Needed complementarity of actors for variety innovation

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NEEDED COMPLEMENTARITY OF ACTORS FOR VARIETY INNOVATION

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Abstract - In France, farmers may use only registered crop varieties, listed in the annual French or European official catalogue of species and varieties. For arable species, that represents the context of this paper, a variety is defined by official legislation as being distinct, uniform and stable (DUS) and is evaluated for its value for cultivation and use (VCU) on environments homogenized by an intensive cropping system. The evaluation is mainly focused on the yield and the industrial quality.
But new demands are emerging resulting in -or in response to- the diversification of agriculture. Consequently the demand for a diversity of varieties well adapted to new cropping system and to new outlets is increasing. Our objective is to study the equilibrium between variety offer and demand and how the breeding system may fit the needs. The offer is appreciate by the evolution, over the time, of the number of varieties proposed in the catalogues and by the evolution of the number and of the identity of breeding actors. The number of varieties has greatly increased while the number of breeding firms (essentially private firms) is decreasing. The new demand of variety was studied through several enquiries and is represented by 4 models. Each model needs specific breeding scheme and relevant breeding actors. These different ways to envision varieties and plant breeding must not preclude one another but must be considered as complementary and able to renew the way to implement plant improvement for agriculture. In such context, public institute have a great role to play and mainly in the development of participatory plant breeding projects.

Key words : Variety innovation, GxE interactions, Participatory plant breeding, organic breeding, plant improvement

INTRODUCTION

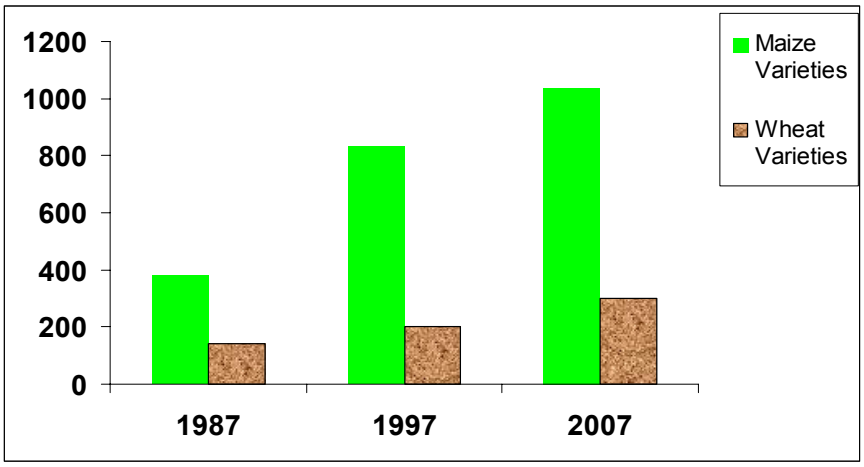
In France, farmers may use only registered crop varieties, listed in the annual French or European official catalogue of species and varieties. For arable species, a variety is defined by official legislation as being distinct, uniform and stable (DUS) and is evaluated for its value for cultivation and use (VCU) on environments homogenized by an intensive cropping system. The evaluation is mainly focused on the yield and the industrial quality.
But new demands are emerging resulting in -or in response to- the diversification of agriculture. Consequently the demand for a diversity of varieties well adapted to new cropping system and to new outlets is increasing. Facing this demand, we assist to a concentration of the offer, in the hand of few economical actors. Our objective is to study the equilibrium between variety offer and demand and how the breeding system may fit the needs. The offer will be appreciate by the evolution, over the time, of the number of varieties proposed in the catalogues and by the evolution of the number and of the identity of breeding actors. The demand will be studied through several enquiries and represented by models.

1. THE FRENCH VARIETY OFFER

1.1. Evolution of the number of varieties

By comparing over a 20 years period, we observe an increase in the number of varieties of maize or wheat present in the French catalogues published in 1987, 1997 and 2007 (fig. 1). This number was multiplied by two during the last 20 years for wheat, by three for maize and by five for sunflower (data not shown).

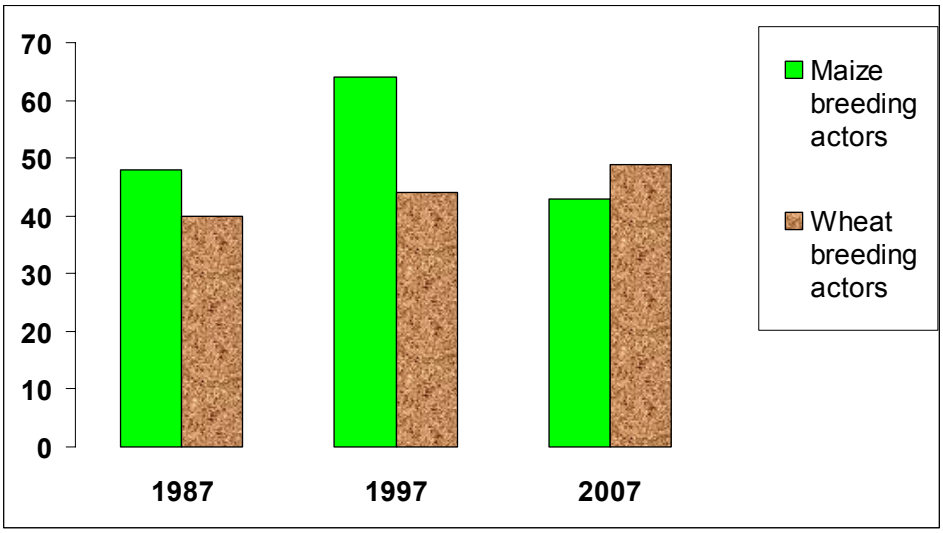
Figure 1. Evolution of the number of maize and wheat varieties registered in the list A - French Official catalogues of species and varieties



Source : French Official catalogues of species and varieties- published by GNIS (ed. 1987, 1997, 2007).

Considering the same period, the number of breeding actors in 2007 is equivalent to those in 1987, even if an increase was noticed in 1997.

*Figure 2: Evolution of the number of **maize and wheat breeding actors** who have registered at least one variety in the French catalogue*



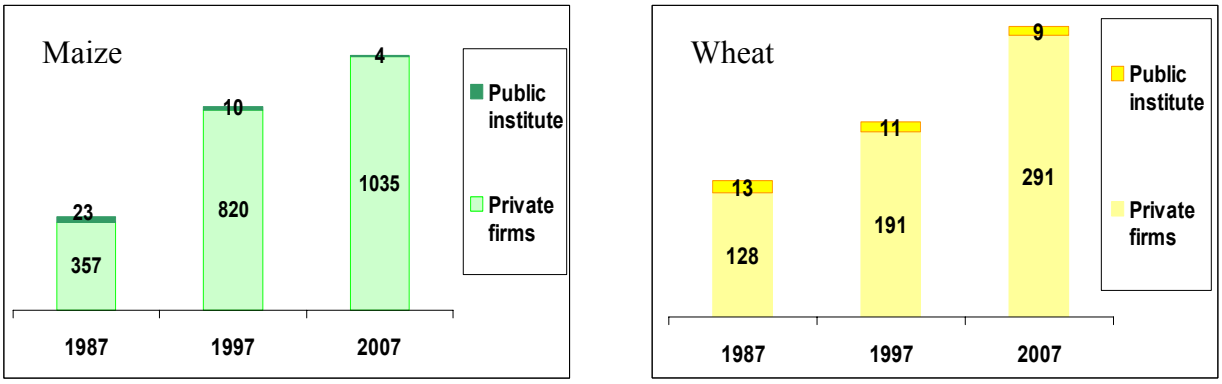
Source : French Official catalogues of species and varieties- published by GNIS (ed. 1987, 1997, 2007).

Consequently, the mean number of varieties per breeding actor is greatly increasing: 7.9 in 1987, 12.9 in 1997 and 24.2 in 2007.
Among the breeding actors, we notice a high level of renew. 380 breeding actors are mentioned in the Catalogue in 2007 and 63% are new (new names of the breeding company) in 2007 compared to 1987.

1.2. Who are the breeding actors?

There are less and less public institutes but mainly private firms (fig 3). In France, INRA was the main public institute having the mission to improve varieties when founded. But today, the Department of Genetics and Plant Improvement of INRA continue to ensure crop breeding only on six species and for precise targets: maize ensilage, rustic bread wheat, durum wheat for organic agriculture, winter pea, grapevine and fruit trees.

Figure 3. Number of registered maize or wheat varieties bred by private seed firms and by public institute



Source : French Official catalogues of species and varieties- published by GNIS (ed. 1987, 1997, 2007).

In the catalogue, varieties are obtained by numerous breeding companies…. but almost all are subsidiaries to very few multinational companies. Among them, the four first multinationals (Monsanto, Dupont/Pioneer, Syngenta and Limagrain/Vilmorin) represent more than 25% of market. The French seed sector realized 2.3 billion euros turnover in 2008. France is today the first European seed producer and the second at the international level, in matter of seeds exportation. Besides Limagrain, three others French breeding : RAGT, Euralis and inVivo are in the world 20 top.

The course to innovation is one point that accelerates the concentration. « What is important for a breeder is to market at least one variety per year. The new is primary for our consumer society » (L.Forêt – AgriObtention-pers.comm.).

The firm concentration is sit down on a portfolio of intellectual property rights.

The processus of seed sector concentration began long time ago based on fusions, acquisitions and alliances. This was necessary to face the long and costly investments and ensure a portfolio of activities and invest on new technologies. However, considering only classical indicators such as C4, i.e the weight of the 4 first enterprises on the market, concentration appears relatively limited with a C4 equal to 25.5% en 2008, and 21% in 1997 (Goldsmith, 2001). The weight on the market appears as an indicator not enough relevant to characterize the concentration and it seems necessary to look also on the structure of property rights by species and by country (Srinivasan, 2008).

1.3. Which type of variety innovation may a farmer find in a catalogue?

For economical reasons, private firms target the profitable market and therefore, are interested in breeding varieties adapted to conventional farming for industrialized processors and long chain market. Because of the U of DUS (distinctness, uniformity and stability), the varieties are pure lines for autogamous species, hybrids for allogamous species, or clones for species with vegetative reproduction. To create such variety, the classic plant improvement system, described as a centralized, sequential, linear process **(**Sperling et al. 2001)**,** is generally used by private plant breeders**.** Five main stages, (i) setting of objectives, (ii) creation of variability, (iii) selection, (iv) evaluation and (v) diffusion, compose the breeding program. The main objective of breeding programs is developing varieties that can be widely distributed and are thus suitable for a broad range of environment. The need for wide adaptation inevitably leads to a minimization of **GxE** interactions. The main pathway to minimization within industrial agriculture has been standardization of production conditions so as to render each **E** (environment) as uniform as possible. **E** is often considered as the interaction between the biophysical environment and crop management. Crop management may be viewed simply as a way of modifying or controlling biophysical environment by minimizing or exacerbating its limiting factors (depending on whether one wishes to express the potential or the shortcomings of a genotype**)**. The aim of private plant breeder is not to predict **GxE** interactions so much as to reduce their effects and to adapt **E** to **G** by standardizing **E.** This standardization consists to eliminate all limiting factors present in the biophysical environment by supply of inputs. This approach contributes to a standardized variety**,** under regulations for registration that imposes uniformity, and under the dominant market conditions that impose specific yield and technological quality (Desclaux et al. 2008).

2. AN INCREASING DEMAND FOR OTHER TYPE OF VARIETY

2.1. New target for plant breeding

Besides these classical types of variety present in the catalogue, a large diversity of varieties is required. Others models of Agriculture are emerging based on a large diversity of farming systems (low input, organic, agroecology, agroforestry…), and of farmers and consumers requirements (tab1).

For low input environments a different breeding logic is required. A limited margin of maneuver does not allow crop management to compensate for the limiting factors of the biophysical environment**;** and the wide range of uses prevents the emergence of a uniform, universal logic for variety**.** The aim is no longer to adapt the environment to the variety but just the reverse, to try to adapt variety to a wide range of environments.
This change is potentially disruptive to established plant breeding. The effort required partially explains the difficulty in rethinking breeding systems for new environments.

Tableau 1. Change of Paradigms

Paradigms (from Bardsley, 2003)	
Private firms	What is also needed…
• Conventional breeding for conventional farming	• Alternative breeding for innovating farming (organic, low input, …)
• Large adaptability	• Specific adaptability
• Uniformity (pure lines, hybrids, clones)	• Heterogeneity : populations, mixtures, …
• Breeding: from numerous crosses	• Breeding : from populations
• Innovations= from biotechnologies	• Innovations = from farmers Know-how
• Farmers = Customers	• Farmers = Partners

Source : derived from Bardsley, 2003.

2.2. Varieties for special outlets

For commercial reasons, some industrial enterprises aim to control both the seed sector and the agri-food sector. For instance, to produce a particular type of bread (Pain Jacquet), Limagrain creates wheat varieties that can be grown by farmers only under contract. The objective for the company is no longer to ensure the wide diffusion of a varietal innovation but to control and target the diffusion (stage v - Sperling et al. 2001) of a specific final product by imposing a variety, its guidelines and the exclusive delivery of the harvest. The evaluation stage of the breeding scheme (stage iv) thus may be narrow or even circumvented; the variety might not have to be registered in the official catalogue because seeds are diffused only within specified limits, such as an integrated value chain or a club. The purchase of the harvest at a guaranteed price is a main reason the kit comprising -variety, crop management and biophysical area - is accepted by farmers. The selection stage (stage iii) is either

conducted generically by choosing from the genetic diversity, or is considerably simplified, by introducing the gene of technological interest into a variety to obtain for instance a waxy maize or oleic sunflower. The logic of this model can be extended to include the privatization of genetic resources and their economic valorization via the integration of an entire sector (by firms involved both in plant breeding and agro-industrial sectors). The stage of setting objectives (stage i) creates opportunities for the combination or the emergence of value chains and specific market niches. It is as if the stages proposed by Sperling et al. 2001 (Table 2) were inverted (from stage v to stage i) by the desire to first control the diffusion stage. But, if this contractual flexibility offers an opportunity to escape to the classical seeds reglementation, it has been surprisingly reintroduced as a reglementary rule by the creation of a special list dedicated to "varieties reserved for industrial uses" (Anvar, 2008).

2.3. Patrimonial varieties

Some farmers, called by sociologists 'whole chain farmer', make not only the production but also the processing of their harvest. They are looking for a genetic resource with patrimonial and identity characters, able of becoming a "flag" variety at reduced cost, (a symbol of a social movement) or a « sentry variety » (considered by the Slow Food movement as a shield against uniform industrialized products). The variety of interest here is a designated phenotype, labeled « local population » or « old variety ». The objective is an extremely localized individual adaptation - at the scale of one farm, or even of one field. « Farmers must have at their disposal an enormous range of varieties which are as adaptable as possible: in other words, are accessible to different types of evolution, and thus neither very uniform nor very stable » (Kastler 2006). Irrespective of the biology of the species (self or open pollinated), the means range from the cultivation of populations under natural selection to mild pressure of mass selection by dynamic management (Goldringer et al. 2007). Evaluation and diffusion are no longer based on the classical criteria defining genetic progress (e.g yield or technological quality) but rather on consumer satisfaction.

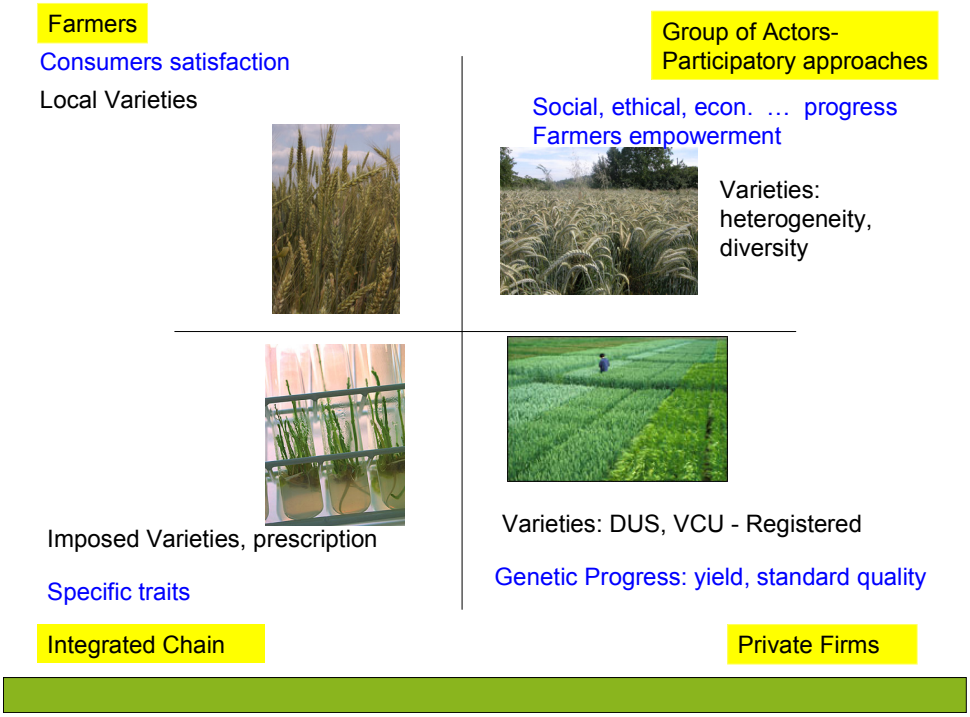
2.4. Multifunctional varieties

The aim is to reconcile the design of a new system for plant breeding and collective action. This model gives more equal weight to agro-ecological interactions (environmental aspects of sustainability) and socio-economic interactions (between actors). The organization of the emergent system of complex interactions may be facilitated by a participatory approach.

« Participatory plant breeding » (PPB) was originally developed in countries in the South. In Europe today, PPB concerns local projects for the creation of varieties adapted to environments in which organic and low input agriculture is practiced (Desclaux and Hédont 2006). PPB is described as an approach involving all the actors of a given sector not only in setting of breeding objectives, but also in managing the breeding process and the creation of varieties (Gallais 2006). It aims to respond to systemic issues and demands for which classic breeding appears to be unsuited (Almekinders and Hardon 2006; Cecarelli et al. 2001; Witcombe et al. 2003).

The reason this model is of considerable heuristic interest is that it modifies the stages profoundly: each stage becomes a function that will tend to exacerbate and reveal **GxE** interactions in both the agro-ecological and socio-economic dimension of the environment.

Figure 4. Four models of diversification of agriculture



source : derived from Sylvander, Pers comm.; Desclaux et al. 2008

3- WHAT COULD BE THE ROLE OF THE PUBLIC RESEARCH IN SUCH A CONTEXT?

In France, before 1946, plant improvement was made by farmers and few private breeding houses. Then, when created, the role of INRA was considered as major on the improvement of a great number of species. At the same time we attended a very fast evolution of the knowledge in genetics and biology.

Now, research in plant genetic is largely dominated and leaded at international scale by big multinationals firms and INRA loose its dominant position (Bonneuil and Thomas, 2009).

The role of INRA in plant improvement is delicate. INRA has not to compete with breeding private firms: " In that moment, there are 18 private breeders in France and it seems much more interesting that INRA concentrates its means, already too weak, on fundamental research rather than creating varieties and be a 19th breeder" (V.Desprez, cited by Bonneuil and Thomas, 2009); but anyway, INRA has also the role to go until the demonstration of a concept and not limit its mission to produce only fundamental knowledge (C.Tabel- RAGT-pers.comm).

Does the public institute must remain involved on plant breeding only for niche species or niche criteria?
Niche species means species that are not economically profitable for plant breeders. Sorghum, winter pea, oat, lupine, ... belong to the orphan species class. The lack of breeding

may lead the farmers to retire progressively such species in their cropping system. The need of a diversification of crop rotations requires breeding work on several species. It implies to make an important effort also on the improvement of several legumes.
As the same, some species able to play ecological roles (pollutes soils remediation, bioagressors refuges, impact on the soil microbial communities, water improvement, and reduction of gas emission…), or some targets needing a long anticipation (global change, multifactorial modifications: less water, more CO_2, more T…), are not compatible with the economical and temporal stakes of private breeders.
Niche criteria means specific target linked to innovating cropping system or to non-dominant target market: resistance to drought, pest tolerance, nitrogen and phosphorus use efficiency, adaptation to organic or low input conditions, intercropping, adaptation to hand craft process, nutritional value, ….

But does INRA have the financial means and the right organization to be able to cover all the requirements? The originality of INRA is to integer the application field. Important qualifications on plant improvement are present and should be used till variety creation. It seems important not to take away researchers from the field (C.Tabel, RAGT, pers.comm).

Researchers at INRA must also take a new posture that recognize the farmers as specialists of their environment and crops and make them full partners of research. The mobilization of users is a key condition of the success. Innovating lies on the integration of knowledge coming from the world of uses, the knowledge of farmers, of processors and the desire of consumers and not only from the experience of the breeder (Mcmeekin, et al, 2002, cited by Bonneuil).
Those who detain the need and context-of-use information are different from those like engineers having generic solution information. The knowledge and information needed to innovate are distributed into users collective with whom the R&D must collaborate to reach the aim (von Hippel, 2005).

CONCLUSION

The diversity of production systems and of valorization leads to a diversity of requirements for variety innovation. More largely, the evolution of the way of life and of the taste elicits the innovation of opinion (Bonneuil and al, 2009). An innovation must be conceived and construed with the market in the same interactive process.
According to the breeding actors and to their objectives, target varieties and breeding scheme differs. These different ways to envision varieties and plant breeding must not preclude one another but must be considered as complementary and able to renew the way to implement plant improvement for agriculture. « To Improve means to exploit a diversity of phenotypes. But recent selection tend to focus on genes and no more on phenotype » (Paillotin, 2006). The involvement of a great diversity of actors in plant breeding will help to integer the concept of phenotype in a whole that take into account systemic realities and heterogeneity of environment.
Because the phenomenon of concentration of breeding companies is increasing, some questions arise about the capacity of this sector to propose innovations closed to society demands. " The progressive withdrawal of INRA from plant breeding is only one aspect of the submission to the strictness of private seed sector " (Bonneuil and Thomas, 2009).
"Genetics, such as atomic bomb, is an arm that must be controlled by the Nation" (C.Beranger, cited by Bonneuil and Thomas, 2009) . "What would it means for INRA, to be a "under Monsanto » ? The aim of a public institute like INRA is not to compete with private firms but to ensure compliance with rules. Make better with more ethic and precaution " (JD Vincent , 2006). Without a great development of participatory plant breeding projects, it remains a risk that the diversity of requirements of new varieties would not be fitted.

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