



# CHALLENGES AND OPPORTUNITIES FOR SUSTAINABLE RICE-BASED PRODUCTION SYSTEMS

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# AN INTEGRATED STUDY OF THE DEVELOPMENT OF ORGANIC RICE CULTIVATION IN THE CAMARGUE (FRANCE)

**Mouret J-C[1], Hammond R[1], Dreyfus F[1], Desclaux D[2], Marnotte P[3], Mesléard F[4]**

*[1]INRA UMR Innovation Montpellier, 2 Place Viala 34060 Montpellier France, mouret@ensam.inra.fr;*

*[2]INRA UMR DGPC Montpellier; [3] CIRAD-AMATROP Montpellier;*

*[4]Station Biologique de la Tour du Valat, Arles*

**Abstract**

In the Camargue, rice and durum wheat are associated in rotations that have an ambivalent ecological impact: on the one hand, these two crops contribute to the preservation of the surrounding ecosystem, while on the other hand, when cropped intensively, they can threaten the ecological equilibrium of this protected area. In this context, organic agriculture would seem to be an alternative adopted by a certain number of producers and processors. However, the pioneers of this practice encounter numerous problems, both agronomic and economic. The study presented here aims: to construct a pluridisciplinary approach to analyse the conditions of the development of organic cereal cultivation in the Camargue: to identify the principal factors that limit the development of this new practice: to produce knowledge useful in helping ricegrowers put into practice organic cropping systems.

**Keywords**

Organic rice, Camargue, interdisciplinary approach, agronomy, ecology, sociology, weed science.

## Introduction

In the two regions Languedoc-Roussillon and Provence-Alpes-Côtes d'Azur (P.A.C.A.), durum wheat and rice accounts for nearly 160,000 hectares (20,000 ha of rice, 140,000 ha of durum wheat). In the Camargue, these two crops are associated in crop rotations, wifh an ambivalent ecological impact. On the one hand they contribute to the maintenance of the surrounding ecosystem (soil desalinisation due to the flooding of ricefields, weed control and soil structuring due to wheat cropping) and on the other hand, when managed intensively,

present a risk to the ecological equilibrium of a conservation area (National Regional Park and National Reserve).
Today questions are raised concerning these two crops as seen within their mass production logic (conventional agriculture, undifferentiated markets) because of fierce competition from other Mediterranean production areas, the threat to regulatory protection (the Common Agricultural policy, P.A.C., subsidy) and agronomic difficulties related to climatic constraints (temperature for rice, hydraulics for durum wheat).
In this context, organic agriculture appears as an alternative adopted by a certain number of producers and processors. Beyond responding to an ever-growing demand for organic rice, semolina and pasta, the development of these networks could be the opportunity (i) on a regional level, to create a commercial advantage by combining the Mediterranean identity with the credibility of a national certificate, (ii) at the Camargue level, to fully assure the durability of a protected sensitive ecosystem.
However, the first producers to adopt this practice encounter numerous problems both agronomic and economic

- the lack of technical data (weeds, fertilisation, varieties),
- the frequency and management of the durum wheat/rice rotation
- the economic viability of switching to organic farming.

What's more, other professionals (breeders, collectors, processors) question how to adapt to or anticipate the development of this new agricultural prototype.

## 1. Interdisciplinarity, the first scientific challenge.

This was conceived following the hypothesis that a new agricultural prototype should be approached in an interdisciplinary way, to both find practical solutions and help advance disciplinary investigations. The main agricultural organisations and participants involved in the development of organic cereal networks throughout the Languedoc and P.A.C.A. regions were contacted and accepted to participate in a common project.
The aim is thus to work towards a pluridisciplinary and reflexive analysis of the building of collective innovation processes associating producers, collect/process organisations and researchers of different disciplines to resolve jointly and progressively agronomic and economic problems.
Interdisciplinarity is defined as the joint research of several disciplines concerned by a common object, here being the cereal production in Camargue soil conditions in the framework of organic farming specifications. The aim is to be able to cross-examine the questions that led to and that are tackled by the project, the methods and the results of each participating discipline; agronomy, ecology, genetics, weed science and sociology. The need for such a questioning concerning organic farming is all the greater as this prototype profoundly implicates the experimental sciences. It is indeed based on the principle of environmental artificialisation which entails the taking into account of a number of elements that don't respect disciplinary borders and highlights the diversity of choices for applied sciences. While shaking up disciplinary attitudes this prototype is in harmony with a social movement to which researchers must respond, as must decision-makers of the research institutions who support their work.
In the construction of the project, an emphasis was placed on the organisation of centres of activities based on different themes « associating a limited number of disciplines so as to initiate a number of various collective training processes that contribute to a progression towards a pluridisciplinary approach associating all partners ».
In practice, the limited participation of partners to the project as well as the number and the availability of scientists prevented a formalised multi-centred functioning, and the activity centres are mainly reduced to just one researcher from the relevant core discipline. In reality,

the organisation of the interdisciplinary approach was developed by actual events; either by the crop cycle imposing a schedule on the different disciplines involved (agronomy, ecology, genetics, weed science, sociology), or by production deadlines to which the collection was subjected.

### 1.1 Activities

Activities retained as contributing to interdisciplinarity are those that generate interactions, one to one or public, between researchers of different disciplines concerning common elementary objectives. Their cognitive content is that of the explanation of the manner that each one has to qualify these objectives, of the contribution to the group production of mutual knowledge, and of the establishment of rules and of creating confidence. They thus help define the role of each implicated scientist, regarding the type of question to address as much as the participation within the interdisciplinary work group. They also help to understand the institutional conditions within which each person situates his activity in the group and to evaluate available resources.

Activities centred on these interactions are extremely varied according to the actors implicated and action developed. In addition, they are by definition, complex in the sense that they associate, to different degrees, exchange and co-construction on the one hand, and on the other simple presentation of facts and results.

Nevertheless, for clarity, they can be classed into two groups. In the first activity class are retained:

- in situ visits, field tours, interviews with actors,
- joint participation in meetings initiated by members of the project, open to partners and other colleagues. They can also result following invitation from outside organisations
- the diffusion of various papers from the different disciplines
- the setting-up of training programmes on a subject when there is parallel intervention

In the second group, activities are presented whose aim is to encourage exchange and debate between concerned researchers leading to objectivisation and formalisation of actual knowledge and of the project situation

- joint drafting of replies to tenders – programming and conception of various interventions (holding a meeting of organic farmers)
- joint supervision of student work
- the setting up of training programmes on subjects jointly constructed and with a common objective for associated scientists.

### 1.2 The establishment of a set of references of situations encountered

These different activities nourish and instigate dialogue between scientists. They are the basis for the production of a common bank of knowledge which consists of situation or case references. These are intermediary objects in that they are the result of the acceptation of the work definition of objects of common interest. Everyone sees them from their viewpoint but responds to a common designation, a qualification richer than a single disciplinary viewpoint, and an awareness relatively alert to all the elements that influence the studied object. These work definitions, established by practice rather than formal procedure, position the aforementioned, stimulating the contextualisation of disciplinary contributions. However they remain sufficiently vague so as to let each person identify, behind these denominations, that which is relevant to his discipline.

The research objects cover the entire range of components of an « agricultural prototype ». They permit disciplines to come together, for the most part two by two, but sometimes as well in a bigger group. They involve:

- field parcels and their biophysic characteristics, soil and populations
- technical objects : seeds, inputs, crop management sequence
- systems of activity
- farmers and their relationships
- production and processing network personnel, and local network types
- counsellors (organic and conventional)

This list is far from complete and reveals gaps concerning the natural environment (irrigation water, lagoons…), biological life in the soil and micro-economic aspects. Contacts between agronomy and sociology are by far the most frequent. This is of course mainly due to the physical and institutional proximity at the Innovation Mixed Research Unit (U.M.R.). It is though also due to the fact that these disciplines have a great number of research objects in common through which they embrace their own questioning of the studied situations and, in particular, agricultural practices. By consequence numerous activities are jointly led which multiplies even more their contact with the aim of stimulating cognitive exchanges.

### 1.3 The building of partnerships

Beyond reference sets, research training also embraces the manner actors function together, formally or informally, as well as the resources, particularly cognitive, available to the project.

The programme was build on the presence in the field for the last fifteen years of agronomists (led by J.C. Mouret) from the U.M.R. Innovation and on the realisation of a survey design concerning conventional field parcels as well as more and more organic situations (Dreyfus, Mouret, 2002)

Since 1998, researchers of other disciplines (weed science, ecology) and of other institutions (C.I.R.A.D.), Tour de Valat Organic station) interested by organic development have already been in contact with the agronomists.

This beginning partly accounts for the gaps and weaknesses in the project. The former are related to the non-consideration during drafting of certain fundamental aspects of the new area of study. This concerns hydrology and questions related to the quality of irrigation and lagoon water. Also the ecology of the microbe population and the functioning of the rhizosphere are essential elements for a study of soil fertility, yet are not included in the project. The latter are related to a lack of preparatory work which prevented a clear appraisal of commitments taken and an evaluation of the contribution reasonably expected of everyone concerned. Indeed, the various institutions employing researchers place different degrees of importance on the question of organic agriculture. Also, researchers not in contact with members of the work group never significantly participated in prior work. Thus can be found an important weakness concerning rice genetics, or again, ecophysiology.

Besides unequal scientific relations, the partnership with professional organisations could not fully operate. Up to the present these institutions worked within the dominant framework of conventional agriculture. Organic questions represent a minor part of their activities.

Concerning producers themselves, one of the programme objectives is to facilitate their contribution to the construction of a system of collective action aimed at producing knowledge relevant to their action. Because of their small number, their diversity and the absence of representative organisations, agronomists and sociologists endeavoured to contact individually each producer.

In any case, professional partners are more and more interested by the subject of organic farming. The scientific community is organising itself within transversal structures dealing with this question. The work undertaken will thus rapidly be taken into account, and the confidence built within the group will help to tackle more directly the necessary construction of formalised scientific and professional partnership.
Nevertheless, beyond these advantages, it is the disciplinary interest that there is to work together and to have available an enriched set of references enabling the production of quality work that bodes well for the future of this research action.
For the sociologist, the weed scientist, the geneticist, the ecologist, the work of the agronomist (rooted for years in the dynamics of local apprenticeship) is the indispensable key to understand the real environment. When experimental sciences come up against a new paradigm, they are then an obligatory « pass point ». The results presented below cannot be overloaded by methodology. However it is only after detailed discussion with them that the different protocols of all the other disciplines are drawn up.

## 2. A presentation of the results of different disciplines

### 2.1. Agronomy aspects

Within the framework of an integrated research approach involving sociology, economy, ecology and genetics, the agronomy programme realised four specific research actions:

- an analysis of the functioning of organic crop cultivation systems
- a spatio-temporal field survey of organic and conventional ricefields
- experiments aimed at testing the effects of mechanical weeding in organic ricegrowing
- a survey of the weed population in Camargue ricefields

#### 2.1.1. An analysis of the functioning of organic crop cultivation systems in the Camargue

In-depth interviews of a directive or semi-directive nature dealing with the manner in which farmers reason and put into practice their organic crop cultivation systems have helped to identify and analyse

- the different types of farms, totally or partially converted to organic practices
- the technical aspects of the conversion period
- crop cultivation systems employed and their agronomic logic
- relationships between rotation and crop planning
- the consequence of these agricultural activities on the spreading of the work load throughout the year

Crop cultivation systems were analysed from three angles:

- the identification of rules of decision that govern the installation of rotations and crop planning
- associated crop management sequences
- the overall coherence

Rice management within an organic crop cultivation system cannot just be limited to practices operated during a given season. It must take into account all practices realised during the management of the rotation.
Strategies of conversion to organic farming and the management of the organic rice-based cultivation systems that result are strongly correlated to farmer motivation. Two distinct groups have been identified:

- pioneers, motivated for ethical reasons and converted to organic farming around twenty years ago when the first commercial niches for organic products were established. Within this group, crop rotations include diverse species (pulses for

example) and crop cultivation practices (hand weeding) are relatively stabilised. On these farms, most, if not the whole of the Utilisable Agricultural Land Area (S.A.U.) is organically managed

- the newly converted, for whom recent conversion can be seen as a timely strategy to counter difficulties in the conventional sector. The sought objective is to ensure the viability of the farm by seeking the most economic production combinations. These farmers choose mixed cropping systems (organic and conventional) in order to limit risks related to a technical and/or economic failure of the organic production system. On these farms, crop cultivation systems are not stabilised, crop rotations little established and cultivation practices, while respecting organic specifications, refer to conventional practices.

Our work was essentially centred on the functioning of present-day organic crop cultivation systems. Thus overall perspectives of these farms could not be established, so no prevision is possible of the future functioning of these crop cultivation systems that takes into account the evolution of technico-economic factors. It would therefore be relevant to use simulations by means of an appropriate tool to assess the reproducibility and the durability of these systems in various scenarios with the objective of helping farmers in their decision making.

### 2.1.2. Spatio-temporal ricefield surveys

This research action had three objectives:

- to realise an agronomic diagnostic based on a study of the relationship between the effects of crop management on the environment along with the climate and the consequences on yield variability
- to constitute a suitable observatory for the gathering of information specific to each discipline involved in the project
- to create conditions favourable for the putting into practice the interdisciplinary approach

These last two objectives are dealt with elsewhere in the chapters on disciplinary and interdisciplinary advances.

The agronomic diagnostic underlines a very important variability in paddy rice yield. For the year 2002 the average yield was 3,5 t/ha with a minimum of 0,5 t/ha and a maximum of 7,0 t/ha. Seventy five per cent of this variability is explained by the weed aerial biomass at harvest. In spite of a wide range of weed species, two groups are the most frequent and the most abundant (Echinchloa and Cyperaceae). Weed infestation is related to the nature of the preceding crop and the time lapse between two rice years. Fields where the preceding « crop » was « new land » comprising of wasteland or old prairies are only lightly infested by weeds. Opposed to this fields parcels with a second or third successive rice crop are very infested except for parcels surveyed in 2003 which were manually weeded and where at the same time a complex management of weed control was imposed throughout crop cultivation and between cropping. With durum wheat or alpha-alpha as a preceding crop, weed infestation was always important but variable according to intercrop management (false seeding for example).

### 2.1.3. The effects of mechanical weeding in organic ricegrowing

An experiment carried out « in the field » in 2002 demonstrated that it was possible to realise a mechanical weeding operation in a flooded ricefield. In the Camargue, rice is traditionally seeded directly into water. In order to test the effect of mechanical weeding it was necessary to adapt a crop management system so as to sow in lines to enable the passage of a tractor drawn cultivator. The experiment results show a positive effect of the weeding on paddy grain yield. The weeding resulted in a significant reduction of weed infestation between the lines

and by consequence competition with the rice was diminished. However, this weeding method, or at least the cultivator used in the experiment, did not eliminate weeds in the row and consequently, although yield was significantly higher than in the control, it was unsatisfactory.
Thus, within the conditions of the experiment (field parcel with a second successive rice crop, and the instigation of an operation entailing a modification to the cropping sequence), the result did not incite the farmer to develop this technique.
Mechanical weeding must be seen as an operation that is complementary to other priority interventions that aim to significantly reduce the weed grain stock before crop installation. Nevertheless it would be perhaps beneficial to conceive a weeding tool that diminished weed competition on the row, and this in relation to the development stage of the rice crop. Thoughts turn for example to a form of weeding tool, which would slightly turn over the soil, burying weed seedlings without derooting the rice plants. Apart from the effects of weeding, perhaps it would be useful to analyse the effect of working the soil on re-oxygenating the flooded environment and the consequences on the evolutionary dynamics of nutritive elements; mineral nitrogen in particular.

### 2.1. A weed survey of Camargue ricefields

Weed control in conventional ricegrowing is essentially centred upon the use of herbicides. Their suppression in organic systems has not, in the majority of cases, been replaced by other control techniques. In 2002, a weed survey of Camargue ricefields covered 218 parcels, of which 29 were organically cultivated. The analysis of floristic notations illustrates the important weed population in organic managed fields. In these fields 61% are very infested and only 13% could be considered sufficiently weed-free, whereas these proportions for fields conventionally managed are 5% and 56% respectively.
The main species are Poaceae, as Echinochloa crus-galli (barnyard grass) or Oryza sativa (red rice), Cyperaceae (« triangles ») mainly Scirpus maritimus, Scirpus mucronatus and Cyperus difformis, and Dicotyledones such as Lindernia dubia or Ammania coccinea.
During the 2003 season, floristic notations carried out in organically managed fields chosen for the agronomic survey confirmed these results. Weed control begins with the ability to identify different weeds and by a better knowledge of damage caused by the principal species: a manual presenting the flora of the Camargue ricegrowing environment is being prepared and a assessment of weed competition with the rice crop has begun (with Echlinochoa crus-galli in 2003). An inventory of control methods used by ricegrowers will equally be established by analysing the agronomic field survey and will be published in a booklet to be widely diffused.
Crop management sequence experiments are necessary to establish the worth of false-seeding operations, of increasing plant density and of mechanical weeding, as well as water management, especially between main crops.

### 2.2. Ecology aspects

The purpose of our research action was to analyse cultural practices (conventional as opposed to organic) on invertebrate and vertebrate populations in Camargue ricefields. Places designated for the gathering of information were within the framework of field parcels used for the agronomic survey.
Populations of epibenthic macroinvertebrates (invertebrates whose size is equal to or superior to 1mm present on the surface, in the water column or in the first few centimetres of sediment) constitute an important source of food for water birds (of potential importance in preservation terms, the Camargue being classified as an important international site for water birds, a migratory halt of primary importance). Our results show that certain groups of

invertebrates are particularly affected by conventional practices. This is true for coleopteran, heteropteres in June and odonates during August. Contrarily molluscs prosper much more with conventional cultivation. The absence of species or groups of species and the dominance (abundance) of certain groups such as molluscs would seem to reflect the type of agriculture. From this point of view, results obtained on several of the ricegrowers farms of the agronomic survey network, would cast a doubt on cultivation practices announced (the non-use of insecticides for example).
The analysis (G.L.M.) illustrates the major role of pesticide (Fipronil) of which the sole purpose is to control chironomidae grubs. The low number of predators in conventionally managed fields (2 to 12% as opposed to 18 to 40% in organic conditions throughout the growing period), indirectly leads to an absence of effect of the treatment on Chironomidea (a phenomenon already observed in the case of other insects). If, from an agronomic point of view, the insecticide application doesn't achieve its aim, two of the invertebrate groups heavily affected (coleopteran, Odonates) are among the favourite prey of an emblematic group of Mediterranean wetland and ricefield birds: the heron.
As regards amphibian populations, two taxons, mainly *Hyla meridionalis* and more rarely *Rana sp.* have been catalogued. The abundance of the two species varies throughout the season. Tree frog tadpoles have been observed from the very first sampling period, whereas green frog tadpoles appeared later. This first study concerning amphibians in Camargue ricefields would indicate that amphibians are more abundant in organic systems than in conventional. In addition, organic fields seem more favourable for the reproduction of both species. Old ricefields attract a larger number of individuals than those more recently flooded due to a fidelity to the laying site from one year to another, as seen concerning frogs. The situation of the field parcel (the presence of a water supply near the ricefield, a cover of vegetation around the borders), as well as other cropping practices such as water management (the role of draining) are equally important factors concerning the presence of amphibians in ricefields.
During this study only the most visible anomalies were sought, the real impact of pesticides used in ricefields on amphibian development could not be clearly illustrated. Essentially future experiments ought to concern amphibians (a group threatened on a worldwide scale). The objective would then be to test the effect of different pesticides individually and in combination on the reproduction and development of grubs.

**2.3 Genetic aspects**

During this first phase of the study, an analysis was undertaken concerning the variety selection criteria adapted to the organic cultivation of durum wheat. Rice variety selection will be studied during the second phase to start in 2005.

**2.4 Sociology aspects**

The principal objective of the sociologist is to study, at the moment of the development of a new agricultural prototype:

- the conditions of the restructuring of agronomic research on conventional ricegrowing practices based on a network of referential field parcels
- local dynamics of knowledge nourished by the cognitive strategies of actors concerned

From an operational point of view, the sociologist intervenes, interacts with his study object by attempting to help in an evolution towards a collective system of action destined to jointly build up practical knowledge for organic ricegrowing.
Work is centred around three programmes:

- to characterise and to categorise the various training strategies relating to underlying technical questions in the aim of assuring their diversity but also their similarities and complementarities. Data gathering over, they are now being treated. However the drawing up of a typology has already been possible. This distinguishes six cognitive blocks more or less engaged in innovation processes either active or temporarily stabilised. Reflecting the agronomic survey, cropping systems are again an important explanatory variable of this typology. The importance of cereals in the crop rotation or the presence of forage and the availability of organic matter are discriminatory. The methods and the motivations for conversion account for a lot in the difference between blocks. This typology has been completed by a first contact with the technical advice network. Generally interrelationships are few and infrequent and co-operative technicians and input supply agents represent the most important source of apprenticeship, but not for every block.
- to employ a research/intervention type of approach destined to create a structure for, and to stimulate, dialogue between producers and between producers and researchers. A first meeting was organised, each and every organic ricegrower being invited. 30% attended and met for the first time their colleagues. The different cognitive blocks, previously identified during the programme, were represented. Themes of interest shared by the participants in all their diversity were brought to the fore. They rejoin previous work as well as the agronomic investigations. Already the production of a pamphlet on weed control practices is programmed for the end of the year. Other meetings are being prepared.
- to construct the reflexivity of the group of researchers so as to analyse the emergence conditions (i) of the interdisciplinary group to which they belong and (ii) of the professional and scientific partnerships in which they engage. This research activity is based on data gathered by the observations of the participating sociologist. At the same time, the agronomist, having the most direct contact in the field, keeps a diary to register events, activities, interviews which feed a database of paramount importance for enriching his own discipline, interdisciplinarity and collective partnership; the group only treated this theme during a meeting concerning the writing of the present paper. An outside viewpoint could prove necessary to develop this analysis.

**Conclusion**

The recent development of organic ricegrowing in the Camargue has been accompanied by the emergence, for farmers committed to this production system, of numerous technical, economical and social questions. To attempt overall reply to these questions, an interdisciplinary and interinstitutional approach has been envisaged which associates agronomists, ecologists, sociologists, genetic scientists and economists. Interdisciplinarity became a scientific challenge centred on common activities necessitated by the building-up of sets of situation references and by the establishment of a researcher/actor relationship. The first results presented in this communication bring partial discipline replies to the aforementioned questions. A global analysis brings to light transversal questions, in particular:

- nitrogen dynamics related to organic fertilisation practices, crop precedents and genotypes
- the collective analysis of organic ricegrowing practices and the production of agronomic knowledge concerning the new agricultural prototype in the Camargue

- the prospective development of organic crop rotations and their impact on the natural fauna

These questions aren't the only ones raised by the development of organic agriculture in the Camargue. However, these are the ones that stimulate, at the present stage of the development programme, the interactions between members of the work group. They incite however a reinforcement and an enlargement of scientific and professional partnerships.

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