVI	Optimized Soil-Adjusted Vegetation Index
PA	Plant Area
PAI	Plant Area Index
SAVI	Soil-Adjusted Vegetation Index
SDSS	Spatial Decision Support System
SIPI	Structure Insensitive Pigment Index
SWP	Stem Water Potential
TOMMY	Terrestrial Orchard Monitoring Method Yaw
UAV	Unmanned Aerial Vehicle
VI	Vegetation Indix
WP	Work Package

Executive Summary

D3.6 "*Data for SDSS I*" forms part of Task 3.3 of the CrackSense project, which focuses on generating high-resolution, multi-source data to support the development of a Spatial Decision Support System (SDSS) for assessing fruit cracking incidence. Within this framework, intensive sensing data, collected at tree, plot, and regional levels, were gathered across multiple crops (pomegranate, citrus, sweet cherry, and table grapes) during the 2023 and 2024 seasons. The data include physiological, environmental, and remote sensing measurements, structured into harmonized templates across partners and countries. Aligned with the objectives of Task 3.3, these datasets support AI/ML model development by integrating proximal measurements, UAV-based remote sensing, edge computing, and sensor networks. The processed datasets have been uploaded to the centralized **CrackSense database** (initially developed under D4.1) and will be openly accessible by the end of the project. This deliverable also presents the new database, in which all processed data from each pilot site are organized and accessible, enabling easy filtering and export for modelling. These efforts provide the data backbone for predictive tools, enabling site-specific management and early risk detection of cracking.

1. Introduction

CrackSense aims to reduce food loss by minimising fruit yield losses caused by field-level cracking. To achieve this, the project is developing scalable sensing technologies that provide real-time sensor data through targeted experimental and piloting activities. The collected data will be structured across multiple spatial scales, **fruit**, **tree**, **plot**, and **regional**, and integrated with Earth Observation sources (e.g., Sentinel-1 and Sentinel-2 from Copernicus) and environmental datasets. These datasets will support the monitoring of agricultural production for four key crops: **pomegranate**, **citrus**, **sweet cherry**, and **table grapes**, and will enable farmers and growers to manage their resources more efficiently and sustainably, while also supporting policymakers in making better-informed decisions at regional and national levels. To translate this data into actionable insights, a Spatial Decision Support System (SDSS) will be developed. The SDSS will analyse large, multi-source datasets using AI-driven models to assess and forecast fruit cracking risk, thereby supporting informed decision-making at multiple scales. Given the central role of data in this process, robust data management is critical to the success of the CrackSense project.

D3.6 aims to **report the data collected from experimental plots during the 2023 and 2024 cultivation seasons**, which have been used to train the predictive models presented in D3.5. In addition, it documents the structure of the new database, where all experimental data from 2023 and 2024 have been consolidated into a harmonized database format to enable integration into the SDSS platform.

Tables **1** summarize the datasets collected across all project sites and crops, providing a transparent overview of data harmonization and supporting robust inter-site and inter-crop comparison.

Table 1. Collection dates and physiological stages per experimental crop per country.

Date	Country	Crop	Plot location	Flight No.	Physiological stage
7.6.23	Israel	Citrus	Kfar Habad	1	Stage I
28.6.23	Israel	Citrus	Kfar Habad	2	Stage I-II
19.7.23	Israel	Citrus	Kfar Habad	3	Stage I-II
28.8.23	Israel	Citrus	Kfar Habad	4	Stage II
7.9.23	Israel	Citrus	Kfar Habad	5	Stage II
20.9.23	Israel	Citrus	Kfar Habad	6	Stage II
1-5.10.23	Israel	Citrus	Kfar Habad	7	Stage III- green
5-9.11.23	Israel	Citrus	Kfar Habad	8	Stage III- color break
9.5.23	Israel	Pomegranate	Tsor'a	1	Full bloom
21.6.23 (S1)	Israel	Pomegranate	Tsor'a	2	Peel color changes to red, green
23.7.23 (S2)	Israel	Pomegranate	Tsor'a	3	Green fruit
15.8.23 (S3)	Israel	Pomegranate	Tsor'a	4	Color break
11.9.23 (S4)	Israel	Pomegranate	Tsor'a	5	Reddish color
09.10.23 (S5)	Israel	Pomegranate	Tsor'a	6	Red fruit
31.10.23 (S6)	Israel	Pomegranate	Tsor'a	7	Harvest-dark red
11.6.23	Israel	Grapes	Lachish	1	Post fruit set
5.7.23	Israel	Grapes	Lachish	2	Pre-veraison
6.8.23	Israel	Grapes	Lachish	3	Post-veraison
1.5-5.5.24	Israel	Citrus	Kfar Habad	1	Stage I
30.5-3.6.24	Israel	Citrus	Kfar Habad	2	Stage I-II
1.7-3.7.24	Israel	Citrus	Kfar Habad	3	Stage I-II
1.8-5.8.24	Israel	Citrus	Kfar Habad	4	Stage II
1.9-5.9.24	Israel	Citrus	Kfar Habad	5	Stage II
1.10-5.10.24	Israel	Citrus	Kfar Habad	6	Stage II
1.11-5.11.24	Israel	Citrus	Kfar Habad	7	Stage III- green
1.12-5.12.24	Israel	Citrus	Kfar Habad	8	Stage III- color break
-	Israel	Pomegranate	Tsor'a	1	Full bloom
18.6.24 (S1)	Israel	Pomegranate	Tsor'a	2	Peel color change red to green
22.7.24 (S2)	Israel	Pomegranate	Tsor'a	3	Green fruit
19.8.24 (S3)	Israel	Pomegranate	Tsor'a	4	Color break
16.9.24 (S4)	Israel	Pomegranate	Tsor'a	5	Reddish color
14.10.24 (S5)	Israel	Pomegranate	Tsor'a	6	Red fruit
4.11.24 (S6)	Israel	Pomegranate	Tsor'a	7	Harvest-dark red
25.6.24	Israel	Grapes	Lachish	1	Post fruit set
25.7.24	Israel	Grapes	Lachish	2	Pre-veraison
25.8.24	Israel	Grapes	Lachish	3	Post-veraison
25.9.24	Israel	Grapes	Lachish	4	Mature (pre-harvest)

06.7.23	France	Citrus	FRCitrus2	1	Stage I
27.7.23	France	Citrus	FRCitrus2	2	Stage I-II
11-13.09.23	France	Citrus	FRCitrus2	3	Stage II
12.10.23	France	Citrus	FRCitrus2	4	Stage III- green
08.11.23	France	Citrus	FRCitrus2	5	Stage III- color break
06.7.23	France	Citrus	FRCitrus1	1	Stage I
27.7.23	France	Citrus	FRCitrus1	2	Stage I-II
11-12.09.23	France	Citrus	FRCitrus1	3	Stage II
12.10.23	France	Citrus	FRCitrus1	4	Stage III- green
08.11.23	France	Citrus	FRCitrus1	5	Stage III- color break
17.07.24	France	Citrus	FRCitrus1	1	Stage I
08.08.24	France	Citrus	FRCitrus1	2	Stage I-II
10.09.24	France	Citrus	FRCitrus1	3	Stage II
09-11.10.24	France	Citrus	FRCitrus1	4	Stage III- green
15.11.24	France	Citrus	FRCitrus1	5	Stage III- color break
18.07.24	France	Citrus	FRCitrus2	1	Stage I
14.08.24	France	Citrus	FRCitrus2	2	Stage I-II
10.09.24	France	Citrus	FRCitrus2	3	Stage II
09-11.10.24	France	Citrus	FRCitrus2	4	Stage III- green
15.11.24	France	Citrus	FRCitrus2	5	Stage III- color break
23-24-29.04.24	France	Sweet cherry	FRsweetcherry	1	Stage I
16.05.24	France	Sweet cherry	FRsweetcherry	2	Stage I-II
05.06.24	France	Sweet cherry	FRsweetcherry	3	Stage II
24.06.24	France	Sweet cherry	FRsweetcherry	4	Stage III

22.05.2023	Greece	Pomegranate	GRPOM	2	Full bloom
15.06.2023	Greece	Pomegranate	GRPOM	3	Peel color change red-green
03.07.2023	Greece	Pomegranate	GRPOM	4	Green fruit
05.08.2023	Greece	Pomegranate	GRPOM	5	Color break
01.09.2023	Greece	Pomegranate	GRPOM	6	Reddish color
27.09.2023	Greece	Pomegranate	GRPOM	7	Red fruit
20.10.2023	Greece	Pomegranate	GRPOM	8	Harvest-dark red
15.06.2023	Greece	Grapes	GRGrapes	1	Post fruit set
18.07.2023	Greece	Grapes	GRGrapes	2	Pre-veraison
17.08.2023	Greece	Grapes	GRGrapes	3	Post-veraison
25.05.2024	Greece	Pomegranate	GRPOM	1	Full bloom
14.06.2024	Greece	Pomegranate	GRPOM	2	Peel color change red-green
04.07.2024	Greece	Pomegranate	GRPOM	3	Green fruit
01.08.2024	Greece	Pomegranate	GRPOM	4	Color break
05.09.2024	Greece	Pomegranate	GRPOM	5	Reddish color
17.10.2024	Greece	Pomegranate	GRPOM	6	Red fruit
25.10.2025	Greece	Pomegranate	GRPOM	7	Harvest-dark red
07.06.2024	Greece	Grapes	GRGrapes	1	Post fruit set
01.07.2024	Greece	Grapes	GRGrapes	2	Pre-veraison
18.07.2024	Greece	Grapes	GRGrapes	3	Post-veraison
02.08.2024	Greece	Grapes	GRGrapes	5	Post-veraison

14.06.2023	Germany	Sweet cherry	LVGA_Cerry	1	stage II, transition stage II/III
21.06.2023	Germany	Sweet cherry	LVGA_Cerry	2	transition stage II/III - early stage III
28.06.2023	Germany	Sweet cherry	LVGA_Cerry	3	early stage III - mid-stage III
05.07.2023	Germany	Sweet cherry	LVGA_Cerry	4	early stage III - mid-stage III
12.07.2023	Germany	Sweet cherry	LVGA_Cerry	5	mid-stage III - maturity
19.07.2023	Germany	Sweet cherry	LVGA_Cerry	6	mid-stage III - maturity
26.07.2023	Germany	Sweet cherry	LVGA_Cerry	7	maturity

2. Methodology

To ensure consistency and interoperability across different partners, countries, and crops, a common data collection and reporting protocol was implemented from the beginning of the CrackSense project. After the completion of each cultivation season (2023 and 2024), each responsible partner reported their datasets using predefined Excel templates with a unified structure, applicable to all four target crops: table grapes, pomegranate, citrus, and sweet cherry. The raw data, as provided by the partners, were initially uploaded to the initial version of the CrackSense database, developed under D4.1. In parallel, each partner was responsible for processing and formatting the collected data to be ready for model training and evaluation. These processed datasets were compiled into crop- and country-specific Excel files, aligned with the requirements of the modelling activities carried out under WP3 and reported in D3.5. Following the development of the central database structure, AUA uploaded all cleaned and processed data to the unified platform. The structure of the uploaded datasets is described in detail in sub-section 3.2, while the available filtering functionalities are presented in Section 4. The database enables users to select specific parameters, time ranges, or crop types of interest and download the filtered content in *.csv* format, ensuring accessibility

and flexibility for both research and operational use. The updated version of the database will be made open access by the end of the project, guaranteeing long-term exploitation and reuse.

In addition to field-level data, local environmental parameters were also gathered, including climatic variables (e.g., temperature, relative humidity, rainfall) and soil characteristics (e.g., moisture at multiple depths, texture). These data were linked with yield and observed cracking incidence and severity, as well as with the effectiveness of horticultural practices (e.g., irrigation, mineral application, PGR treatments). TOMMY fruit surface temperature (FST) data were stored as raw data in the AUA CrackSense database and have been made open access as clean processed data on availability for 2023 and 2024 data so far (D2.4, https://technologygarden.atb-potsdam.de/cracksense/). This enables future analyses of the interaction between environmental conditions and treatment efficiency, potentially creating different pedoclimatic conditions.

Furthermore, historical data were collected from all partner countries in a standardized format to support the development of regional-scale prediction models. Partners were asked to complete a structured Excel template designed to capture both experimental and contextual metadata. Table 2 summarises the main sources of data used for model development and validation, including their timeframes, collection context, responsible contributors, and intended use across CrackSense activities.

Table 2. An overview of data sources used for model development and validation, including their time period associated work package, responsible data collectors, and intended modelling purpose.

Source type	Time period	Collected under	Data collector	Purpose
Experimental Plots	2023-2024	WP2/WP3	Research partners	*Development* of tree-/plot-level models
Piloting activities	2025-2026	WP5	Research partners	*Validation* of tree-/plot-level models
Historical data	10+ years incl. 2023, 2024 & 2025	WP4	Research-led & grower surveys (commercial plots)	Input for regional-scale models

3. Results

3.1 Tree scale: TOMMY fruit surface temperature data

Single-instance and time-series data collected using the close-range remote sensing unit TOMMY (developed under WP2) are available through the open-access Fruit Surface Temperature (FST) database and distributed via structured *Excel* files. All raw TOMMY data have also been uploaded to the CrackSense repository to ensure long-term accessibility and integration with other SDSS datasets. These data capture high-resolution measurements at the fruit/tree scale, including the spatial location of individual fruits within the canopy, estimated fruit size, and thermal parameters such as mean fruit surface temperature and temperature gradient.

Table 3. Parameters included in the TOMMY fruit-/tree-scale dataset, capturing spatial and thermal measurements at the individual fruit level.

	Name	Description	Type	Unit
Location	Fruit ID and Spatial location within the canopy	ID, x, y, z in local coordinate system	Float	m
Fruit Measurements	Fruit size	Estimated fruit size	Float	mm
	Fruit T	Measured mean fruit temperature	Float	°C
	Fruit T gradient	Measured fruit temperature gradient	Float	K
	Canopy T	Measured mean canopy temperature	Float	°C
	Canopy T gradient	Measured canopy temperature gradient	Float	K
Climate data	Air T, precipitation, radiation	Local weather variables	Float	various

3.2 Tree/ plot scale: Initial templates for the data collection

To ensure consistency, interoperability, and efficient data integration into the CrackSense platform, a standardized data structure was established among all participating partners. Data collected during the 2023 and 2024 cultivation seasons were reported using pre-defined Excel templates that followed a harmonized schema for all studied crops. These templates captured information at multiple scales, including tree-level, plot-level, and sensor-based daily measurements, covering key physiological, phenological, environmental, and remote sensing parameters. The structured files were subsequently uploaded to the initial project database (developed under D4.1) and later integrated into the updated centralized repository by AUA. In parallel, historical and regional datasets were collected in a dedicated format to support region-wide modeling and SDSS development. The following sections describe in detail the organization and content of these structured data files.

3.2.1 Tree-plot scale: Constant information

To ensure that data collected across diverse plots and trees can be meaningfully interpreted and compared, a set of **constant parameters** was recorded for each experimental site. These include agronomic, geographical, and structural characteristics of the plots, such as the country, species, rootstock, year of planting, irrigation type, and water quality. Capturing this baseline information is essential for contextualizing the observed physiological and remote sensing measurements and for understanding the site-specific factors that may influence cracking risk, supporting data harmonization across partners and seasons.

Table 4. An overview of constant agronomic and environmental parameters collected at the plot level across all pilot sites. These parameters provide foundational context for interpreting physiological responses and sensor measurements in relation to cracking risk.

	Name	Description
Key plot parameters	**Country**	-
	Species	-
	Treatment	
	Year of Planting	Both are considered to produce the plot trees' age. Changed planting is when a farmer decides to uproot all fields and replant it. In this case, the latter is taken
Constant plot parameters	**Site**	Site name
	Study year	The study year of the measurements
	Pruning timing	Yes or no and when
	watering	The irrigation treatment
	Rootstock	Trees are built with scion grafting operations on different rootstocks.
	Water	Type of water used to irrigate the field
	P water	Purification treatment level of wastewater (reclaimed type) used for irrigation, the higher the level, the more purified water gets
	Irrigations per week	According to the farmer report, the weekly frequency irrigated during the season, ordinal values according to the frequency.
	Water to Ha/ year	Amount of water irrigated per Hac

3.2.2 Tree-plot scale: Yearly Information

To ensure temporal consistency and accurate longitudinal monitoring, each partner collected yearly data for all experimental, pilot and survey plots. These records primarily focus on cracking-related outcomes, such as yield and cracking percentage, alongside agronomic, edaphic, and treatment-related variables. The structured format allows for harmonized data entries across countries and crops, enabling streamlined pre-processing and integration into machine learning pipelines. Additionally, soil composition and hormonal treatment applications were documented, as these are known to influence cracking incidence. Where available, outlier-corrected versions of the yield and cracking data were also provided to improve model robustness.

Table 5. Parameters included in the yearly monitoring dataset at plot and tree level, including soil composition, hormonal treatments, and cracking-related outputs.

	Name	Description	Type	Units
Key plot parameters	Country	-	String	-
	Species	-	String	-
	Treatment	-	String	-
	Year of Planting	Both are considered to produce the plot trees' age. Changed planting is when a farmer decides to uproot all field and replant it. In this case, the latter is taken	Integer	-
	Site	Site name	String	-
	Study year	The study year of the measurements	Integer	-
Key tree parameters	TreeID	ID of the study trees	Integer	-
	TreeIDLon	Longitude of the study trees	Float	Degrees[0]
	TreeIDLat	Latitude of the study trees	Float	Degrees[0]
	Elevation	Mean elevation of the study trees	Float	meters
	Variance zone	The variance zone of the study tree	String	-
	Row and Line	Orchard coordinates Row and Line of the study trees	Integer	-
	Girdling	Yes or No and when	String	-
Soil texture	30 cm Sand	Sand concentration in 30 cm depth	Float	%
	30 cm Silt	Silt concentration in 30 cm depth	Float	%
	30 cm Clay	Clay concentration in 30 cm depth	Float	%
	60 cm Sand	Sand concentration in 60 cm depth	Float	%
	60 cm Silt	Silt concentration in 60 cm depth	Float	%
	60 cm Clay	Clay concentration in 60 cm depth	Float	%
	90 cm Sand	Sand concentration in 90 cm depth	Float	%
	90 cm Silt	Silt concentration in 90 cm depth	Float	%
	90 cm Clay	Clay concentration in 90 cm depth	Float	%
Soil composition (macro and micro nutrients)	N	N concentration by fire	Float	%
	P	P concentration by fire	Float	%
	K	K concentration by fire	Float	%
	Mg	Mg concentration by fire	Float	%
	Ca	Ca concentration by fire	Float	%
	Na	Na concentration by fire	Float	%
	B	B concentration by fire	Float	mg Kg-1
	Cl	Cl concentration by fire	Float	%
Yield and Splitting	Total Weight	Total yield weight with splitting	Float	Kg
	Total Weight without outliers	Total yield weight with splitting without outliers	Float	Kg
	Total Fruit (non split)	Yield without splitting	Float	Number of fruits
	Total Fruit (non split) without outliers	Yield without splitting without outliers	Float	Number of fruits
	Average Fruit Weight	Average fruit weight	Float	grams
	Average Fruit Weight without outliers	Average fruit weight without outliers	Float	grams
	Splitting	Percentage of splitting	Float	%

	Splitting without outliers	Percentage of splitting without outliers	Float	%

3.2.3 Tree-plot Scale: Field Monthly measurements

Monthly measurements provide valuable insight into the dynamic physiological status of trees, closely linked to cracking susceptibility. These measurements include key parameters such as Stem Water Potential (SWP), stomatal conductance, and plant area index (PAI), factors known to reflect water status, canopy structure, and transpiration efficiency. Measurements were synchronized with UAV flights, enabling combined analysis of proximal and remote sensing data. These repeated measures capture temporal variation in stress response and support fine-tuning of predictive models.

***Table 6. Monthly collected physiological and nutritional parameters associated with cracking incidence, aligned* with drone flight campaigns and phenological stages.**

	Name	Description	Type	Units
Date	Flight date	The date of the drone flight	String	Date
Stage	Phenological stage	Phenological stage of the tree	Integer	
Monthly Measurements	PAI	Measured plant area index (PAI) by SunScan	Float	m2 m-2
	SWP	Measured Stem Water Potential (SWP)	Float	mPa
	Std SWP	Standard deviation of the measured SWP	Float	m2 m-2
	Stomatal Conductance	Measured stomatal conductance	Float	mmol m−2 s−1
	Std stomatal conductance	Standard deviation of the measured stomatal conductance	Float	mmol m−2 s−1
Monthly Measurements	Leaf mineral treatments	Leaf minerals	Float	%
	Peel minerals	Peel minerals	Float	%

3.2.4 Tree-plot Scale: Sensor daily measurements

To monitor physiological dynamics and environmental conditions at high temporal resolution, daily sensor-based measurements were collected across CrackSense experimental sites. These included trunk and fruit growth metrics, truck maximal daily shrinkage, soil moisture at multiple depths, and meteorological parameters. Such measurements are crucial for identifying microclimate effects on cracking incidence and modeling temporal plant responses to abiotic stressors. While most data were recorded on a daily/hourly basis, in some cases (depending on sensor availability or experimental setup), measurements such as trunk and soil moisture were recorded monthly. Table 6 lists the full set of sensor-derived parameters in the database, their descriptions, and associated units.

Table 7. Summary of sensor-based daily measurements at tree/plot level, including dendrometer, soil moisture, and meteorological observations used in CrackSense pilots.

	Name	Description	Type	Units
Date	Flight date	The date of the drone flight	String	Date
Tree Measurements	Tree Sensor ID	Id of the tree dendrometer	Integer	
	MDS	Maximum daily shrinkage	Float	µm day-1
	Trunk growth	Daily trunk growth	Float	µm day-1
	Maximum trunk growth	Maximum daily trunk growth	Float	µm day-1
	Minimum trunk growth	Minimum daily trunk growth	Float	µm day-1
	Accumulated trunk Growth	The accumulated trunk growth from April	Float	µm
Fruit Measurements / TOMMY data	Fruit Sensor ID	ID of fruit sensor	Float	
	Fruit size	Fruit size	Float	cm
	Average fruit size	Average Fruit size	Float	cm
	Fruit growth	Daily fruit growth	Float	µm
	FDS	Fruit daily shrinkage	Float	µm day-1
	Accumulated fruit Growth	The accumulated fruit growth from April	Float	µm
Soil moisture Measurements	Soil moisture Sensor ID	ID of soil moisture sensor	Float	
	Soil moisture 20cm	Soil moisture in 20 cm depth	Float	%
	Soil moisture 40cm	Soil moisture in 40 cm dept	Float	%
Meteorology Measurements	Air Temperature	Daily average air temperature	Float	°C
	Dew Point	Daily dew point	Float	°C
	VPD	Daily average vapor pressure deficit	Float	kPa
	Relative Humidity	Daily average relative humidity	Float	%
	Wind Speed Max	Daily maximum wind speed	Float	m s-1
	Air Pressure	Daily average air pressure	Float	mbar
	Rain	Daily accumulated rain	Float	mm day-1
	ET0	Daily reference/ potential evapotranspiration	Float	mm day-1

3.2.5 Remote Sensing data

Remote sensing provides spatially continuous, non-destructive insights into crop canopy status, supporting the early detection of stress-related cracking. Throughout the 2023 and 2024 experimental seasons and the 2025 piloting season, UAV-based imagery was acquired to extract thermal, multispectral, and LiDAR-derived variables at the tree and plot levels. These data include canopy temperature (Tc), canopy water stress index (CWSI), spectral reflectance values across key wavelengths (CW_475 to CW_842), and a range of vegetation indices derived (e.g., NDVI, SAVI, EVI, SIPI, OSAVI). Additionally, LiDAR-derived estimations such as canopy height and plant area were calculated to capture canopy structure and spatial dynamics. Table 7 summarizes the remote sensing variables integrated into the CrackSense database and used for modeling cracking incidence and yield variability.

Table 8. List of remote sensing features derived from UAV flights, including thermal indices, spectral reflectance bands, vegetation indices, and LiDAR-based canopy metrics.

	Name	Description	Type	Units
Date	Flight date	The date of the drone flight	String	Date
Thermal indices	Tc	Average canopy temperature.	Float	0C
	CWSI	Average canopy water stress index.	Float	-
Multispectral reflectance	CW_475	Average spectral reflectance for 475, 560, 668, 717 and 842 nm respectively	Float	-
	CW_560		Float	-
	CW_668		Float	-
	CW_717		Float	-
	CW_842		Float	-
	CW_560		Float	-
Vegetation indices	NDVI	Normalized difference vegetation index	Float	-
	SAVI	Soil adjusted vegetation index	Float	-
	EVI	Enhanced vegetation index	Float	-
	MSAVI	Modified soil adjusted vegetation index	Float	-
	GNDVI	Green NDVI	Float	-
	GNDI	Greenness normalized index	Float	-
	NDRE	Normalized difference red edge index	Float	-
	IPVI	Infrared percentage vegetation index	Float	-
	SIPI	Structure insensitive pigment index	Float	-
	OSAVI	Optimized soil adjusted vegetation index	Float	-
	CI	Chlorophyll index	Float	-
	DVI	Different vegetation index	Float	-
LiDAR estimations	DEM	Digital elevation model. Average elevation of the tree above the sea,	Float	-
	LiDAR_PAI	Predicted PAI	Float	-
	Area	Projected canopy area	Float	-
	PA	Plant area = LiDAR_PAI * Area	Float	-

3.3 Experiment data for tree/ plot scale models

All raw and processed data from the 2023 and 2024 cultivation seasons across all crops and countries have been uploaded to the CrackSense database. The processed datasets, prepared for modelling activities, were initially collected in standardized Excel templates by AUA from the respective partners. Following internal quality checks and harmonization, AUA integrated these datasets into the extended version of the project database, which includes advanced filtering functionalities and is described in Section 4. This structured data input supports the modelling activities reported in D3.5 and enables the subsequent development of the SDSS under WP4.

3.3.1 Citrus

3.3.1.1 Israel

For the 2023 and 2024 cultivation seasons, ARO provided a complete dataset aligned with the CrackSense data structure. The reported information includes constant parameters such as treatment, year of planting, rootstock, and irrigation regime. Yearly data cover yield, cracking, and hormonal treatments, and soil composition data. Monthly physiological measurements include stem water potential (SWP) and stomatal conductance, with values typically recorded monthly. Fruit size is available from July 2023/2024 to the

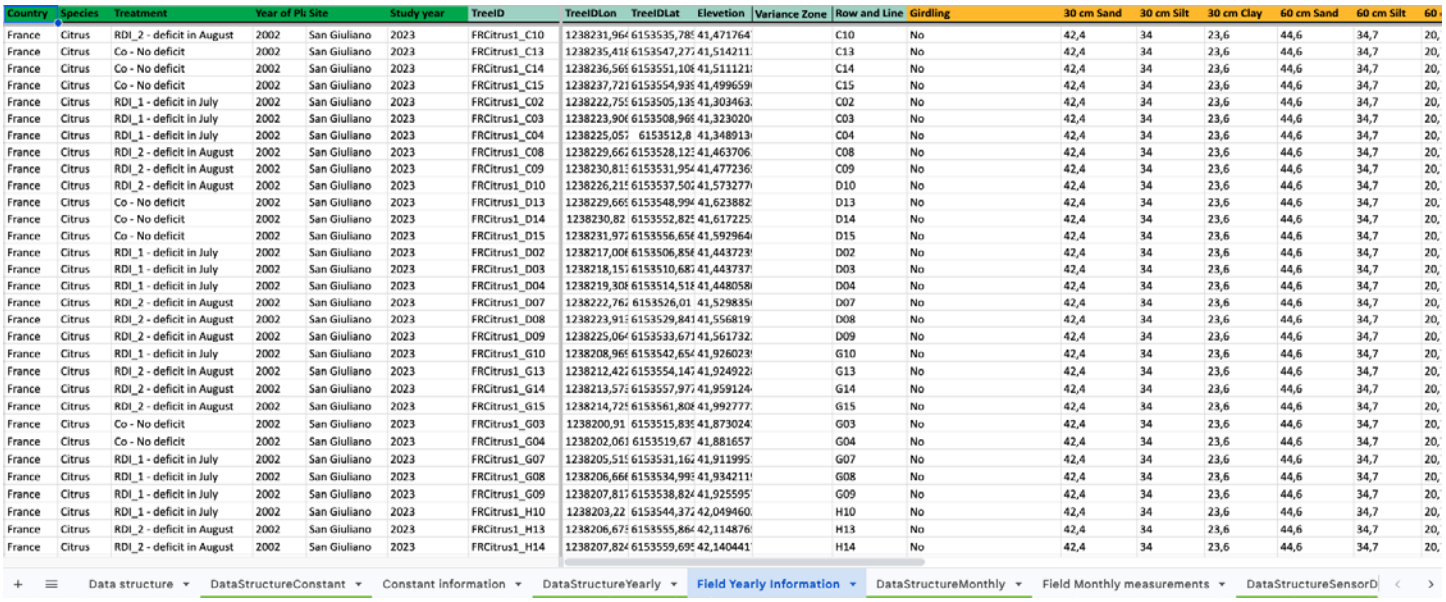
harvest date. Daily trunk sensor data (MDS, trunk growth) follow a near-continuous sequence from April 2023 to January 2025. Soil moisture monitoring was conducted continuously. Meteorological data were collected continuously, with some gaps. Remote sensing data include vegetation indices for all flight dates, while LiDAR-based parameters (e.g., PAI, canopy area) were calculated on a monthly basis during the irrigation season. All reported data have been uploaded to the central CrackSense database and used for model training (D3.5).

Counti	Specie	Treatm	Year of Plantin	TreeID	Variance Zone	Row and Li	TreeIDLon	TreeIDLat	Elevetio	Site	Flighting da		LAI [m	SWP	SWP_STEI	Stotmatal CondUctu	Stomatal Conductance_STE
Israel	Citrus	Pi	2007	Pi 02	Green	R_02_L_09	655083,203	185042,697	42,499	Kfar Chabad	6/7/2023			-1,33	0,0678847061	0,0436	0,01166447598
Israel	Citrus	Pi	2007	Pi 06	Green	R_02_L_45	655171,314	185100,892	40,912	Kfar Chabad	6/7/2023			-1,47	0,1275735082	0,0832	0,01422111107
Israel	Citrus	R	2007	R 02	Green	R_05_L_11	655078,486	185061,356	42,85	Kfar Chabad	6/7/2023			-1,52	0,1755230279	0,054	0,00894427191
Israel	Citrus	R	2007	R 05	Green	R_05_L_31	655127,824	185092,298	42,152	Kfar Chabad	6/7/2023			-1,48	0,15612495	0,0906	0,01101181184
Israel	Citrus	G	2007	G 02	Green	R_08_L_12	655072,047	185078,887	43,064	Kfar Chabad	6/7/2023			-1,76	0,0984885780	0,044	0,01204159458
Israel	Citrus	G	2007	G 04	Green	R_08_L_28	655112,51	185104,565	42,343	Kfar Chabad	6/7/2023			-1,69	0,0351188458	0,0436	0,008065977932
Israel	Citrus	Pr	2007	Pr 02	Green	R_11_L_11	655059,034	185092,728	43,531	Kfar Chabad	6/7/2023			-1,38	0,0578311719	0,05	0,006123724357
Israel	Citrus	Pr	2007	Pr 05	Green	R_11_L_29	655105,531	185121,516	42,585	Kfar Chabad	6/7/2023			-1,37	0,0807430767	0,042	0,00331662479
Israel	Citrus	G	2007	G 08	Green	R_14_L_10	655048,798	185105,716	43,958	Kfar Chabad	6/7/2023			-1,89	0,1266227994	0,0736	0,009719053452
Israel	Citrus	G	2007	G 11	Green	R_14_L_27	655090,871	185134,2	42,622	Kfar Chabad	6/7/2023			-1,83	0,2016873268	0,023	0,007028513356
Israel	Citrus	Pr	2007	Pr 08	Green	R_17_L_10	655041,962	185123,271	44,006	Kfar Chabad	6/7/2023			-1,41	0,0142400062	0,0444	0,009657121724
Israel	Citrus	Pr	2007	Pr 10	Green	R_17_L_22	655070,385	185140,564	43,61	Kfar Chabad	6/7/2023			-1,24	0,0616666666	0,0386	0,01209380006
Israel	Citrus	R	2007	R 08	Green	R_20_L_09	655027,918	185134,875	44,722	Kfar Chabad	6/7/2023			-1,34	0,1733333333	0,0434	0,0054
Israel	Citrus	R	2007	R 09	Green	R_20_L_15	655042,451	185145,541	43,934	Kfar Chabad	6/7/2023			-1,52	0,1665916498	0,0526	0,01019117265
Israel	Citrus	Pi	2007	Pi 08	Green	R_23_L_09	655017,792	185150,707	44,754	Kfar Chabad	6/7/2023			-1,37	0,1234683945	0,0546	0,01425692814
Israel	Citrus	Pi	2007	Pi 10	Green	R_23_L_19	655043,36	185167,88	43,789	Kfar Chabad	6/7/2023			-1,39	0,0604841577	0,0732	0,01394775968
Israel	Citrus	G	2007	G 14	Green	R_26_L_09	655009,389	185165,946	45,255	Kfar Chabad	6/7/2023			-1,94	0,117697824	0,0204	0,004654030511
Israel	Citrus	G	2007	G 16	Green	R_26_L_19	655033,098	185182,249	44,117	Kfar Chabad	6/7/2023			-1,71	0,0458257569	0,041	0,01062544117
Israel	Citrus	R	2007	R 14	Pink	R_29_L_07	654994,534	185177,81	45,841	Kfar Chabad	6/7/2023			-1,53	0,110315205	0,022	0,004404543109
Israel	Citrus	R	2007	R 18	Pink	R_29_L_18	655024,835	185198,837	44,43	Kfar Chabad	6/7/2023			-1,55	0,0389800518	0,0416	0,008274055837
Israel	Citrus	Pi	2007	Pi 14	Yellow	R_32_L_05	654979,185	185190,118	46,001	Kfar Chabad	6/7/2023			-1,24	0,0923008366	0,0312	0,01374190671
Israel	Citrus	Pi	2007	Pi 16	Yellow	R_32_L_10	654991,977	185198,409	45,558	Kfar Chabad	6/7/2023			-1,56	0,2162046356	0,0416	0,01602997193
Israel	Citrus	Pr	2007	Pr 14	Yellow	R_35_L_04	654966,784	185203,907	45,956	Kfar Chabad	6/7/2023			-1,46	0,1053960784	0,0316	0,008028698525
Israel	Citrus	Pr	2007	Pr 18	Pink	R_36_L_05	654967,404	185210,365	45,844	Kfar Chabad	6/7/2023			-1,41	0,0033333333		
Israel	Citrus	Pi	2007	Pi 01	Green	R_02_L_04	655070,277	185034,15	42,767	Kfar Chabad	6/28/2023		7				
Israel	Citrus	Pi	2007	Pi 02	Green	R_02_L_09	655083,203	185042,697	42,499	Kfar Chabad	6/28/2023		6,3				
Israel	Citrus	Pi	2007	Pi 03	Green	R_02_L_15	655099,224	185051,825	42,477	Kfar Chabad	6/28/2023		5				
Israel	Citrus	Pi	2007	Pi 04	Green	R_02_L_25	655123,962	185067,854	42,113	Kfar Chabad	6/28/2023		5,9				
Israel	Citrus	Pi	2007	Pi 05	Green	R_02_L_34	655144,452	185081,847	41,652	Kfar Chabad	6/28/2023		4,5				
Israel	Citrus	Pi	2007	Pi 06	Green	R_02_L_45	655171,314	185100,892	40,912	Kfar Chabad	6/28/2023		5,8				
Israel	Citrus	R	2007	R 01	Green	R_05_L_04	655061,264	185050,018	43,177	Kfar Chabad	6/28/2023		8,3				
Israel	Citrus	R	2007	R 02	Green	R_05_L_11	655078,486	185061,356	42,85	Kfar Chabad	6/28/2023		7,7	-1,67	0,0860716755	0,0332572	0,003206644249

Figure 1. Example of the structured dataset submitted for citrus orchards (2023-2024) from Israel, following the standardized CrackSense data model for the tree-plot model.

3.3.1.2 France

For the 2023 and 2024 cultivation seasons, INRAe provided comprehensive datasets for citrus orchards located in San Giuliano, including treatment type, planting year, rootstock, girdling, and detailed soil composition for each tree. Yield data were reported consistently across both years, although no hormonal treatments were applied. Monthly measurements include stem water potential (SWP), recorded at key phenological stages: in 2023, SWP was measured only during stages I and II, whereas in 2024 it was extended to all three key stages. No stomatal conductance data were reported for either year. Daily measurements cover meteorological data (air temperature, humidity, wind, etc.) from April 2023 to December 2024. Trunk growth data (MDS and daily variation) were collected from August to December 2024, and fruit size was monitored from August to November 2024. Soil moisture data were not recorded. Remote sensing data include vegetation indices, estimated canopy area, and LiDAR-derived features for all UAV flights, except for September 2024, for which VI data are missing.



Country	Species	Treatment	Year of Pl	Site	Study year	TreeID	TreeIDLon	TreeIDLat	Elevetion	Variance Zone	Row and Line	Girdling	30 cm Sand	30 cm Silt	30 cm Clay	60 cm Sand	60 cm Silt	60
France	Citrus	RDI_2 - deficit in August	2002	San Giuliano	2023	FRCitrus1_C10	1238231,964	6153535,785	41,471764		C10	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	Co - No deficit	2002	San Giuliano	2023	FRCitrus1_C13	1238235,418	6153547,277	41,514211		C13	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	Co - No deficit	2002	San Giuliano	2023	FRCitrus1_C14	1238236,569	6153551,108	41,511121		C14	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	Co - No deficit	2002	San Giuliano	2023	FRCitrus1_C15	1238237,721	6153554,935	41,499659		C15	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_1 - deficit in July	2002	San Giuliano	2023	FRCitrus1_C02	1238222,759	6153505,135	41,303463		C02	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_1 - deficit in July	2002	San Giuliano	2023	FRCitrus1_C03	1238223,906	6153508,965	41,323020		C03	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_1 - deficit in July	2002	San Giuliano	2023	FRCitrus1_C04	1238225,057	6153512,8	41,348913		C04	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_2 - deficit in August	2002	San Giuliano	2023	FRCitrus1_C08	1238229,662	6153528,125	41,463706		C08	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_2 - deficit in August	2002	San Giuliano	2023	FRCitrus1_C09	1238230,815	6153531,954	41,477236		C09	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_2 - deficit in August	2002	San Giuliano	2023	FRCitrus1_D10	1238226,215	6153537,502	41,573277		D10	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	Co - No deficit	2002	San Giuliano	2023	FRCitrus1_D13	1238229,665	6153548,994	41,623882		D13	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	Co - No deficit	2002	San Giuliano	2023	FRCitrus1_D14	1238230,82	6153552,825	41,617225		D14	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	Co - No deficit	2002	San Giuliano	2023	FRCitrus1_D15	1238231,972	6153556,656	41,592964		D15	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_1 - deficit in July	2002	San Giuliano	2023	FRCitrus1_D02	1238217,008	6153506,856	41,443723		D02	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_1 - deficit in July	2002	San Giuliano	2023	FRCitrus1_D03	1238218,157	6153510,687	41,443737		D03	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_1 - deficit in July	2002	San Giuliano	2023	FRCitrus1_D04	1238219,308	6153514,518	41,448058		D04	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_2 - deficit in August	2002	San Giuliano	2023	FRCitrus1_D07	1238222,762	6153526,01	41,529835		D07	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_2 - deficit in August	2002	San Giuliano	2023	FRCitrus1_D08	1238223,913	6153529,841	41,556819		D08	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_2 - deficit in August	2002	San Giuliano	2023	FRCitrus1_D09	1238225,064	6153533,671	41,561732		D09	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_1 - deficit in July	2002	San Giuliano	2023	FRCitrus1_G10	1238208,969	6153542,654	41,926023		G10	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_2 - deficit in August	2002	San Giuliano	2023	FRCitrus1_G13	1238212,427	6153554,147	41,924922		G13	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_2 - deficit in August	2002	San Giuliano	2023	FRCitrus1_G14	1238213,573	6153557,977	41,959124		G14	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_2 - deficit in August	2002	San Giuliano	2023	FRCitrus1_G15	1238214,725	6153561,808	41,992777		G15	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	Co - No deficit	2002	San Giuliano	2023	FRCitrus1_G03	1238200,91	6153515,835	41,873024		G03	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	Co - No deficit	2002	San Giuliano	2023	FRCitrus1_G04	1238202,061	6153519,67	41,881657		G04	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_1 - deficit in July	2002	San Giuliano	2023	FRCitrus1_G07	1238205,515	6153531,162	41,911995		G07	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_1 - deficit in July	2002	San Giuliano	2023	FRCitrus1_G08	1238206,666	6153534,993	41,934211		G08	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_1 - deficit in July	2002	San Giuliano	2023	FRCitrus1_G09	1238207,817	6153538,824	41,925595		G09	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_1 - deficit in July	2002	San Giuliano	2023	FRCitrus1_H10	1238203,22	6153544,372	42,049460		H10	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_2 - deficit in August	2002	San Giuliano	2023	FRCitrus1_H13	1238206,673	6153555,864	42,114876		H13	No	42,4	34	23,6	44,6	34,7	20,
France	Citrus	RDI_2 - deficit in August	2002	San Giuliano	2023	FRCitrus1_H14	1238207,824	6153559,695	42,140441		H14	No	42,4	34	23,6	44,6	34,7	20,

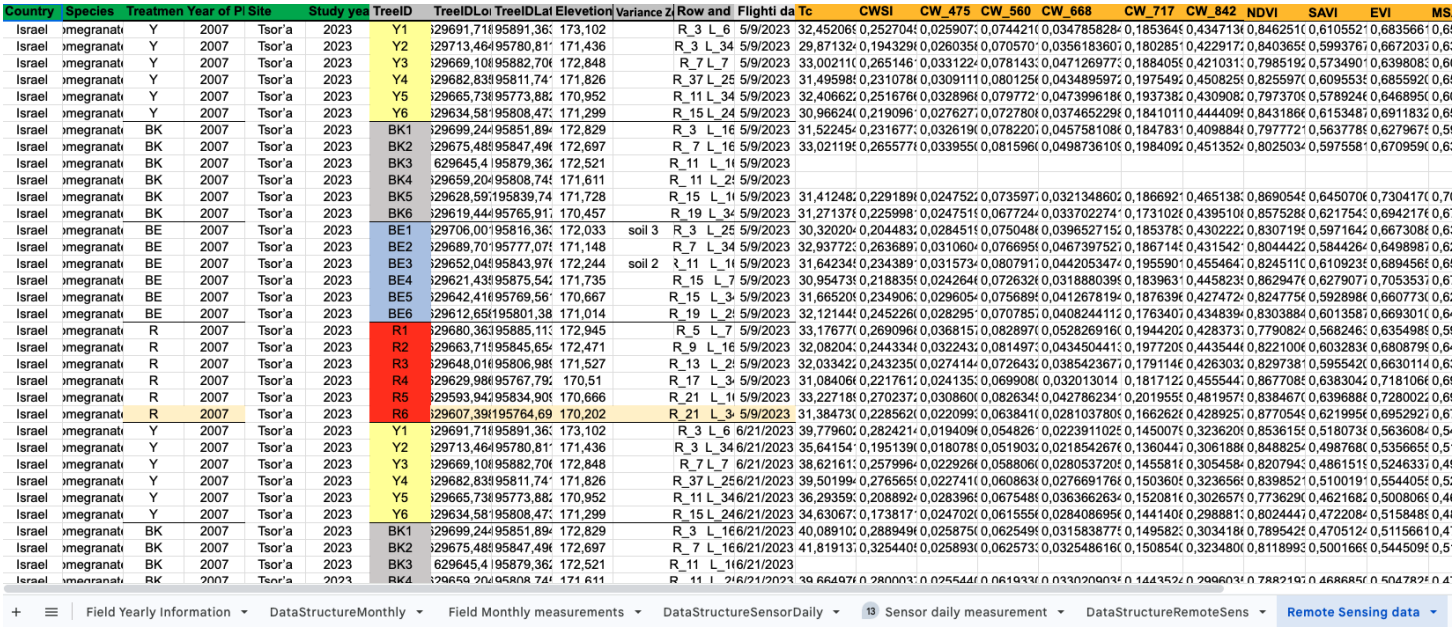
Data structure | DataStructureConstant | Constant information | DataStructureYearly | Field Yearly Information | DataStructureMonthly | Field Monthly measurements | DataStructureSensorD

Figure 2. Example of the structured dataset submitted for citrus orchards (2023-2024) from France, following the standardized CrackSense data model for the tree-plot model.

3.3.2 Pomegranate

3.3.2.1 Israel

For the 2023 and 2024 cultivation seasons, Israel reported extensive pomegranate data across all measurement categories. Soil composition was assessed once in 2023, prior to the experimental setup, using samples collected at three locations within the plot; this assessment was common to all treatments. Yield was recorded for all treatments. Monthly data in 2023 included plant area index (PAI), stem water potential (SWP) (May-November and January), and stomatal conductance (June-November and January), while leaf and peel mineral content was assessed once at the end of the growing season. In 2024, no mineral data were collected, but plant area index (PAI) was measured from June to September, and SWP and stomatal conductance were recorded from June to October. Daily meteorological data were available from April to December 2023, and from April 2024 onward, while soil moisture measurements were taken intermittently in 2023 and more regularly in 2024, though with some gaps. Trunk growth and maximum daily shrinkage (MDS) were monitored throughout the growing season in both 2023 and 2024. Fruit growth measurements were only collected in 2024 from June, also with gaps. Remote sensing data for 2023 included vegetation indices (VIs) from May to September, and LiDAR and DEM data for all flight dates except July and May. Remote sensing data were reported for both years.



Country	Species	Treatmen	Year of Pl	Site	Study yea	TreeID	TreeIDLo	TreeIDLa	Elevetion	Variance 2	Row and	Flighti da	Tc	CWSI	CW_475	CW_560	CW_668	CW_717	CW_842	NDVI	SAVI	EVI	MS
Israel	omegranat	Y	2007	Tsor'a	2023	Y1	629691,71	95891,36	173,102		R_3 L_6	5/9/2023	32,45206	0,25270	0,02590	0,07442	0,03478	0,18536	0,43471	0,84625	0,61055	0,68356	0,6
Israel	omegranat	Y	2007	Tsor'a	2023	Y2	629713,46	95780,81	171,436		R_3 L_34	5/9/2023	29,87132	0,19432	0,02603	0,07057	0,03561	0,18028	0,42291	0,84036	0,59937	0,66720	0,6
Israel	omegranat	Y	2007	Tsor'a	2023	Y3	629669,10	95882,70	172,848		R_7 L_7	5/9/2023	33,00211	0,26514	0,03312	0,07814	0,04712	0,18840	0,42103	0,79851	0,57349	0,63908	0,6
Israel	omegranat	Y	2007	Tsor'a	2023	Y4	629682,83	95811,74	171,826		R_37 L_25	5/9/2023	31,49598	0,23107	0,03091	0,08012	0,04348	0,19754	0,45082	0,82559	0,60955	0,68559	0,6
Israel	omegranat	Y	2007	Tsor'a	2023	Y5	629665,73	95773,88	170,952		R_11 L_34	5/9/2023	32,40662	0,25167	0,03289	0,07977	0,04739	0,19373	0,43090	0,79737	0,57892	0,64689	0,6
Israel	omegranat	Y	2007	Tsor'a	2023	Y6	629634,58	95808,47	171,299		R_15 L_24	5/9/2023	30,96624	0,21909	0,02762	0,07278	0,03746	0,18410	0,44409	0,84318	0,61534	0,69118	0,6
Israel	omegranat	BK	2007	Tsor'a	2023	BK1	629699,24	95851,89	172,829		R_3 L_16	5/9/2023	31,52245	0,23167	0,03261	0,07822	0,04575	0,18478	0,40988	0,79772	0,56377	0,62796	0,5
Israel	omegranat	BK	2007	Tsor'a	2023	BK2	629675,48	95847,49	172,697		R_7 L_16	5/9/2023	33,02119	0,26557	0,03395	0,08159	0,04987	0,19840	0,45135	0,80250	0,59755	0,67095	0,6
Israel	omegranat	BK	2007	Tsor'a	2023	BK3	629645,4	95879,36	172,521		R_11 L_1	5/9/2023											
Israel	omegranat	BK	2007	Tsor'a	2023	BK4	629659,20	95808,74	171,611		R_11 L_2	5/9/2023											
Israel	omegranat	BK	2007	Tsor'a	2023	BK5	629628,59	95839,74	171,728		R_15 L_1	5/9/2023	31,41248	0,22918	0,02475	0,07359	0,03213	0,18669	0,46513	0,86905	0,64507	0,73041	0,7
Israel	omegranat	BK	2007	Tsor'a	2023	BK6	629619,44	95765,91	170,457		R_19 L_3	5/9/2023	31,27137	0,22599	0,02475	0,06772	0,03370	0,17310	0,43951	0,85752	0,62175	0,69421	0,6
Israel	omegranat	BE	2007	Tsor'a	2023	BE1	629706,00	95816,36	172,033	soil 3	R_3 L_25	5/9/2023	30,32020	0,20448	0,02845	0,07504	0,03965	0,18537	0,43022	0,83071	0,59716	0,66730	0,6
Israel	omegranat	BE	2007	Tsor'a	2023	BE2	629689,70	95777,07	171,148		R_7 L_34	5/9/2023	32,93772	0,26368	0,03106	0,07669	0,04673	0,18671	0,43154	0,80444	0,58442	0,64898	0,6
Israel	omegranat	BE	2007	Tsor'a	2023	BE3	629652,04	95843,97	172,244	soil 2	R_11 L_1	5/9/2023	31,64234	0,23438	0,03157	0,08079	0,04420	0,19559	0,45546	0,82451	0,61092	0,68945	0,6
Israel	omegranat	BE	2007	Tsor'a	2023	BE4	629621,43	95875,54	171,735		R_15 L_7	5/9/2023	30,95473	0,21883	0,02426	0,07263	0,03188	0,18396	0,44582	0,86294	0,62790	0,70535	0,6
Israel	omegranat	BE	2007	Tsor'a	2023	BE5	629642,41	95769,56	170,667		R_15 L_3	5/9/2023	31,66520	0,23490	0,02960	0,07568	0,04126	0,18763	0,42742	0,82477	0,59289	0,66077	0,6
Israel	omegranat	BE	2007	Tsor'a	2023	BE6	629612,65	95801,38	171,014		R_19 L_2	5/9/2023	32,12144	0,24522	0,02829	0,07078	0,04082	0,17634	0,43483	0,83038	0,60135	0,66930	0,6
Israel	omegranat	R	2007	Tsor'a	2023	R1	629680,36	95885,11	172,945		R_5 L_7	5/9/2023	33,17677	0,26909	0,03681	0,08289	0,05282	0,19442	0,42837	0,77908	0,56824	0,63549	0,5
Israel	omegranat	R	2007	Tsor'a	2023	R2	629663,71	95845,65	172,471		R_9 L_16	5/9/2023	32,08204	0,24433	0,03224	0,08149	0,04345	0,19772	0,44354	0,82210	0,60328	0,68087	0,6
Israel	omegranat	R	2007	Tsor'a	2023	R3	629648,01	95806,98	171,527		R_13 L_2	5/9/2023	32,03342	0,24323	0,02741	0,07264	0,03854	0,17911	0,42630	0,82973	0,59554	0,66301	0,6
Israel	omegranat	R	2007	Tsor'a	2023	R4	629629,98	95767,79	170,51		R_17 L_3	5/9/2023	31,08406	0,22176	0,02413	0,06990	0,03201	0,18171	0,45554	0,86770	0,63830	0,71810	0,6
Israel	omegranat	R	2007	Tsor'a	2023	R5	629593,94	95834,90	170,666		R_21 L_1	5/9/2023	33,22718	0,27023	0,03086	0,08263	0,04278	0,20195	0,48195	0,83846	0,63968	0,72800	0,6
Israel	omegranat	R	2007	Tsor'a	2023	R6	629607,39	95764,69	170,202		R_21 L_3	5/9/2023	31,38473	0,22856	0,02209	0,06384	0,02810	0,16626	0,42892	0,87705	0,62199	0,69529	0,6
Israel	omegranat	Y	2007	Tsor'a	2023	Y1	629691,71	95891,36	173,102		R_3 L_6	6/21/2023	39,77960	0,28242	0,01940	0,05482	0,02239	0,14500	0,32362	0,85361	0,51807	0,56360	0,5
Israel	omegranat	Y	2007	Tsor'a	2023	Y2	629713,46	95780,81	171,436		R_3 L_34	6/21/2023	35,64154	0,19513	0,01807	0,05190	0,02185	0,13604	0,30618	0,84882	0,49876	0,53566	0,5
Israel	omegranat	Y	2007	Tsor'a	2023	Y3	629669,10	95882,70	172,848		R_7 L_7	6/21/2023	38,62161	0,25799	0,02292	0,05880	0,02805	0,14558	0,30545	0,82079	0,48615	0,52463	0,4
Israel	omegranat	Y	2007	Tsor'a	2023	Y4	629682,83	95811,74	171,826		R_37 L_25	6/21/2023	39,50199	0,27656	0,02274	0,06086	0,02766	0,15036	0,32365	0,83985	0,51001	0,55440	0,5
Israel	omegranat	Y	2007	Tsor'a	2023	Y5	629665,73	95773,88	170,952		R_11 L_34	6/21/2023	36,29359	0,20889	0,02839	0,06754	0,03636	0,15208	0,30265	0,77362	0,46216	0,50806	0,4
Israel	omegranat	Y	2007	Tsor'a	2023	Y6	629634,58	95808,47	171,299		R_15 L_24	6/21/2023	34,63067	0,17381	0,02470	0,06155	0,02840	0,14414	0,29888	0,80244	0,47220	0,51584	0,4
Israel	omegranat	BK	2007	Tsor'a	2023	BK1	629699,24	95851,89	172,829		R_3 L_16	6/21/2023	40,08910	0,28894	0,02587	0,06254	0,03158	0,14958	0,30341	0,78954	0,47051	0,51156	0,4
Israel	omegranat	BK	2007	Tsor'a	2023	BK2	629675,48	95847,49	172,697		R_7 L_16	6/21/2023	41,81913	0,32544	0,02589	0,06257	0,03254	0,15085	0,32348	0,81189	0,50016	0,54450	0,5
Israel	omegranat	BK	2007	Tsor'a	2023	BK3	629645,4	95879,36	172,521		R_11 L_16	6/21/2023											
Israel	omegranat	BK	2007	Tsor'a	2023	BK4	629659,20	95808,74	171,611		R_11 L_2	6/21/2023	39,66497	0,28000	0,02554	0,06193	0,03302	0,14435	0,29960	0,78821	0,46868	0,50478	0,4

Field Yearly Information | DataStructureMonthly | Field Monthly measurements | DataStructureSensorDaily | Sensor daily measurement | DataStructureRemoteSens | Remote Sensing data

Figure 3. Example of the structured dataset submitted for pomegranate orchards (2023-2024) from Israel, following the standardized CrackSense data model for the tree-plot model.

In addition to the processed datasets uploaded to the CrackSense FST database, raw data files from TOMMY system (from WP2) have also been made available.

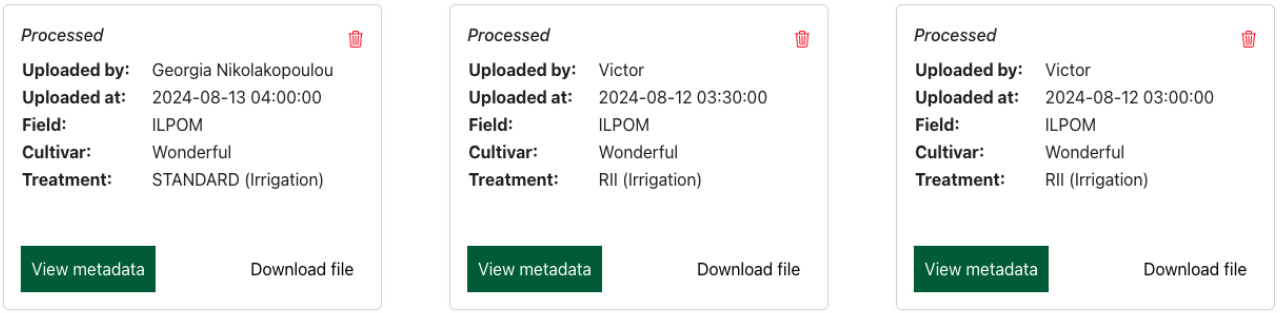


Figure 4. Example of raw data entries uploaded to the CrackSense central repository for pomegranate orchards in Israel

3.3.2.2 Greece

Field constant information was fully provided. Yearly data included soil composition for both 2023 and 2024, with partial yield data available for 2023 and complete yield data collected in 2024. Monthly measurements included stem water potential (SWP) on specific dates in both years, while stomatal conductance was also recorded in 2024. Leaf and peel mineral content was not assessed during either season.

For daily monitoring, trunk and fruit growth were recorded three times during the 2023 season and once per month from June to October in 2024, along with soil moisture data. Meteorological data were captured daily, without interruption, across both cultivation years. In terms of remote sensing, vegetation indices (VIs) were derived for all UAV flight dates, whereas LiDAR data were not collected.

Countr	Species	Treatm	Year of Plantin	Site	Study year	TreeID	TreeIDLon	TreeIDLat	Elevetion	Variance Zo	Row and Line	Flighti date	Phenological s
Greece	Pomegranate	High irriga	2019	Dalamana	2023	1	2.278.966.277	3.765.007.436	57.103		R_1 L_2	11/09/2023	2
Greece	Pomegranate	High irriga	2019	Dalamana	2023	2	2.278.942.100	3.765.002.070	56.983		R_3 L_2	11/09/2023	2
Greece	Pomegranate	High irriga	2019	Dalamana	2023	3	2.278.917.398	3.764.995.747	56.950		R_5 L_2	11/09/2023	2
Greece	Pomegranate	Standard i	2019	Dalamana	2023	4	2.278.920.878	3.764.989.481	56.911		R_5 L_5	11/09/2023	2
Greece	Pomegranate	Standard i	2019	Dalamana	2023	5	2.278.945.077	3.764.994.568	57.009		R_3 L_5	11/09/2023	2
Greece	Pomegranate	Standard i	2019	Dalamana	2023	6	2.278.969.883	3.765.000.095	57.086		R_1 L_5	11/09/2023	2
Greece	Pomegranate	Low irrigat	2019	Dalamana	2023	7	2.278.978.709	3.764.990.129	57.093		R_1 L_8	11/09/2023	2
Greece	Pomegranate	Low irrigat	2019	Dalamana	2023	8	2.278.954.123	3.764.985.489	57.051		R_3 L_8	11/09/2023	2
Greece	Pomegranate	Low irrigat	2019	Dalamana	2023	9	2.278.936.854	3.764.981.449	56.920		R_5 L_8	11/09/2023	2
Greece	Pomegranate	High irriga	2019	Dalamana	2023	1	2.278.966.277	3.765.007.436	57.103		R_1 L_2	13/10/2023	3
Greece	Pomegranate	High irriga	2019	Dalamana	2023	2	2.278.942.100	3.765.002.070	56.983		R_3 L_2	13/10/2023	3
Greece	Pomegranate	High irriga	2019	Dalamana	2023	3	2.278.917.398	3.764.995.747	56.950		R_5 L_2	13/10/2023	3
Greece	Pomegranate	Standard i	2019	Dalamana	2023	4	2.278.920.878	3.764.989.481	56.911		R_5 L_5	13/10/2023	3
Greece	Pomegranate	Standard i	2019	Dalamana	2023	5	2.278.945.077	3.764.994.568	57.009		R_3 L_5	13/10/2023	3
Greece	Pomegranate	Standard i	2019	Dalamana	2023	6	2.278.969.883	3.765.000.095	57.086		R_1 L_5	13/10/2023	3
Greece	Pomegranate	Low irrigat	2019	Dalamana	2023	7	2.278.978.709	3.764.990.129	57.093		R_1 L_8	13/10/2023	3
Greece	Pomegranate	Low irrigat	2019	Dalamana	2023	8	2.278.954.123	3.764.985.489	57.051		R_3 L_8	13/10/2023	3
Greece	Pomegranate	Low irrigat	2019	Dalamana	2023	9	2.278.936.854	3.764.981.449	56.920		R_5 L_8	13/10/2023	3
Greece	Pomegranate	High irriga	2019	Dalamana	2023	1	2.278.966.277	3.765.007.436	57.103		R_1 L_2	01/11/2023	4
Greece	Pomegranate	High irriga	2019	Dalamana	2023	2	2.278.942.100	3.765.002.070	56.983		R_3 L_2	01/11/2023	4
Greece	Pomegranate	High irriga	2019	Dalamana	2023	3	2.278.917.398	3.764.995.747	56.950		R_5 L_2	01/11/2023	4
Greece	Pomegranate	Standard i	2019	Dalamana	2023	4	2.278.920.878	3.764.989.481	56.911		R_5 L_5	01/11/2023	4
Greece	Pomegranate	Standard i	2019	Dalamana	2023	5	2.278.945.077	3.764.994.568	57.009		R_3 L_5	01/11/2023	4
Greece	Pomegranate	Standard i	2019	Dalamana	2023	6	2.278.969.883	3.765.000.095	57.086		R_1 L_5	01/11/2023	4
Greece	Pomegranate	Low irrigat	2019	Dalamana	2023	7	2.278.978.709	3.764.990.129	57.093		R_1 L_8	01/11/2023	4
Greece	Pomegranate	Low irrigat	2019	Dalamana	2023	8	2.278.954.123	3.764.985.489	57.051		R_3 L_8	01/11/2023	4
Greece	Pomegranate	Low irrigat	2019	Dalamana	2023	9	2.278.936.854	3.764.981.449	56.920		R_5 L_8	01/11/2023	4
Greece	Pomegranate	High irriga	2019	Dalamana	2024	2	2.278.942.100	3.765.002.070	56.983		R_3 L_2	14/06/2024	1
Greece	Pomegranate	High irriga	2019	Dalamana	2024	6	2.278.920.878	3.764.989.481	56.911		R_5 L_5	14/06/2024	1
Greece	Pomegranate	High irriga	2019	Dalamana	2024	7	2.278.978.709	3.764.990.129	57.093		R_1 L_8	14/06/2024	1
Greece	Pomegranate	Standard i	2019	Dalamana	2024	1	2.278.966.277	3.765.007.436	57.103		R_1 L_2	14/06/2024	1
Greece	Pomegranate	Standard i	2019	Dalamana	2024	5	2.278.945.077	3.764.994.568	57.009		R_3 L_5	14/06/2024	1
Greece	Pomegranate	Standard i	2019	Dalamana	2024	9	2.278.936.854	3.764.981.449	56.920		R_5 L_8	14/06/2024	1
Greece	Pomegranate	Low irrigat	2019	Dalamana	2024	3	2.278.917.398	3.764.995.747	56.950		R_5 L_2	14/06/2024	1
Greece	Pomegranate	Low irrigat	2019	Dalamana	2024	4	2.278.969.883	3.765.000.095	57.086		R_1 L_5	14/06/2024	1

Figure 5. Example of the structured dataset submitted for pomegranate orchards (2023-2024) from Greece, following the standardized CrackSense data model for the tree-plot model.

In addition to the processed datasets uploaded to the CrackSense FST database, raw data files from the TOMMY system (from WP2) have also been made available.

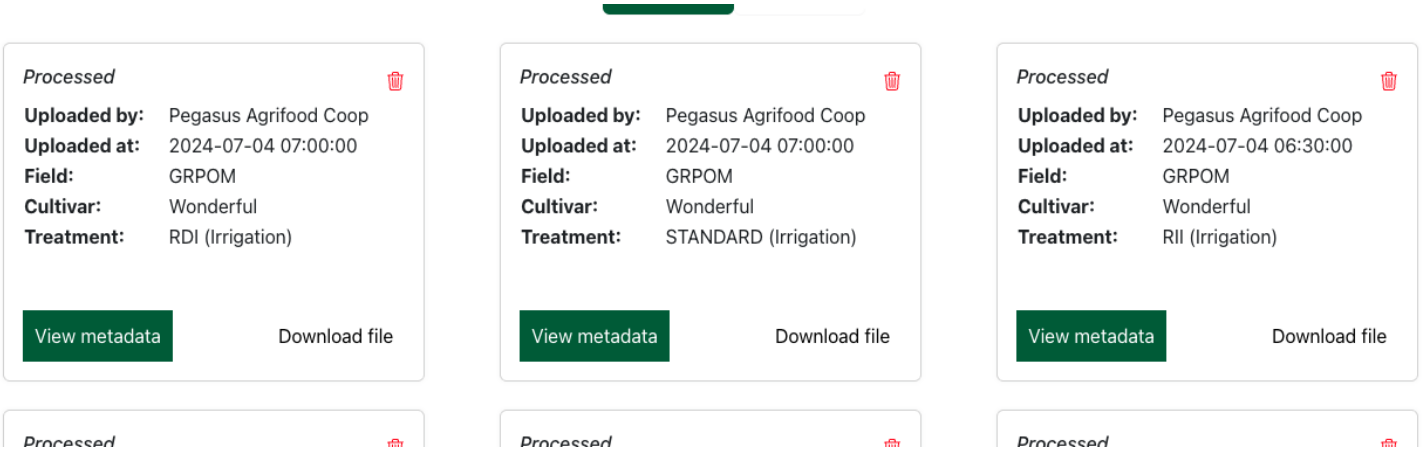


Figure 6. Example of raw data entries uploaded to the CrackSense central repository for pomegranate orchards in Greece

3.3.3 Grape

3.3.3.1 Israel

Constant field information was fully reported. Soil composition, hormone treatment, and yield data are available for both 2023 and 2024. Stem water potential (SWP) measurements began in May 2023, and stomatal conductance was monitored from June 2023; both were recorded monthly until September 2024. Fruit-related measurements, including berry weight, total soluble solids (TSS), and additional traits, were collected monthly from July to September during both years. Daily measurements include maximum daily shrinkage (MDS) and trunk growth from January 2023 to October 2024, as well as soil moisture monitoring from January 2023 to November 2024. Fruit growth was also measured daily for most of 2023 and during selected months in 2024. Meteorological data were recorded daily and continuously across both years.

Countr	Specie	Treatm	Year of Plantin	Site	Study	TreeID	TreeIDLoi	TreeIDLat	Elevetio	Varianc	Row a	Flight date
Israel	vine	Black	2012	Lachish	2023	Black1_E	605696,431	182763,962	237,085		4	10.5.23
Israel	vine	Black	2012	Lachish	2023	Black1_W	605695,793	182762,122	237,156		4	10.5.23
Israel	vine	Black	2012	Lachish	2023	Black2_E	605663,623	182728,646	237,1		10	10.5.23
Israel	vine	Black	2012	Lachish	2023	Black2_W	605663,088	182726,864	237,053		10	10.5.23
Israel	vine	Black	2012	Lachish	2023	Black3_E	605659,76	182752,249	237,984		13	10.5.23
Israel	vine	Black	2012	Lachish	2023	Black3_W	605659,209	182750,296	237,876		13	10.5.23
Israel	vine	Black	2012	Lachish	2023	Black4_E	605644,643	182775,872	238,859		19	10.5.23
Israel	vine	Black	2012	Lachish	2023	Black4_W	605644,009	182773,795	238,839		19	10.5.23
Israel	vine	Black	2012	Lachish	2023	Black5_E	605618,502	182761,927	238,596		25	10.5.23
Israel	vine	Black	2012	Lachish	2023	Black5_W	605617,771	182759,637	238,47		25	10.5.23
Israel	vine	Blue	2012	Lachish	2023	Blue1_E	605680,023	182747,23	237,25		7	10.5.23
Israel	vine	Blue	2012	Lachish	2023	Blue1_W	605679,711	182745,247	237,441		7	10.5.23
Israel	vine	Blue	2012	Lachish	2023	Blue2_E	605654,062	182733,045	237,34		13	10.5.23
Israel	vine	Blue	2012	Lachish	2023	Blue2_W	605653,13	182730,912	237,253		13	10.5.23
Israel	vine	Blue	2012	Lachish	2023	Blue3_E	605655,135	182773,141	238,496		16	10.5.23
Israel	vine	Blue	2012	Lachish	2023	Blue3_W	605654,469	182771,453	238,532		16	10.5.23
Israel	vine	Blue	2012	Lachish	2023	Blue4_E	605628,599	182758,712	238,546		22	10.5.23
Israel	vine	Blue	2012	Lachish	2023	Blue4_W	605627,961	182757,159	238,477		22	10.5.23
Israel	vine	Blue	2012	Lachish	2023	Blue5_E	605608,75	182763,952	238,541		28	10.5.23
Israel	vine	Blue	2012	Lachish	2023	Blue5_W	605608,071	182762,094	238,454		28	10.5.23
Israel	vine	Green	2012	Lachish	2023	Green1_E	605674,545	182728,181	237,068		7	10.5.23
Israel	vine	Green	2012	Lachish	2023	Green1_W	605674,206	182726,435	236,868		7	10.5.23
Israel	vine	Green	2012	Lachish	2023	Green2_E	605675,705	182768,331	237,719		10	10.5.23
Israel	vine	Green	2012	Lachish	2023	Green2_W	605675,366	182766,861	237,703		10	10.5.23
Israel	vine	Green	2012	Lachish	2023	Green3_E	605649,176	182753,707	238,227		16	10.5.23
Israel	vine	Green	2012	Lachish	2023	Green3_W	605648,684	182751,875	238,151		16	10.5.23
Israel	vine	Green	2012	Lachish	2023	Green4_E	605622,736	182739,805	237,508		22	10.5.23
Israel	vine	Green	2012	Lachish	2023	Green4_W	605622,387	182738,044	237,373		22	10.5.23
Israel	vine	Green	2012	Lachish	2023	Green5_E	605614,659	182783,076	239,446		28	10.5.23
Israel	vine	Green	2012	Lachish	2023	Green5_W	605614,088	182781,43	239,431		28	10.5.23
Israel	vine	White	2012	Lachish	2023	White1_E	605690,474	182744,941	237,204		4	10.5.23
Israel	vine	White	2012	Lachish	2023	White1_W	605689,656	182742,785	237,213		4	10.5.23
Israel	vine	White	2012	Lachish	2023	White2_E	605685,403	182766,15	237,344		7	10.5.23

Data structure | DataStructureConstant | Constant information | DataStructureYearly | Field Yearly Information | DataStruc

Figure 7. Example of the structured dataset submitted for vineyards (2023-2024) from Israel, following the standardized CrackSense data model for the tree-plot model.

3.3.3.2 Greece

Constant information on the field is available. Soil composition, hormonal applications, and yield is available for both 2023 and 2024. In 2023, stem water potential (SWP) and berry weight were measured in August and September, while in 2024 these parameters were recorded once per critical phenological stage. Stomatal conductance was not measured in either year. Daily meteorological data are available for both years, but no soil moisture and a few trunk growth data were collected in 2023. In 2024, soil and trunk measurements were taken once per critical phenological stage. No fruit size data are available for either year. Remote sensing data includes vegetation index values for all flight dates in both years.

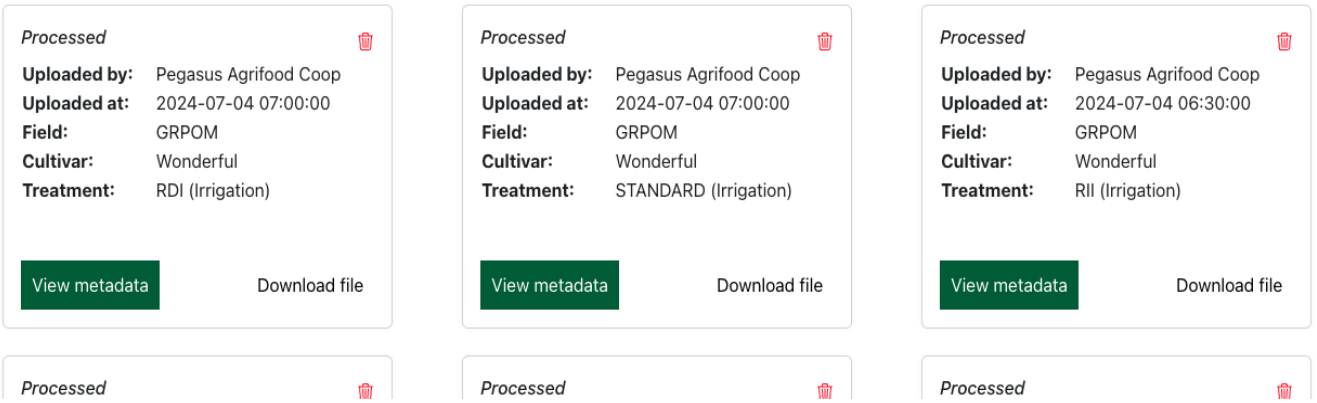


Figure 8. Example of raw data entries uploaded to the CrackSense central repository for table grape vineyards in Greece

In addition to the processed datasets uploaded to the CrackSense FST database, raw data files from the TOMMY system (from WP2) have also been made available.

3.3.4 Sweet cherry

3.3.4.1 Germany

For the 2024 cultivation season, the German pilot site reported a comprehensive dataset for sweet cherry monitoring. Constant field information was fully provided, including treatment type, year of planting, site

characteristics, and rootstock details. Yearly measurements included yield data and soil composition, covering all necessary parameters to support crack prediction modelling. No hormonal treatments were reported for this year. At the monthly level, detailed physiological measurements were collected. These included the SWP measured across several key phenological stages. Additional data on leaf mineral composition was also included, providing a robust physiological profile of the monitored trees. Daily sensor-based measurements included meteorological data, soil moisture, and trunk and fruit growth dynamics, enabling high-resolution monitoring throughout the season. Remote sensing data, including vegetation indices, were reported for all relevant drone flight dates. These datasets provide essential spatial and temporal insights for model development.

Counti	Species	Treatm	Year of Plantir	Site	Study year	TreeID	TreeIDLon	TreeIDLat	Elevation	Cultivar	Row and Line	Analysis da	Phenological st	SWP	Std SWP
Germany	sweet cherry	cultivars	2011	Muenchel	2024					mean	mean	11/26/2024			
Germany	sweet cherry	cultivars	2011	Muenchel	2024					mean	mean	3/11/2024			
Germany	sweet cherry	cultivars	2011	Muenchel	2023					mean	mean	3/20/2023			
Germany	sweet cherry	cultivars	2011	Muenchel	2025					mean	mean	3/20/2025			
Germany	sweet cherry	cultivars	2011	Muenchel	2024	R8_T4	52.5225909133	14.1288614066	62.809	Kordia	R8 T4	6/4/2024	mid stage III	-1,4	0,2
Germany	sweet cherry	cultivars	2011	Muenchel	2024	R8_T5	52.5225680033	14.12888265	62.857	Kordia	R8 T5	6/4/2024	mid stage III	-1,1	0,1
Germany	sweet cherry	cultivars	2011	Muenchel	2024	R8_T6	52.5225500483	14.1288987433	62.910	Kordia	R8 T6	6/4/2024	mid stage III	-1,1	0,1
Germany	sweet cherry	cultivars	2011	Muenchel	2024	R8_T7	52.52253149	14.128918915	62.950	Kordia	R8 T7	6/4/2024	mid stage III	-1,1	0,2
Germany	sweet cherry	cultivars	2011	Muenchel	2024	R8_T4	52.5225909133	14.1288614066	62.809	Kordia	R8 T4	6/11/2024	mid stage III	-1,1	0,2
Germany	sweet cherry	cultivars	2011	Muenchel	2024	R8_T5	52.5225680033	14.12888265	62.857	Kordia	R8 T5	6/11/2024	mid stage III	-0,7	0,1
Germany	sweet cherry	cultivars	2011	Muenchel	2024	R8_T6	52.5225500483	14.1288987433	62.910	Kordia	R8 T6	6/11/2024	mid stage III	-0,7	0,0
Germany	sweet cherry	cultivars	2011	Muenchel	2024	R8_T7	52.52253149	14.128918915	62.950	Kordia	R8 T7	6/11/2024	mid stage III	-0,6	0,1
Germany	sweet cherry	cultivars	2011	Muenchel	2024	R8_T4	52.5225909133	14.1288614066	62.809	Kordia	R8 T4	6/18/2024	maturity	-1,5	0,1
Germany	sweet cherry	cultivars	2011	Muenchel	2024	R8_T5	52.5225680033	14.12888265	62.857	Kordia	R8 T5	6/18/2024	maturity	-1,1	0,1
Germany	sweet cherry	cultivars	2011	Muenchel	2024	R8_T6	52.5225500483	14.1288987433	62.910	Kordia	R8 T6	6/18/2024	maturity	-1,2	0,1
Germany	sweet cherry	cultivars	2011	Muenchel	2024	R8_T7	52.52253149	14.128918915	62.950	Kordia	R8 T7	6/18/2024	maturity	-1,2	0,1
Germany	sweet cherry	cultivars	2011	Muenchel	2025	R8_T4	52.5225909133	14.1288614066	62.809	Kordia	R8 T4	6/6/2025	early stage III	-1,4	0,0
Germany	sweet cherry	cultivars	2011	Muenchel	2025	R8_T5	52.5225680033	14.12888265	62.857	Kordia	R8 T5	6/6/2025	early stage III	-1,3	0,2
Germany	sweet cherry	cultivars	2011	Muenchel	2025	R8_T6	52.5225500483	14.1288987433	62.910	Kordia	R8 T6	6/6/2025	early stage III	-1,2	0,1
Germany	sweet cherry	cultivars	2011	Muenchel	2025	R8_T7	52.52253149	14.128918915	62.950	Kordia	R8 T7	6/6/2025	early stage III	-1,3	0,1
Germany	sweet cherry	cultivars	2011	Muenchel	2025	R8_T4	52.5225909133	14.1288614066	62.809	Kordia	R8 T4	6/13/2025	mid stage III	-1,5	0,1
Germany	sweet cherry	cultivars	2011	Muenchel	2025	R8_T5	52.5225680033	14.12888265	62.857	Kordia	R8 T5	6/13/2025	mid stage III	-1,2	0,0
Germany	sweet cherry	cultivars	2011	Muenchel	2025	R8_T6	52.5225500483	14.1288987433	62.910	Kordia	R8 T6	6/13/2025	mid stage III	-1,4	0,1
Germany	sweet cherry	cultivars	2011	Muenchel	2025	R8_T7	52.52253149	14.128918915	62.950	Kordia	R8 T7	6/13/2025	mid stage III	-1,3	0,0
Germany	sweet cherry	cultivars	2011	Muenchel	2025	R8_T4	52.5225909133	14.1288614066	62.809	Kordia	R8 T4	6/20/2025	mid stage III	-1,5	0,0
Germany	sweet cherry	cultivars	2011	Muenchel	2025	R8_T5	52.5225680033	14.12888265	62.857	Kordia	R8 T5	6/20/2025	mid stage III	-1,3	0,1
Germany	sweet cherry	cultivars	2011	Muenchel	2025	R8_T6	52.5225500483	14.1288987433	62.910	Kordia	R8 T6	6/20/2025	mid stage III	-1,2	0,1
Germany	sweet cherry	cultivars	2011	Muenchel	2025	R8_T7	52.52253149	14.128918915	62.950	Kordia	R8 T7	6/20/2025	mid stage III	-1,3	0,1
Germany	sweet cherry	cultivars	2011	Muenchel	2025	R8_T4	52.5225909133	14.1288614066	62.809	Kordia	R8 T4	6/27/2025	maturity	-1,4	0,1
Germany	sweet cherry	cultivars	2011	Muenchel	2025	R8_T5	52.5225680033	14.12888265	62.857	Kordia	R8 T5	6/27/2025	maturity	-1,3	0,1
Germany	sweet cherry	cultivars	2011	Muenchel	2025	R8_T6	52.5225500483	14.1288987433	62.910	Kordia	R8 T6	6/27/2025	maturity	-1,4	0,0

DataStructureConstant | Constant information | DataStructureYearly | Field Yearly Information | DataStructureMonthly | Field Monthly measurements | Data

Figure 9. Example of the structured dataset submitted for sweet cherry (2023-2024) from Germany, following the standardized CrackSense data model for the tree-plot model.

3.3.4.2 France

Data was collected only in 2024. Field information is available. Yearly yield and splitting data were recorded in May and June. Stem water potential (SWP) was measured across phenological stages I-III, while stomatal conductance and leaf and peel mineral analyses were not performed. Daily meteorological data are available from April to June, but no soil moisture, trunk growth, or fruit measurements were collected. Remote sensing data, including vegetation indices and LiDAR measurements, are available for all flight dates, although LiDAR-derived PAI data are missing.

In addition to the processed datasets uploaded to the CrackSense FST database, raw data files from TOMMY system (from WP2) have also been made available.

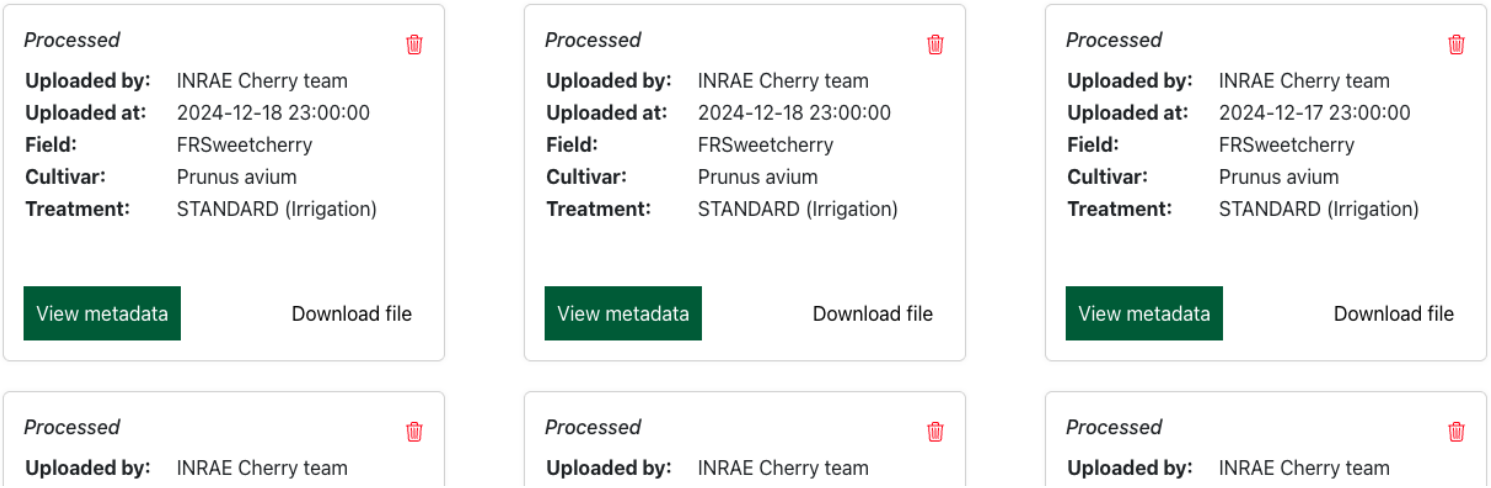


Figure 10. Example of raw data entries uploaded to the CrackSense central repository for sweet cherry orchards in France

3.3.4.3 Lithuania

Only data from the TOMMY system (WP2) were collected in Lithuania, focusing on high-resolution fruit surface temperature monitoring. The raw data files have been uploaded and are accessible via the CrackSense FST database.

3.5 Historical data for regional-scale models

To support the development of region-scale models for cracking prediction, historical data from different regions in Israel, Greece, France, Lithuania, and Germany have been gathered using a harmonized structure (Table 8). This dataset includes static information such as plot identifiers, species, geographic location, and soil characteristics, as well as yearly agricultural practices, yield records, and field observations related to cracking. The standardized templates have been used to ensure consistency across crops, pedoclimatic conditions, and field conditions, enabling robust AI-based model training for spatial prediction at regional levels. The data were collected retrospectively from commercial orchards, covering diverse management regimes and environmental settings. This comprehensive historical dataset will serve as a foundational layer for training the region-wide Spatial Decision Support System (SDSS) models under WP4.

Table 9. Structure of the historical data template used to collect plot-level information for regional-scale cracking prediction models across partner countries.

	Feature name	Description	Example values
constant	PlotID	specific location of a plot based on shape file, the plot ID is pointing to a row of relevant information on the plot within the shape file. PlotID together with Longtitude/ Latitude of plot center will allow to validate information and location of plot.	-
	Plot Shape File	The name of shape file to extract plot coordinates	country_orchards.shp shape file comes together with several supporting files (cpg, dbf, prj, shx): country_orchards.cpg, country_orchards..dbf, country_orchards..prj, country_orchards..shx
	PlotID Column Name	identification of PlotID within the shape file table	-
	CRS	Coordinate Reference System of shape file. should be constant and align to project standard: WGS84 (EPSG:4326)	EPSG:4326
	Country	Country name	-
	Plot_long	center location of the plot longtitude in global standard (CRS=EPSG:4326)	34.61884752
	Plot_lati	center location of the plot latidude in global standard (CRS=EPSG:4326)	31.48555794
	Location	Description of the plot location as an aid to locate the plot area on the country map	Eastern to the Beit Eliezer neighborhood
	Species	-	Citrus, Sweet Cheries, Grapes, Pomegranates
	Cultivar	-	
	Year of planting, year of changed planting	Both are considered to produce the plot trees' age. Changed planting is when a farmer decides to uproot all field and replant it. In this case, the latter is taken	1990 etc.
	Rootstock	Trees are built with scion grafting operations on different rootstocks.	Sour orange, Volka etc.
	Soil texture	Soil texture estimated by farmers into classes	Heavy, Medium, Light, and combinations like Light-Medium
	Clay [%]	The actual precentage of clay in the soil, supporting information that can be converted to level of High, Medium or Low	20, 14.3
	Water	Type of water used to irrigate the field, supporting information that can be converted to watering categories like Fresh or Reclaimed water	Fresh, Reclaimed, Well, Dam Fresh=Dam, can stay as informative, should converted to Fresh before used in models
	P water	Purification treatment level of wastewater (reclaimed type) used for irrigation, the higher the level, the more purified water gets	Primary, Secondary, Tertiary, or None when water is not wastewater
Irrigation technique	Gravity irrigation	Irrigated orchard (yes/ no)	Yes or no
	Localised irrigation	type of irrigation system/ technique used	drip, micro-sprinkler
Yearly data	Data source	Survey plots as exact collected data, versus Farmer plots as answered by farmers	S or F
	Year of the data collection	the year of observation (hydrological year from October to September)	2018-2019
Watering	Watering frequency	According to the farmer report, the weekly frequency irrigated during the season, ordinal values according to the frequency.	2, 3, 3-4
	Watering frequency period	to allow entering watering of twice a month, or once a week.	weekly, monthly
	Watering period	Period of watering in months range e.g. July-September	7-9
	Water to Ha/ year	Amount of water irrigated per Hectare	In mm Liters = mm X 10,000 (Area of Ha in m2)
	Product	Name of Product	Gibberellin, NAA, DP, MAX, etc.
	Concentration	concentration percentage	5, 10
	Timing	Which month treatment was applied e.g. March, June	3, 6
	Number of applications	How many times the treatment is applied	2, 5
Girdling/Pruning	Girdling	Yes or no	1, 0
	Pruning	Yes or no	1, 0

	Pruning timing	Pruning done in which season	1- spring, 2- summer, 3-fall, 4- winter
Yield/Splitting	Yield to Hac (for each specfic plot)	Yield by Hac	In Tons
	Estimated percentage of cracking per plot	By estimating the number of cracked fruit on the ground per estimated yield based on a monthly visit in the plot	%
	Timing of main cracking event	During which visit (month) there was the highest number of cracked fruits on the ground, e.g. July	7
	Fruit size	Fruit size influences susceptibility to cracking, the average fruit size should be entered	Average size (mm)
	Rainfall	Amount of rain during cracking period (between veraison and harvest for grapes) when possible provide full season rainfall monthly (mm)	Volume in millimetres (mm)

3.5.1 Israel

3.5.1.1 Citrus

Israel's citrus historical dataset includes data from over **500 plots** collected between 2018 and 2021 through a combination of field assessments by the research team and structured farmer surveys. For the 2023 and 2025 seasons, additional data were gathered from a few dozen surveyed plots, respectively, along with approximately **202 plots (2023)** and **190 plots (2024)** from broader farmer surveys. Additionally, we surveyed 35 and 45 plots in 2023 and 2024, respectively. The historical dataset focuses on the 'Nova' and 'Or' cultivars and includes detailed plot-level information such as year of planting or replanting, rootstock, planting density, and soil texture. Water availability parameters include purification type and irrigation techniques. Yearly records, available for a subset of plots, include the source and year of data collection, watering frequency and timing, and total irrigation volume per hectare. Agronomic practices such as girdling and pruning (including timing) are also recorded. Furthermore, the application of growth regulators (e.g., GA, NAA, DP, MAX), yield per hectare (tons/ha), and estimated fruit cracking percentage are documented. These parameters collectively support the calibration of regional-scale predictive models for fruit cracking by linking environmental and management data to productivity and cracking incidence outcomes.

3.5.1.2 Grapes

The historical dataset for table grapes in Israel includes data from **81 plots**, collected during a single growing season to capture baseline regional variability. In addition, data were gathered from **15** farmer-surveyed plots in 2023 and 25 plots in 2024, expanding the spatial and temporal coverage of the dataset.

The information collected includes key parameters such as year of planting, rootstock, planting density, irrigation method and frequency, water availability, and soil texture. Agronomic management practices, such as pruning schedules and the use of growth regulators, are also documented, along with yield estimates and fruit cracking occurrences when available. This dataset provides a valuable foundation for regional-scale modeling of cracking risk in grapes, supporting the development and validation of AI-driven Decision Support Systems tailored to local conditions.

3.5.1.3 Pomegranates

Regional data for pomegranate cultivation in Israel includes surveys from **80 farmer-managed plots in 2023** and an additional **80 plots in 2024**, ensuring continuity and regional representativeness across two consecutive seasons.

Each survey plot includes data on planting year, rootstock, planting density, soil texture and clay content, irrigation source and technique, water availability, and agronomic practices such as pruning and girdling. Where available, applications of growth regulators (e.g., GA, NAA) are also recorded. Yield estimates and fruit cracking incidence are documented to support risk analysis. This dataset enables the integration of environmental, physiological, and management factors into regional-scale predictive models for cracking,

contributing to the development of robust, location-aware SDSS tools.

3.5.2 France

3.5.2.1 Citrus

France's regional citrus dataset includes **26 plots** cultivated with triploid mandarin hybrids. For each plot, comprehensive agronomic and environmental information is available, including the year of planting or replanting, rootstock, planting density, soil texture, and clay content (%). Water-related parameters are thoroughly documented, including irrigation type (gravity or localized systems), water-purification level, watering frequency and periods, and total annual water volume applied per hectare. Management practices such as girdling, pruning, and pruning timing are also recorded. Yield data (tons/ha), estimated fruit cracking percentage and its dominant timing, and fruit size metrics are included for each plot. Additionally, rainfall values are captured, and each data point is referenced with the corresponding year and source. This dataset provides a detailed, structured view of citrus production conditions in France, supporting the development of spatially aware fruit cracking prediction models.

3.5.2.2 Sweet cherry

France's sweet cherry dataset is maintained by Ctifl and represents one of the largest long-term repositories in the project. It spans data from 1983 to the present, covering three major sites and including more than 25,000 entries. Of these, over 2,800 entries relate to sweet cherry varieties with at least 10 recorded observations each and data related to fruit cracking. Notably, six key cultivars are highly represented in the dataset, with between 79 and 275 data points per cultivar. The dataset includes comprehensive records on cultivar performance, agronomic practices, environmental conditions, and cracking occurrence. While the database forms a valuable basis for regional modeling and varietal-level risk analysis, it is currently under review and flagged for future upgrading and harmonization. In addition, more recent datasets from private companies may be available to complement or update existing records.

3.5.3 Greece

3.5.3.1. Grapes

The Greek regional dataset for table grapes includes **75 plots**, primarily planted with Thompson Seedless, along with a smaller number of Crimson grapevines. Historical data were collected in 2017 and 2018, with additional data from 75 farmer-surveyed plots in both 2023 and 2024, ensuring consistent coverage across seasons. For each plot, detailed information is available on geographic coordinates, planting and replanting year, soil type, and clay content (%), rootstock, planting density (trees/ha), and total plot area (ha). Water management parameters include total water applied, purification method (P water), year of reporting, and irrigation interval (days). Agronomic practices such as pruning timing, girdling, and use of hormonal treatments targeting berry size and coloration are also documented. Production data include yield per hectare (tons/ha), estimated percentage of fruit cracking, and the timing of main cracking events. This dataset provides a robust foundation for regional-scale modeling of cracking risk and yield variability in Greek table grape cultivation.

3.5.3.2 Pomegranate

The regional dataset for pomegranate cultivation in Greece comprises data from approximately **50 farmer-surveyed plots** in both 2023 and 2024. For each plot, the dataset includes precise field coordinates and coordinate system, cultivar, year of planting or replanting, soil type, clay content, rootstock, planting density (per stremma), and field size (in stremma). Irrigation details include the water source, level of wastewater treatment, reference year, irrigation frequency per week, and total annual irrigation volume per stremma (in liters). Agronomic practices such as applied hormonal treatments, pruning months, and bark girdling are recorded. Production-related data includes final marketed yield, potential yield per tree,

exportable yield, and local market yield. The dataset also captures the estimated percentage of cracked fruit, the months when cracking predominantly occurs, and any additional stress events or anomalies affecting crop development. This rich dataset supports the training and evaluation of regional-scale cracking prediction models tailored to Greek pomegranate production systems.

3.5.4 Lithuania

3.5.4.1 Sweet cherry

The Lithuanian dataset for sweet cherry includes historical data from 74 plots, primarily derived from ongoing varietal and management trials conducted between 2021 and 2022. These plots form the core of the national sweet cherry collection and provide detailed records on cultivar characteristics, agronomic practices, and observed cracking incidence. In addition to the historical dataset, 19 farmer-surveyed plots from the same years further expand the coverage of commercial orchard conditions. 17 farmer-surveyed plots were added in 2023 and another 17 plots in 2024, contributing supplementary data on commercial practices and field conditions. The year 2025 experienced very harsh climatic conditions, during which the majority of fruits froze, and only 5 plots were added to the collection that year. Collected parameters include planting year, cultivar, pruning and irrigation methods, fruit yield, and cracking percentage. Together, these datasets enhance regional-scale understanding of sweet cherry production in Lithuania and support the calibration of cracking-prediction models adapted to local climatic and agronomic conditions.

3.5.5 Germany

3.5.5.1 Sweet cherry

Germany contributed data from **5 farmer-surveyed sweet cherry plots,** providing insight into local production conditions and cracking incidence. For each plot, information includes cultivar, planting year, pruning practices, yield, and estimated percentage of fruit cracking. Although limited in number, these entries offer valuable real-farm observations to support the development of regional-scale cracking risk models and to complement larger experimental datasets from other countries.

4. New CrackSense database and functionalities

A new web-based database system was developed to enable the structured collection, management, and export of agronomic, physiological, sensor, and remote sensing data at the tree and plot levels. The database supports multi-year studies across different crops and countries and enables researchers to retrieve standardized datasets for further statistical analysis.

The system is implemented using modern web-based architecture, with Laravel as the backend framework, MariaDB as the relational database management system, and React as the frontend framework. A key feature of the system is the ability to export filtered datasets in CSV/Excel format, facilitating interoperability with external data analysis tools.

4.1 System Architecture and Data Flow

The application follows a three-tier architecture. The frontend, developed in React, provides an interactive user interface that enables users to filter and query datasets by predefined criteria. The Laravel backend handles these requests through RESTful API endpoints, where input validation and query logic are applied. The backend communicates with the MariaDB database, retrieves the relevant records, and returns structured data to the frontend. Finally, the same queried dataset can be exported as a CSV file for offline analysis. The standardized schema and tree-level linkage ensure data consistency across study years, locations, and measurement types, supporting both current analyses and future project extensions.

Each record in the database is associated with a unique Tree ID, which is automatically generated by the

system. This identifier ensures traceability across all data categories while reducing user input errors, since users do not need to enter it manually.

Access to the platform is restricted through a user authentication and authorization mechanism based on email and password credentials. User authentication is handled by the Laravel backend, which manages secure login sessions and ensures that only authorized users can access the database querying and export functions. This access control layer protects sensitive experimental and sensor data from unauthorized use and supports controlled data sharing among project collaborators. By enforcing authenticated access, the system ensures data integrity, accountability, and compliance with standard data management practices.

4.2 Database Schema and Stored Variables

4.2.1 General Metadata

General metadata is shared across all data categories and enables consistent identification and grouping of records. Each entry includes a system-generated Tree ID, crop species, country, optional variety, and study year. Supported crop types include table grape, pomegranate, citrus, and sweet cherry, each associated with specific countries.

4.2.2 Soil Data

Soil data are stored per Plot ID and study year and include both physical texture measurements and chemical properties. Soil texture is recorded at depths of 30 cm, 60 cm, and 90 cm, with sand, silt, and clay percentages stored for each depth. In addition, soil nutrient measurements include N, P, K, Mg, Ca, Na, B, and Cl.

4.2.3 Yield and Fruit Cracking Data

Yield-related data capture both total production and quality-related indicators. Stored variables include total weight, total fruit count, average fruit weight, and fruit cracking percentages, each calculated with and without statistical outliers. These measurements are associated with a specific study year.

4.2.4 Horticultural Measurements

Physiological data are linked to a study year and, where applicable, a specific date or phenological stage. Leaf and peel mineral content measurements include macro- and micronutrients such as N, P, K, Mg, Ca, B, Fe, Zn, Mn, and Cu. Water stress indicators include stem water potential (SWP), stomatal conductance, and their corresponding standard deviations. Plant area index (PAI) is also recorded.

4.2.5 Sensor Data

Sensor-derived data are stored with a study year and date and cover multiple measurement domains. Tree sensors record metrics such as maximum daily shrinkage (MDS), daily trunk growth, and accumulated growth. Fruit sensors include growth rates and accrued growth. Soil moisture sensors record volumetric water content at depths of 15 cm, 30 cm, 45 cm, and 60 cm. Weather sensors capture environmental conditions including air temperature, dew point, vapor pressure deficit (VPD), relative humidity, wind speed, air pressure, rainfall, and reference evapotranspiration (ET_o).

4.2.6 Remote Sensing Data

Remote sensing data are stored per study year and date and include vegetation indices such as NDVI, SAVI, EVI, MSAVI, GNDI, NDRE, IPVI, SIPI, OSAVI, CI, and DVI. Thermal indices include the crop water stress index (CWSI). Spectral band reflectance values and canopy structure metrics such as projected area, LiDAR-derived PAI, canopy area, and digital elevation model (DEM) values are also included.

4.2.7 Frontend Data Query and Export Interface

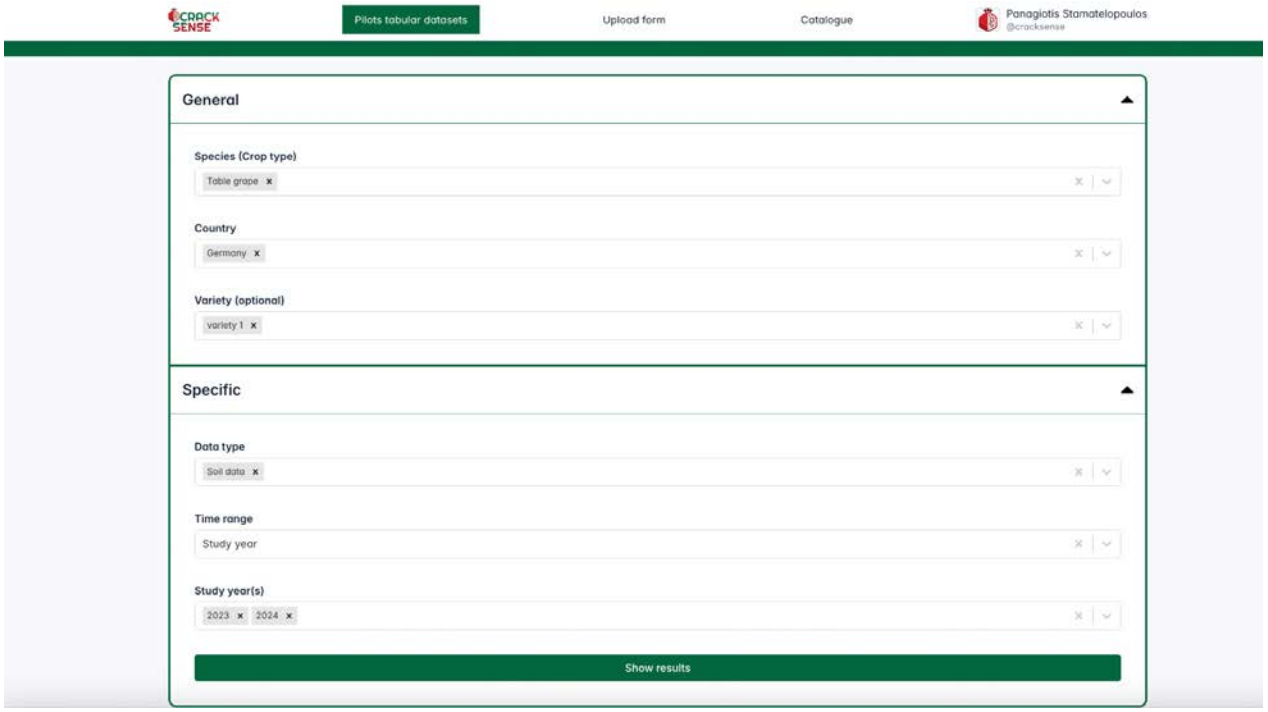
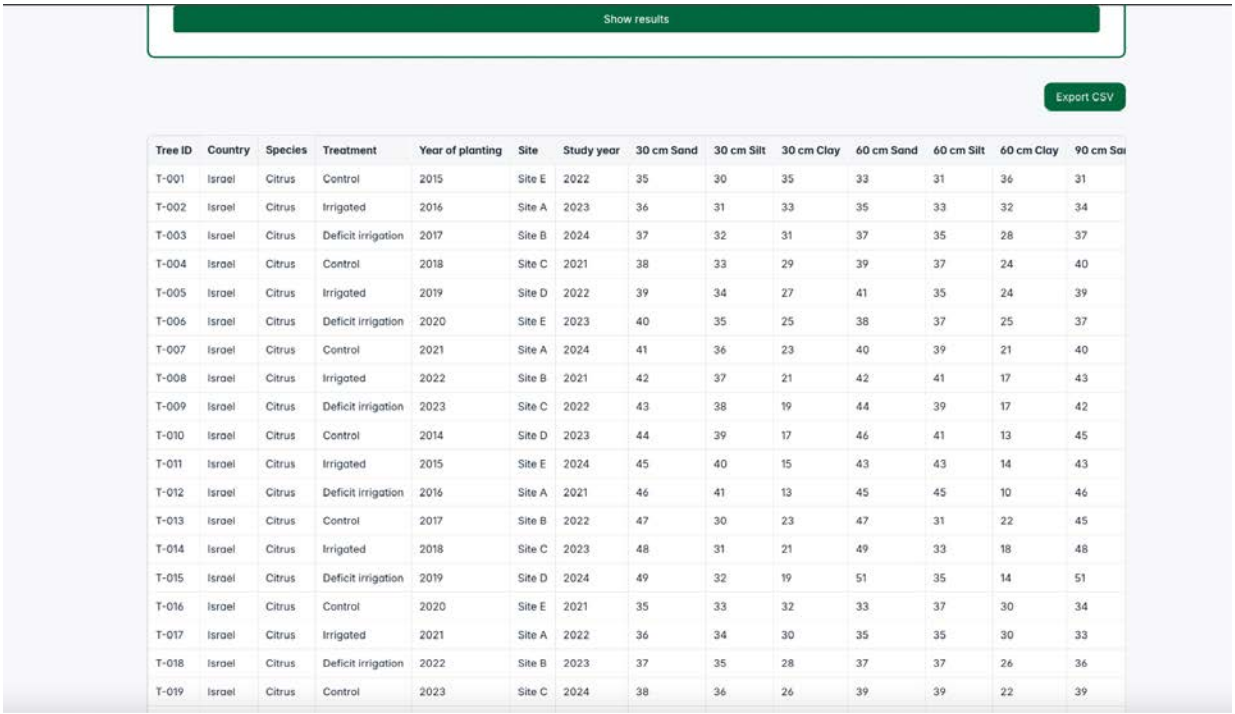


Figure 11. : React-based frontend interface allows users to filter datasets by species, country, variety, data type, and study year before querying the database.

The frontend interface allows users to define both general and specific query parameters. General metadata filters include crop species, country, and optional variety, while specific filters will enable the selection of data type and temporal range, such as study year. This design ensures that users retrieve only relevant subsets of data, reducing unnecessary data handling and improving usability.

Once the query parameters are defined, the results are displayed in a tabular format populated directly from the database.



Tree ID	Country	Species	Treatment	Year of planting	Site	Study year	30 cm Sand	30 cm Silt	30 cm Clay	60 cm Sand	60 cm Silt	60 cm Clay	90 cm Sa
T-001	Israel	Citrus	Control	2015	Site E	2022	35	30	35	33	31	36	31
T-002	Israel	Citrus	Irrigated	2016	Site A	2023	36	31	33	35	33	32	34
T-003	Israel	Citrus	Deficit irrigation	2017	Site B	2024	37	32	31	37	35	28	37
T-004	Israel	Citrus	Control	2018	Site C	2021	38	33	29	39	37	24	40
T-005	Israel	Citrus	Irrigated	2019	Site D	2022	39	34	27	41	35	24	39
T-006	Israel	Citrus	Deficit irrigation	2020	Site E	2023	40	35	25	38	37	25	37
T-007	Israel	Citrus	Control	2021	Site A	2024	41	36	23	40	39	21	40
T-008	Israel	Citrus	Irrigated	2022	Site B	2021	42	37	21	42	41	17	43
T-009	Israel	Citrus	Deficit irrigation	2023	Site C	2022	43	38	19	44	39	17	42
T-010	Israel	Citrus	Control	2014	Site D	2023	44	39	17	46	41	13	45
T-011	Israel	Citrus	Irrigated	2015	Site E	2024	45	40	15	43	43	14	43
T-012	Israel	Citrus	Deficit irrigation	2016	Site A	2021	46	41	13	45	45	10	46
T-013	Israel	Citrus	Control	2017	Site B	2022	47	30	23	47	31	22	45
T-014	Israel	Citrus	Irrigated	2018	Site C	2023	48	31	21	49	33	18	48
T-015	Israel	Citrus	Deficit irrigation	2019	Site D	2024	49	32	19	51	35	14	51
T-016	Israel	Citrus	Control	2020	Site E	2021	35	33	32	33	37	30	34
T-017	Israel	Citrus	Irrigated	2021	Site A	2022	36	34	30	35	35	30	33
T-018	Israel	Citrus	Deficit irrigation	2022	Site B	2023	37	35	28	37	37	26	36
T-019	Israel	Citrus	Control	2023	Site C	2024	38	36	26	39	39	22	39

Figure 12. Tabular visualization of retrieved soil data per Tree ID, including soil texture variables at multiple depths, with functionality to export the results as a CSV file.

The results table provides a structured view of tree-level data, including metadata and measured variables. An Export CSV function allows users to download the displayed dataset in an Excel-compatible format, ensuring consistency between the visualized and exported data.

5. Conclusions

During the second and third years of the CrackSense project, significant progress has been made in the collection, structuring, and centralization of data required for cracking prediction modelling. Comprehensive tree-, plot-, and regional-scale datasets were collected from all experimental and pilot crops and countries following a harmonized structure. These datasets capture physiological, environmental, agronomic, and remote sensing variables essential for modeling cracking incidence and yield variability. All cleaned and standardized datasets have been uploaded to the updated CrackSense database, which now supports advanced filtering and export functionalities to facilitate model training and decision support. Historical datasets from commercial and research plots were also gathered to support regional-level predictive modeling. The structured data collected and reported under this deliverable have already been used to develop AI-based models as described in D3.5. They will serve as a foundation for the operationalization of the Spatial Decision Support System (SDSS) in WP4. This deliverable ensures that the data backbone for AI-driven fruit cracking prediction is complete, interoperable, and accessible for further analysis and platform integration.