



DIVERSify: Designing InnoVative plant teams for Ecosystem Resilience and agricultural Sustainability

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Executive Summary

A list of agronomic, productivity, environmental and economic indicators and metrics has been collated for data gathering activities in Work Package 4 field validation trials. In consultation with both Work Package 4 Core Partners and other work package leads, each measure was assigned an importance level, for both Core Partners and Participatory Farmer data activities. These have been determined with consideration of what will be realistically achievable on a field scale, and in order to ensure that outcomes produced will be practical, relevant and of most benefit to the project. In order to ensure data quality and consistency, standard protocol documents for the measures have been produced, which will be shared with Core Partners and Participatory Farmers to use in trials.



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1. Introduction

In order to robustly assess plant team performance it is necessary to measure a variety of metrics. There is a wide range of such metrics and indices, and each indicator frequently has a number of ways in which pertinent data may be gathered. In order to determine best agronomic and agricultural practice when using plant teams on a geographically relevant scale, it is essential to assess plant traits and agronomic, productivity, environmental and economic indices in a standardised and synchronised manner, while still allowing sufficient geo-specificity to ensure relevance. These can supplement mechanistic information, providing a more complete picture of productivity and economic viability on a broad scale.

To ensure data quality and consistency across multiple Core Partner and Participatory Farmer sites, specific protocols for data gathering have been created for use on plant team validation platforms in Work Package 4. In this deliverable report, we describe the basic minimum data collection requirements determined for each group - Core Partners and Participatory Farmers – involved in gathering data, with reference to the Standard Protocol documents devised for each, to ensure that data gathering activities will produce outcomes that are practical, relevant and of most benefit to the project.

2. Implementation

2.1. Selection of measures for data gathering activities

In consultation with Work Package 4 Core Partners and other Work Package leads, a list of plant trait, agronomic and productivity indicators, environmental indicators, and economic viability assessment measures has been collated for data gathering activities in field validation trials (summarised in Table 1).

Each measure was designated as either ‘essential’ or ‘useful’, to indicate which measures would constitute the basic minimal data gathering requirements, and which would provide valuable additional data. Consideration was given during the preparation of the list regarding which measures would be practical to collect in the field, and which would be realistically achievable by Core Partners and Participatory Farmers. Frequency and timing of collection was also discussed and determined for basic minimum requirements. Thus, two diverging lists were produced to reflect the differences in expected detail and input.

In addition to the list of indicators described, a number of relevant Metadata items were identified as requiring collection as part of the data gathering and plant team validation process, but which would not require Standard Protocols to be produced for data gathering activities. A summary of some of the categories and nature of these Metadata are indicated in Table 2.





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Table 1. Plant team validation trial indicators selected for data gathering activities. ‘Essential’ measures indicate the basic minimum requirement for data collection, and ‘Useful’ measures indicate additional useful measures. Hatched lines in the Participatory Farmer columns indicate the measure will not be listed for collection in their protocol documents.

Measure	Core Partners		Participatory Farmers		Frequency and timing
	Essential	Useful	Essential	Useful	
<i>Agronomic and productivity indicators</i>					
Use of BBCH growth stages					At each collection point
Germination					Once – at BBCH G.S. 11
Establishment/survival					Once – at maturity
Days to maturation					Once – at maturation
Grain yield					Once – at harvest
Grain sale price					Once – at harvest/sale
Straw yield					Once – at harvest
Straw sale price					Once – at harvest/sale
Seed weight					Once – at harvest
Seed sale price					Once – at harvest/sale
Canopy height					Twice – at BBCH G.S. 30 and 70
Canopy closure					Twice – at BBCH G.S. 30 and 70
Number of tillers (grain)					Once – at BBCH G.S. 70
Number of heads (grain)					Once – at BBCH G.S. 70
Number of branches (legumes)					Once – at BBCH G.S. 80
Number of pods (legumes)					Once – at BBCH G.S. 80
Number of seeds per pod (legumes)					Once – at BBCH G.S. 80





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Vegetative biomass					Twice – at BBCH G.S. 30 and 70
Lodging					Once – at BBCH G.S. 60
Leaf area index					Once – at BBCH G.S. 40-50
Root biomass					Once – at BBCH G.S. 40-50
Plant growth habit					Once – at BBCH G.S. 40-50
Plant length					Once – at BBCH G.S. 40-50
Internode length					Once – at BBCH G.S. 40-50
Nitrogen content of leaves, non-destructive					Once – at BBCH G.S. 40-50
Nitrogen content of leaves, destructive					Once – at harvest
Nitrogen content of seed					Once – after harvest
Seed protein content					Once – after harvest
Seed starch content					Once – after harvest
Seed sugar content					Once – after harvest
<i>Environmental indices</i>					
Pest incidence					Once – at BBCH G.S. 60
Pest severity					Once – at BBCH G.S. 60
Arthropod diversity					Once – at BBCH G.S. 60
Arthropod abundance					Once – at BBCH G.S. 60
Herbivory					Once – at BBCH G.S. 60
Disease incidence					Once – at BBCH G.S. 60
Disease severity					Once – at BBCH G.S. 60
Weed ground cover					Once – at BBCH G.S. 60
Weed biomass					Once – at BBCH G.S. 60





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Weed species diversity					Once – at BBCH G.S. 60
Soil Nitrogen					Twice in each trial year – pre-sowing and post-harvest
Soil organic matter content					Twice in each trial year – pre-sowing and post-harvest
Soil chemical analyses					Twice in each trial year – pre-sowing and post-harvest
<i>Economic viability assessment measures</i>					
Price of seeds					Once for each seed type
Seeding rate					Once – at sowing
Seeding cost per hectare					Once for each seed type – at sowing
Fertiliser application rate					Once for each application
Price of fertiliser					Once for each application
Cost of fertiliser application per hectare					Once for each application
Pesticide type					Once for each application
Pesticide application rate					Once for each application
Price of pesticide					Once for each application
Cost of pesticide application per hectare					Once for each application
Type of energy consumed					Once for each energy type – at end of crop cycle
Energy consumption rate					Once for each energy type – at end of crop cycle
Energy unit price					Once for each energy type – at end of crop cycle
Cost of energy consumed per hectare					Once for each energy type – at end of crop cycle





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Water consumption (if irrigated)					Once – at end of crop cycle
Unit price of water (if irrigated)					Once – at end of crop cycle
Cost of water (if irrigated) per hectare					Once – at end of crop cycle
Labour – Operation type					For both household and hired labour, for each operation type.
Operation time per hectare					For both household and hired labour, for each operation type.
Labour cost per hour					For both household and hired labour, for each operation type.
Labour cost per hectare					For both household and hired labour, for each operation type.

Table 2. Examples of Metadata to be gathered from Core Partner and Participatory Farmer sites.

<i>Category</i>	<i>Examples of specific items</i>
Trial ID	<ul style="list-style-type: none"> • Trial ID – subjective indicator for reference and identification. • Year of trial. • Growing season.
Location of trial	<ul style="list-style-type: none"> • Country and region. • GPS coordinates.
Climate (in year of trial)	<ul style="list-style-type: none"> • Total annual precipitation. • Annual mean, minimum and maximum air temperatures.
Farming system	<ul style="list-style-type: none"> • Farm type (e.g. arable, horticultural, livestock). • Production system (conventional, organic, or integrated). • Tillage regime.
Soil characteristics	<ul style="list-style-type: none"> • Soil type and subtype. • Soil composition – clay, sand, gravel, silt and humus percentage contents.





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Plant team specifications	<ul style="list-style-type: none"> • Plant species tested. • Proportion of each species, seeding density. • End use of crop (e.g. food, silage, feed, etc.)
Additional inputs	<ul style="list-style-type: none"> • Inputs not specified in Economic Viability Assessment measures (see Table 1), e.g. types of mechanical weeding used.
Social factors	<ul style="list-style-type: none"> • Farm size. • Type of livestock (if applicable). • Number of livestock (if applicable).

2.2. Preparation of Standard Protocol documents

The first version of a series of standardised assessment protocols has been devised in Work Package 2 (final version is D18, due month 42), to synchronise data gathering activities and ensure data quality for use in plant trait trials in year 1 of the project within that work package. These were shared with Work Package 4 (document version 0.3), and have been used as a template during the preparation of the Standard Protocol documents for the field validation trials, in order to maximise cohesion of data gathered across the project as well as to ensure data quality. Key modifications were made to reflect practicalities of data gathering on a large-plot/semi-field scale for Core Partners, and simplified to be easily understandable by Participatory Farmers without a scientific background.

3. Output

A first version of a Standard Protocols document was prepared for Core Partners, and another was prepared for Participatory Farmers. Each document contains a detailed procedure used to collect data for the measures outlined in Table 1, depending on the participant type, and includes an Introduction to provide general information on data gathering activities. Protocols are colour-coded for ease of reference, both on each individual protocol page and within the contents page, to allow for easy identification of the basic minimum data gathering requirements and additional useful measures. Each measure protocol has a series of ‘descriptors’, the functions of which are outlined in Table 3, as well as in the Standard Protocols documents’ Introduction section.

The list of measures to be collated was finalised in consultation with the Work Package 4 Core Partners, as well as other work package leads. This was to ensure that a suitable balance was reached in the trade-off between (a) what data and information would be desirable to gather for other work packages (e.g. WP1, Task 1.2; WP4, Task 4.4), and (b) what is realistically achievable and practical to assess on large-scale field plots by Core Partners and Participatory Farmers (both of which can be expected to be able to achieve different levels of detail). In considering the feasibility





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of different data gathering activities, it was also necessary to evaluate what will be reasonable to expect within the funds allocated to each Core Partner, and what will be made available in terms of funds to Participatory Farmers.

With particular relevance to designating measures as ‘essential’ and necessary to collect, these were limited to those measures of fundamental importance to project activities which would also be within the abilities of the majority (if not all) Core Partners to collect. The same was true for those designated as ‘essential’ for collection by Participatory Farmers. Core Partners will be expected to collect detailed data on soil and crop management variables for assessment of plant team agronomic and productivity indices, environmental indicators and economic viability assessment measures during crop growth cycles. Participatory Farmers, on the other hand, will be expected to return a more limited set of data, for assessment of agronomic and productivity indices and economic viability assessments.

While the Standard Protocols will indicate the minimum requirements in terms of both essential measures and frequency of collection, useful measures and information on additional valuable repetition of sampling effort (e.g. more frequent assessment of pest damage or abundance) have also been noted to encourage additional data gathering activities. The list is non-exhaustive, and all data gathering participants will be encouraged to collect data on additional metrics of interest, as well as at more frequent intervals if they so choose, on their validation platforms.

Table 3. Functions of protocol ‘descriptors’, as used in the Standard Protocols documents for Core Partners and Participatory Farmers.

<i>Descriptor</i>	<i>Function</i>
Importance	Indicates whether a measure is designated ‘ <i>essential</i> ’ and therefore must be assessed, or whether a measure would be ‘ <i>useful</i> ’ for the project (but is not compulsory).
Description	Provides some information on the nature or purpose of the measure.
Type	Indicates whether a measure will provide either (a) agronomic and productivity information, (b) environmental information, or (c) economic viability assessment measures.
Plant group	Indicates which of the crop components in the plant team the protocol should be used for.
Target	Shows whether the measure should be reported on at the whole plot, subplot or single plant level.





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Method	Provides a description of the method proposed for collection of data on the measure.
Timing	Indicates the minimum frequency and timing for collection of the measure.
Repetition	Indicates which measures would provide useful repeated measurements beyond the minimum collection points indicated in 'Timing' (e.g. repeated measures of pest density through the season would be useful, although the project only requires collection of this data at one particular growth stage).
Alternatives <i>(Core Partners only)</i>	Suggests alternatives means for assessment of the measure than what is presented in the primary 'Method'. These should only be used in scenarios where it is not possible to use the described 'Method' due to, for example, lack of facilities.
Data format	Provides information on the format unit/scale the data will need to be returned in.
References <i>(Core Partners only)</i>	Shows any references pertaining to the measure.
Author <i>(Core Partners only)</i>	Indicates who contributed to the preparation of the protocol. Original authors have been retained, with editing authors added to each protocol.

4. Outlook

Distribution of the Protocols and associated material will comply with the Communication Strategy that will be devised and finalised as part of Deliverable 4.3 (D28 – Communication plan for liaising with CPs and PFs, due Month 12). The Standard Protocol documents will be shared with Work Package 4 Core Partners directly, and will also be uploaded to the project SharePoint in due course. In addition, the Standard Protocols document for Participatory Farmers will be shared in an editable text format for translation into key languages. All translated documents will also be uploaded to the project SharePoint site. Participatory Farmers are being recruited via a tender and subcontract procedure, and this procedure will identify the key languages required for the protocols. Participatory Farmer protocols will be made available, in the relevant key language, to Participatory Farmers in PDF format. We expect that these will be distributed directly by the Participatory Farmers' points of contact ('buddies') in the project. The 'buddies' will also be responsible for encouraging and providing any additional guidance to their Participatory Farmers, to enable them to





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collect any of the ‘useful’ measures that might be of interest or relevance to them specifically, in addition to those measures deemed ‘essential’.

The Standard Protocol documents are expected to be revised, and to evolve, based on practical experiences and feedback raised during their use in early years of the project. Measures may be added or removed in the future, depending on the requirements and capabilities of both Core Partners and Participatory Farmers involved in the project. Updated versions of the documents will be provided to relevant users as described above. The more extensive Standard Protocols for Core Partners document, as well as the document for Participatory Farmers, will be made publically available in due course as part of Work Package 2’s Deliverable 2.2 (D17, due Month 42), including online via the project website.

An important aspect of the data collection activities will be management of data quality. A plan for this will be considered and drafted as part of Deliverable 4.3 (D28, due Month 12), and will be discussed at the DIVERSify General Assembly in 2018 for confirmation. The nature of any data quality assurance measures will be determined with consideration given to the level of assistance required by individual Participatory Farmers recruited in the tender procedure.

A data collection template will be prepared in collaboration with Work Package 5 and in consultation with other work packages more generally. This will be done in order to standardise data capture as much as possible, to facilitate ease of data use and maximise efficiency of data input into other work packages. A Metadata capture component will be included within the template, for capture of relevant information.

Submitted files are currently stored locally on a secure and backed-up server. All files will, in due course, be uploaded to the project SharePoint and website (as appropriate), and long-term storage will comply with DIVERSify’s data management plan (Zervas, 2017).

References

Zervas, P. (2017) D6.1. – Draft Data Management Plan. Developed by the EU-H2020 project DIVERSify (‘Designing innovative plant teams for ecosystem resilience and agricultural sustainability’), funded by the European Union’s Horizon 2020 Research and Innovation programme under Grant Agreement Number 727284.

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