



INnovations in plant Varlety Testing in Europe

Deliverable D5.2

Proposal of a multi-criteria evaluation in variety testing

Technical References

Project Acronym	INVITE
Project Title	INnovations in plant Variety Testing in Europe
Project Coordinator	François Laurens
Project Duration	60 months
Deliverable No.	D5.2
Dissemination level ¹	CO
Work Package	WP 5 - Integration of new methods and tools in advanced variety testing protocols and demonstration in field trials
Task	T 5.3 - Development and proposals of new protocols to integrate the sustainability and resilience criteria, for specific traits linked to biotic and abiotic stresses and through multi criteria evaluation under conventional and organic cropping
Lead beneficiary	Partner 16 (GEVES)
Contributing beneficiary(ies)	Partner 7 (IRTA), partner 22 (ACTA),
Due date of deliverable	June 2022
Actual submission date	November 2023

¹ PU = Public

PP = Restricted to other programme participants (including the Commission Services)

RE = Restricted to a group specified by the consortium (including the Commission Services)

CO = Confidential, only for members of the consortium (including the Commission Services)

Document history

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Summary

To support and drive varietal innovation with varieties adapted to agro-ecological practices and climate change, rules for registration and recommendation are interesting tools. However, it requires to study how to integrate more social and environmental concerns into registration decisions and recommendations. Multicriteria approaches were analysed, with the aim to propose recommendations towards the definition and validation of a social, environmental and economical index in wheat. This document is based on the current experience and knowledge of GEVES. It is a non-exhaustive description of the multicriteria evaluation of wheat varieties in the French registration and recommendation systems and of the work carried out to integrate more environmental concerns. It must be considered as a base for further discussions.



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1 Introduction

In Europe, registration in the EU Common Catalogue of varieties of agricultural plant species is necessary to market varieties across EU. This requires the registration in a national list of varieties which is possible after their admission to DUS (Distinctness, Uniformity and Stability) tests and, where applicable, VCU (Value for Cultivation and Use) tests. Each member state has developed its own national VCU rules and protocols. Variety characterisation is being pursued post-registration to determine a more detailed or regionalised recommendation in order to support end-users in their varietal choices, handled by different stakeholders in certain countries.

To meet society's expectations, agriculture is moving towards more sustainable cropping systems while being more resilient to climate change. Varietal innovation has an important role to play in this transition by providing farmers with varieties that perform well under these production conditions. Then, to support and drive varietal innovation with varieties adapted to agro-ecological practices and climate change, rules for registration and recommendation are interesting tools. However, it requires to study how to integrate more social and environmental concerns into registration decisions and recommendations.

That is why it was proposed in this project to study and test a multicriteria approach through the definition and validation of a social, economic, and environmental index in wheat (Task 5.3). This technical document is produced by GEVES and is based on its current experience and knowledge. It is a non-exhaustive description of the multicriteria evaluation of wheat varieties in the French registration and recommendation systems and of the work carried out to integrate more environmental concerns. It must be considered as a base for further discussions.

2 Results

2.1 Current French variety registration and recommendation systems

Cultivars must pass the relevant VCU tests and demonstrate improved value for cultivation and use in regard to varietal references available on the French market. If the candidate variety does not satisfy the VCU tests, it will not be registered in the French Catalogue of varieties. The registration system thus has a **normative and a prescriptive purpose**.

The VCU admission decision can be seen as a recommendation of the variety considered suitable for **current and future production contexts** (i.e. agro-climatic areas, fields of use, types of cropping



systems, etc.) met in the Member State. The evaluation and rules for decision should therefore be **representative of the diversity of these contexts**, at least as far as possible. However, when the registration decision has to be taken, **data available are still limited**. Moreover, most trials are conducted in **optimal conditions** to limit the impacts of (a)biotic stresses on crops and avoid losing trials. Then, the challenge is to avoid an elitist registration decision with the risk of excluding varieties with interesting potential in some contexts or the opposite, **making less relevant varieties available** to farmers with an overly open system.

Post-registration evaluation trials carry out in France by technical institutes allow a more detailed characterisation of registered varieties by assessing their performances in additional varied cultivation and use contexts. Data collected enables specific variety recommendations for each region and production contexts, in line with farmers' expectations. Indicators used to assess varieties in registration and post-registration trial systems can be shared, quite similar or complementary. This continuum is an interesting way to reinforce the characterisation and recommendation of varieties.

In France, all the rules used to determine the VCU and to support the registration decision are **written and known in advance**. This means that a large part of the expertise required for the registration decision is brought in a priori during the rule-making process, **done in consultation with various public and private stakeholders**. This particularity of the French registration system controls the adjustment of rules and **makes known for applicants all criteria before the candidate variety submission**.

The **VCU admission decision is based on both the categorisation of candidate varieties** (e.g. use, earliness, technological classification, presence/absence of a substance, ...) **and an evaluation using multiple criteria**. The varietal quotation is a **relative score** that represents the performance of the candidate variety to the VCU tests **compared to the standard varieties**. A varietal score lower than an eligibility threshold, implies that registration will not be accepted. The **number and weight of criteria considered for the quotation varies** between species. Then, **the diversity of rules is important according to the specificities and expectations of each sector**. For some species, such as maize or sunflower, candidate varieties must meet several independent criteria to be registered. For others, such as wheat and potatoes, the different criteria are considered through a multicriteria index. For a third category of species, including rapeseed and peas, both systems are used simultaneously. **The quotation systems are expressed as a yield value. This means that the relative yield of the candidate variety is used and can be adjusted by the value of other criteria translated into yield points**.

For wheat, the quotation is based on the performance of the candidate variety in terms of yield, technological quality and tolerance to (a)biotic stresses (Figure 1). These traits are assessed using one or more experimental protocols considering various types of cultivation practices (with or without fungicide treatments, reduced or no use of mineral nitrogen fertiliser). Specific trial networks have also been set up, one in organic farming for varieties claiming to be used for that purpose, and another dedicated to assessing yield regularity factors. The aim of these protocols and



specific trial networks is **to give a better representation of variety performances under specific growing conditions**. So, in France, the evaluation of varieties of wheat is a **multi-criteria evaluation system** taking into consideration some **agronomic, technological and environmental expectations**.

Figure 1. Example of the French VCU quotation system for winter wheat

Quotation = Average yield of the variety in % of the reference control

= Average of yields obtained in trials using fungicides + Average of yields obtained in trials without fungicides use

≥ **technological threshold - the sum of bonus and malus**

Type A	80
Type BPS	102
Type BP	104
Type BB	104
Type BAU	107
Type BAUimp	109

	2 malus	1 malus	1 bonus	2 bonus
Cold	Note =1	2 < Note ≤ 4	Note ≥ 7.5	
Lodging	Note ≤ 4	4 < Note ≤ 5	Note ≥ 7	
Specific weight	<75	<76	>80	
Protein		GPD -	GPD +	GPD ++

	1 malus	1 bonus
Yellow Rust	Note ≤ 4	-
Brown Rust	Note ≤ 3	
Eyespot	Note =1	Note ≥ 5
Powdery mildew	Note ≤ 4	
Septoria tritici	Note ≤ 4.5	Note ≥ 7
Fusarium wilt	Note ≤ 3	Note ≥ 6
Deviation T-NT	écart > 120%	écart < 80%
Mosaic	-	R
WOBM	-	R

According to this quotation system, the higher the quality, the lower the yield requirements. It also penalises the registration of susceptible varieties and favours resistant varieties.

2.2 Various expectations for varieties

In light of the above, the **registration system relies on the identification of what is expected from varieties**, in order to determine which traits and criteria must be considered and assessed to shed light on relevant varieties.

However, the **criteria that describe a good variety differ from one stakeholder to another and over time**. According to the results of the one-year research project MUSE¹ funded by the French Scientific Interest Group (GIS) Grande Culture GCHP2E², the **importance of the yield level** is currently emphasised by farmers to ensure a high income. In the coming years, a strong demand for suitable wheat varieties in terms of **tolerance to (a)biotic stresses and yield stability was highlighted**. Increasing yield levels should no longer be a priority for farmers, who will need to have varieties with **acceptable yields in years with low potential**. Although it was not mentioned during the interviews with the farmers involved in the project, we can assume that for others, a good variety may be one that can **be resown on the farm the next year**. According to processing companies, the quality of grains and its stability drive the definition of a good variety. Whereas for plant breeders or seed companies, a good variety seems to be one with high marketing potential

¹ One of the aims of the project was to clarify current and future expectations in wheat varieties. For more details, please contact the GIS GC.

² <https://www.gchp2e.fr/>



and return on investment. For some citizens, it would be a rustic variety that requires few inputs to grow and respects the environment. So, **economic factors drivers stay dominant with few environmental expectations.**

But, with the need to move our farming practices towards greater sustainability (Green Deal targets), to protect the environment, human and animal health and to ensure our food security in a context of climate change, **tomorrow's varieties will need to be selected and marketed to meet environmental and social challenges.**

In the light of these economic, social and **environmental concerns, the choice and weighting of criteria** for the registration decision is complex and raise the question of **what a good variety for registration is**, bearing in mind that the registration system in France is also **a tool for driving genetic progress and supporting sustainable cultivation practices.**

2.3 Toward more sustainability in the registration and recommendation systems

Most varietal expectations are economic. Therefore, a first way to address the question of a multicriteria indexes including more sustainability for the registration and recommendation of varieties would be to work from **an economic point of view**. However, quantifying the costs or the economic impacts generated by a social or environmental service provide by a variety is a huge challenge. How to appraise the economic impact of the variety including its impact on the reduction of environmental impacts (e.g. reduction of chemical inputs due to increased tolerance to bioagressors or improved nutritional efficiency), on biodiversity and related ecosystemic services, and on the reduction of greenhouse gases achieved by the adaptation of the farming practices required for its cultivation. It is generally more often studied at the farm scale.

Arvalis, post-registration institute, has developed a **variety recommendation tool** to help end-users choosing wheat varieties according to their expectations³. It offers the possibility of comparing the characteristics of varieties previously selected by the tool, on the basis of information provided by the end-user, i.e. his cultivation particularities (sowing date, soil type, region), to define a pool of varieties adapted to the precocity zone to which the field belongs (3 predefined zones) and the potential risks to which it is exposed (yellow rust, eyespot, lodging, etc.). This filter is carried out on the data and expert appraisals from registration (FR and EU) and post-registration sources. Displayed indicators include:

- the relative yield, expressed as a percentage in relation to the average of yields of other selected varieties. The yield value is an adjusted mean in order to eliminate the effect of the variety's evaluation year,

³ [OAD Choisir ses variétés de blé tendre | ARVALIS](#) (08/17/2023)



- the protein score, based on GPD (Grain Protein Deviation)
- the specific weight,
- the diseases scores, ...

An additional step **compares the economic performance** of the previous list of varieties in function of the estimated pest risk. **Some technical and economic indicators** (e.g. partial margin, gross product) **as well as IFT indicators** (frequency of treatment indexes) have been included to this tool. The user can establish different scenarios by giving a selling price and a potential yield for his field. So, these indicators help farmers choose their varieties by comparing their economic potential. IFT indicators are based on the estimation of the pest or lodging risk levels, according to the cultivation practices previously requested from the user and varietal susceptibilities. Specific calculations are, then, used to value the output into a potential cost €/ha. The relative yield expressed in % is translated into hundredweight per hectare and adjusted to the yield potential of the plot entered, more meaningful for farmers. The gross product, expressed as a percentage in relation to the average of yields of other selected varieties and translate into €/ha, is calculated as the product of yield and wheat price impacted by any bonifications/penalties linked to quality (protein and/or specific weight rebates, etc). The partial margin, also expressed as a percentage in relation to the average of yields of other selected varieties and translate into €/ha, is calculated as the gross margin impacted by costs of the seeds and the phytosanitary protection (excluding seed treatment). This approach of comparing varieties by means of economic indicators makes it possible to meet the expectations of users, i.e. farmers. However, no threshold or weighting is applied in the aggregation of criteria. Yield is the main driver of these economic indicators. The institute is considering **how to recommend varieties that are more compatible with agroecological systems**.

The interest and feasibility of integrating **such indicators into variety registration decision could be discussed** in parallel with the project partners' work on completing these indicators for variety recommendation. But they would not be sufficiently representative of the diversity of concerns expressed by stakeholders and citizens. So, **other criteria should be explored, and choices should be made**.

A variety recommendation tool has also been developed for oilseedrape and sunflower varieties by Terres Inovia⁴. An **agronomic merit index** has recently been added to highlight varieties with interesting potential for sustainable cultivation. This index reflects a **variety's adaptability** and is calculated as a score combining agronomic criteria (earliness, pest risks) that vary according to the production context. It is then combined with a yield index, which is the ratio between the average yield of the variety and the average yield of varieties associated with the localisation of the plot. A **preliminary discussion has been held** as part of **the MUSE project** to learn more about this tool and to discuss on its potential to support the registration decision, which should be continued to explore the issue further. As this index has only recently been published, it will be some time before we know what impact it will have on the variety's choice.

⁴ <https://www.myvar.fr/> (08/17/2023)



In France, the principles of Agroecology are particularly popular, raising the question of the adaptability of varieties to the diversity of the underlying practices and expectations. But, the wide **diversity of agro-ecological systems** means that it is necessary to think about the type(s) of cultivation in **variety registration trials** and the **traits of interest** to be considered and communicated to end-users. The characteristics and performances of varieties cannot be tested in all types of agro-ecological systems. Should we focus on organic farming, which is one type of agroecological system promoted by the European union? Should we include more diversity in term of (agroecological) cultivation practices in trial networks, and therefore introduce more variability between trials to support the registration of varieties with greater adaptability? But how to assess and provide a relevant registration decision with greater intra- and inter-plot variability? The re-conception of trial networks and the **weighting of agroecological criteria** in the registration decision must be thought over in order to promote sustainable agriculture according to specificities and uses of each species concerned. The work carried out as part of the **CASDAR RESO2**, a French research project exploring the adaptation of trial network and registration rules for agro-ecological systems, could provide further substance for this analysis.

With regard to the Green Deal objectives and the willingness to **reduce the use of fertilisers by 20%**, varietal trials may be carried out in a **context of limited fertiliser use, still to be determined**, either to highlight wheat varieties with relevant performance in this context or maybe to penalise or limit varieties that need additional nitrogen inputs to ensure sufficient protein content. A discussion has been initiated as part of a **French working group on nitrogen and varieties** to examine possible ways to work in **wheat and rapeseed**, two crops for which the topic of nitrogen use efficiency in varieties for registration was raised a few years ago and for which levers have been tested. For wheat, since 2012, a **protocol involving a less nitrogen fertilisation** has been applied to a number of trials in the network where the performance of varieties is compared to trials with optimal nitrogen fertilisation. **GPD (Grain Protein Deviation)** is used in VCU quotation and **nitrogen tolerance indicators** are published when varieties are registered. After several years of using this protocol, we are currently discussing its ability to discriminate between varieties in terms of their nitrogen use efficiency. Other options are being explored. Among the possible levers, the weight of GPD (Grain protein Deviation) in registration decision can be reinforced or supplemented by other indicators of nitrogen use efficiency. The trial network could be conducted entirely with suboptimal doses of mineral fertiliser or with a higher proportion of organic fertiliser. However, as with any situation where abiotic stress conditions are encountered, **accurate characterisation of the variety trial environment** is required to validate limiting growth conditions. This is a tipping point for taking greater into account abiotic stress in trial networks. In addition, the **impact of a suboptimal nitrogen fertilisation on wheat quality** must require special attention to meet market expectations. Arvalis is considering integrating “b”, an indicator of nitrogen requirements of varieties for an optimal yield, into its recommendation tool. But this could have little impact on the partial margin given the current economic and political context on nitrogen fertilisation. As far as we know, Germany is working on **using the data acquired** during official trials (under optimal nitrogen fertilisation



conditions) **to highlight varieties with high nitrogen use efficiency** based on analysis of data relating to protein content, yield and GPD.

Improved tolerance of varieties to biotic stress should also be better taken into account in registration decisions, in particular the **potential of varieties to compete with weeds** under conditions of herbicide restriction. Some traits (sometimes, scored also in DUS tests) such as plant morphology or early vigour could be considered as factors in favour of registration or simply notified as informative factors of interest.

Moreover, with the climate change, the **need of varieties that are stable** from one year to the next and/or in different environments is increasing for ensuring production and farmers' incomes. Work is currently ongoing to **identify indicators of stability** which could be used for registration and/or recommendation of varieties. Arvalis's tool calculates a variety regularity score corresponding to the standard deviation of variety X environment interactions assessed on the basis of the yields of fungicide-treated modalities in registration and post-registration trials. **Varietal stability is a crucial trait to take into consideration**, and one for which research efforts are currently underway.

So, there are several possible approaches to integrate environmental concerns:

- With regard to the trial environment and management,
 - o the trial network may include various sites with contrasting agropedoclimatic conditions to express the variability of situations,
 - o factorial trials may be implemented (e.g. different types of nitrogen fertilisation),
 - o all or part of the trial network may be conducted under a particular type of management (limited use of nitrogen, limited irrigation, organic or agroecological management, ...),
 - o special trials may also be considered for specific traits, crop managements or environments.
- A multicriteria index can be defined as
 - o the aggregation of several weighted criteria (economic, technological, environmental, ...)
 - o the aggregation of several multicriteria sub-indexes representative of each kind of expectations.

The strategy to be applied depends on the species and priorities considered. The type of approach, criteria and their weight can have an important impact on final quotation and registration of varieties. Currently, French registration system for wheat is more favourable to varieties that perform well against diseases in the absence of fungicides.



3 Conclusion

The preliminary results of this work have led to highlight the initial points to be considered for the greater integration of environmental issues in registration system of varieties such as:

- A multicriteria index used for registration decision should be representative of the diversity of expectations from varieties and of the national production contexts.
- Environmental concerns may be taken into account, on the one hand, in the management of the variety trial (e.g. limited use of chemical inputs) and on the other, in the selection and weighting of the criteria used in the registration decision.
- Technical and economic indicators and an agronomic merit index have been defined for recommending wheat and rapeseed varieties respectively by Arvalis and Terres Inovia. The experience gained with these approaches can be used to stimulate discussions on the evolution of a multicriteria evaluation of wheat for registration purposes.

The definition of a multi-criteria index with more environmental issues requires more in-depth discussions between the partners of Invite project. Several questions associated with this study need to be examined in more detail, in particular:

- The identification of the relevant environmental criteria to consider for registration decision.
- The cultivation approach to adopt in the experimental network according to the objectives and expectations of the varieties.
- The weight of the various criteria linked to environmental issues in relation to the others in the registration decision.
- The most appropriate analytical or mathematical approach to consider moving towards a multicriteria index representative of social, economic and environmental expectations.

For the next steps, we recommend setting up future exchanges between project partners, especially those interested in this approach and these considerations, in order to co-construct a shared vision of how developing multi-criteria index and evaluation. It would be an opportunity to deconstruct our respective approaches to multi-criteria to enhance them. To achieve this, the first and foremost step is certainly to determine clearly on what we expect from varieties and which traits should be assessed to highlight their potential. Methods for developing (a) multi-criteria index(es) could then be discussed.

