Euphytica **92:** 353–357, 1996.

Traditional seed maintenance and origins of the French lucerne landraces

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Received 25 March 1996; accepted 6 June 1996

Key words: Medicago sativa, lucerne, landrace, seed production, genetic erosion

Summary

As for other forage crops the notion of variety is quite recent in lucerne (*Medicago sativa* L.). Up to 1950 in France, farmers cultivated landraces whose origins were geographically defined. Seed production was a by-product of forage production. Usually, seeds were harvested on the second or third crop, in old lucerne fields. Natural selection created landraces adapted to local conditions. In some years, climatic conditions, especially in northern regions, were unfavourable to seed production. In the exchanges and trades of seeds between French regions, the genetic origin of the seeds was omitted, the geographical origin was only mentioned. Even if France usually exported lucerne seeds, imports occurred in bad years. Seeds were imported from European countries and from North and South America. Varieties from America were poorly adapted to the French conditions for forage production. These foreign varieties have probably intercrossed with the local landraces but no data is available to know to what extent. Among the various French landraces, five main types were defined using morphological characters: 'Flamande' in the north, three types ('Poitou', 'Marais de Luçon', 'Marais de Challans') in the west, and 'Provence' in the south. These landraces have been widely used in breeding since 1950. Even though these five landraces are, up to now, maintained, the other landraces have probably been lost (no more cultivated and not in genebanks), replaced by registered varieties.

Introduction

Lucerne, or alfalfa, is a traditional forage crop in France, widely used for animal feeding. This crop (*Medicago sativa* L. ssp *sativa*) was definitely introduced into France in the 16^{th} century from Spain (Michaud et al., 1988) and spread all over Europe. Lucerne originates from Asia Minor, Transcaucasia, Iran and Turkmenistan and is diversified in the Mediterranean area (Michaud et al., 1988). Sub-species *sativa* is characterised by violet flowers, tap root, erect growth habit, coiled pods and kidney-shaped seeds, and is cold sensitive. The wild sub-species *falcata,* which also belongs to the *M. sativa* complex originated from Central Asia, and is widespread from Siberia to Germany and eastern France. Sub-species *falcata* has yellow flowers, fasciculate roots, prostrate growth habit, sickle-shaped pods and round seeds, and is cold tolerant. Both sub-species *sativa* and *falcata* freely intercross (Lesins & Lesins, 1979) resulting in landraces and varieties from Europe with characters such as variegated flowers, cold tolerance, intermediate content in saponins with the medicagenic acid sapogenin (Mayer, 1948; Julier et al., 1995, 1996). Cold tolerance provided better adaptation to climatic conditions of northern Europe. In France, pollination of lucerne is assured by wild bees, mainly belonging to the genus *Bombus* (*B. terrestris* and *B. pascuorum*), *Andrena* (*A. ovatula* and *A. labialis*), *Melitturga* (*M. clavicornis*), *Melitta* (*M. leporina*) et *Eucera* (*E. longicornis* and *E. clypeata*) (Tasei, 1978).

In France, before 1950, every region cultivated lucerne. Several features affected the evolution of the landraces: (1) the genetic origin of the landraces, (2) the natural selection which occurred between the sowing and the seed harvest, and (3) the introduction of seeds from other regions and from foreign countries (Mayer et al., 1951). The diversity of climates between southern France with a Mediterranean climate, western France with an oceanic climate and eastern France

with a semi-continental climate favoured natural or empirical selection of adapted landraces. However no official list of varieties existed to describe and fix the traits of the landraces. Farmers in some northern regions had, due to wet climate, difficulties to produce seeds, and they often bought seeds from other regions. National and international exchanges brought exotic germplasms that could intercross with local landraces. Even now, most of the existing registered varieties in France have local landraces among their progenitors, whereas the French 'Flamande' type is one of the nine basic sources used in breeding in North America, under de name 'Flemish' (Barnes et al., 1988). Although official lists of varieties were created for some crops in France in 1932, registration of lucerne varieties with rules for distinction, homogeneity and stability only took place in 1950. This paper will focus on the traditional methods of seed maintenance. Methods of seed production influence the genetic background and the evolution of the landraces. Organisation of the lucerne seed trade will be presented because imports of seeds imply arrival of non-indigeneous germplasm. Several studies, made between 1930 and 1960 in order to collect, to evaluate and, to classify the French landraces, will be presented.

Traditional seed maintenance

Methods of seed production for a species are adapted to its floral biology, its physiology and its agricultural uses. Lucerne is cultivated for forage production. For a long time, seed production was considered as a by-product of the forage production, so lucerne fields were never devoted solely to seed production (Bustarret, 1948).

In France, before the creation of an official list of lucerne varieties, landraces were open-pollinated populations. Autotetraploidy and allogamy assure this crop a wide genetic diversity, even within a population. However, very rapid genetic drift can occur if seed production is made in an 'unadapted' environment. Furthermore, genetic drift can be increased if seeds are produced on a several years-old field, where many plants have already died.

Depending on the location in France, from three to six forage harvests can be made in a lucerne field, from the north to the south. The first two harvests are the most productive ones. Even though lucerne was cultivated almost everywhere in France, only a few regions have favourable climate for seed production. In 1930, three regions produced 92% of commercial lucerne seed: the Mediterranean region (44.5%), the Aquitaine Basin (31%), and the Centre-West region (16%) (Alabouvette & Méneret, 1935). However, depending on the climatic conditions of the year, the region south of Paris (the Beauce) could produce high quantity of seeds (Bustarret, 1948).

In most cases, plants were allowed to produce seeds in the second or third crop (Stebler, 1896; Seltensperger, ND; Bustarret, 1948). This procedure allowed harvest of forage in early spring, and of seed sufficiently early before wet periods in autumn. Usually, lucerne fields devoted to seed production were the oldest ones (three to six years old) that were intended to be ploughed in the following autumn (Stebler, 1896; Seltensperger, ND). Forage was the main product of the crop, and seed was only a by-product. Farmers wanted to maximise forage production by harvesting the most productive crops, i.e. the first cut in each year, in the first years of the field. In the second or third crop, especially in old fields, forage production is poor whereas seed production is satisfactory. This procedure, which results from economic considerations, implies that some natural selection had occurred before these fields were used for seed production. Indeed, if about 1000 seeds/m^2 are sown, about 150 plants remained after 3 years, and 50 plants after 5 years (unpublished data). Competition among lucerne plants, competition with weeds, frost sensitivity and pest susceptibility induced plant death. Moreover, in a field, seed production per plant is unequal. Both plant death and different seed production per plant were influenced by the plant genotype, which caused a genetic drift between the seeds sown and the seeds harvested. In the 1950's, Felix (1954) suggested having fields especially devoted to seed production. He recommended to have agronomic practices that favoured seed production. Canal & Desroches (1956) suggested identification of the mother-plants of the varieties, and restricting to a fixed number of generations to obtain the commercial seed in order to avoid genetic drift.

Each farmer who cultivated lucerne tried to produce his own seed. He came to the decision to produce seed if its forage production was sufficient, and if climatic conditions seemed propitious (Alabouvette & Méneret, 1935). This resulted in some irregularity of production. For instance, in some dry years, farmers of the northern regions decided to produce their own seed. In favourable years, if a farmer had too much seed for his own use, he could exchange or sell a part of it. In bad years, he had to get seed from his neighbours or

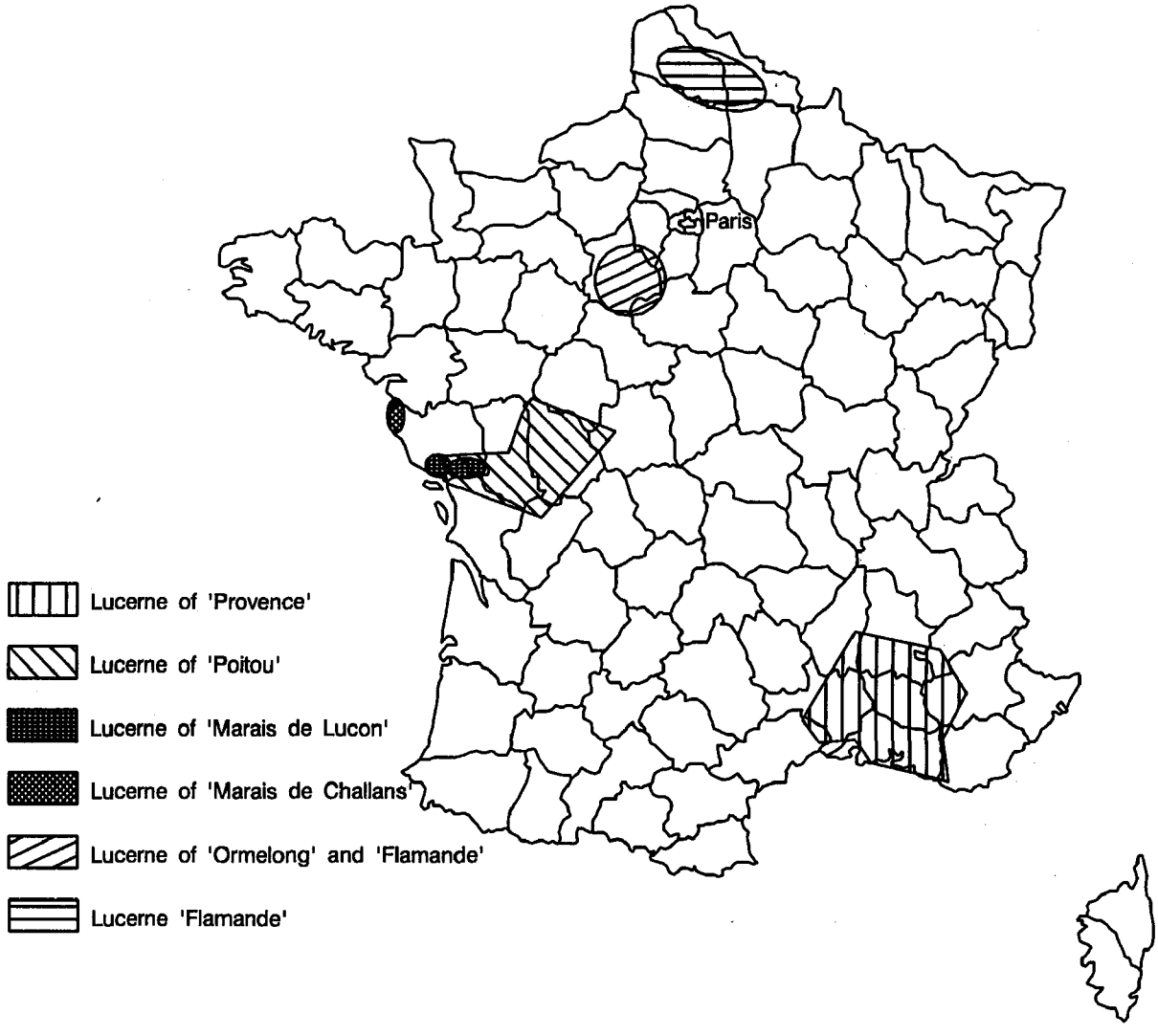

Figure 1. Geographical origin of the French landraces (from Mayer et al., 1951).

to buy them. In 1935, Alabouvette & Méneret recommended farmers to use their own seed because local landraces were supposed to give higher yields, better perenniality and pest resistance. In regions where seed production was impossible, the authors advised use of commercial seed from a climatically similar region.

Organisation of the seed trade

In the period before and just after the Second World War, France produced between 8000 and 16000 t of lucerne seed depending on the year. Only 4000 to 10000 t were on the commercial market, and 2000 to 5000 t were available for exportation (Bustarret, 1948). The fame of the French lucerne seed explains the important exports, especially to the US. Seed merchants used to get seed produced by the farmers, whatever their genetic background. Seed batches were named with their geographical origin (Alabouvette & Méneret, 1935; Mayer, 1948). The main lucerne populations were 'Provence' from the Mediterranean region, 'Poitou-Vendée' from the west, and 'Flamande' (or 'Flemish' in the USA) from the north. Purchasers were mainly interested in seed quality (specific purity, germination ability, colour as an indicator of germination capacity). Seeds originating from the Provence were valued in France but also in oth-

er countries because of their high seed quality due to the favourable climate (Bustarret, 1948). Most years, France over-produced lucerne seeds and exported them. Before 1930, only 'Provence' was exported, and after 1930, exports of the frost tolerant 'Flamande' types also took place (Mayer et al., 1951), but the seed production was very irregular, and in bad years, seed was imported from foreign countries (Alabouvette & Méneret, 1935). In that case, seed was named by the country of origin, without any details of origin. Imports of seed from Hungary, Germany, Italy, Turkestan, North America, Argentine, Peru, Egypt, Anatolia, Ukraine, Spain, South Africa, Portugal were reported (Bustarret, 1948; Mayer et al., 1951). For example, France imported lucerne seed in 1932–1934: of these imports, 4% came from European countries, 40% from Argentine, 29% from the United States, 15% from South Africa and 7% from Turkestan. In most cases, imported seeds, except those from European countries, gave poor forage production in France due to high frost sensitivity and pest susceptibility, and lack of overall adaptation (Stebler, 1896; Bustarret, 1948).

Merely indication of the geographical origin of seed batches was known to be inadequate (Stebler, 1896; Bustarret, 1948), because of the various cultivation modes (cutting or pasture), types of soils and climates, and the exchanges of seeds between French regions and between countries, influenced the genetic background of lucerne. Stebler (1896) and François (1924, 1927) gave lists of weeds that were specific to some origins. Alabouvette & Méneret (1935) mentioned that the presence or absence of some weed seeds was not a convenient method to determine the geographical origin of the lucerne seed because sorting out or addition of weeds could be made by anyone. They stated that seed production had to be organised, and suggested that the lucerne populations to be multiplied had to be selected and that the fields for seed production had to be cared for as for other crops.

Origin of the French lucerne landraces

The preferential use of local landraces induced particular adaptation to the climatic and pedologic conditions of the regions. Soon after the Second World War, collection, evaluation and classification of the French landraces were initiated (Mayer et al., 1951). Because of the presence of ssp. *sativa* and ssp. *falcata* hybrids in the French landraces, Mayer et al. (1951) evaluated the landraces according to the morphological traits that separate the two sub-species: flower colour, root characters, pod shape, seed shape, growth habit, winter development, flowering date, frost resistance. They collected 98 populations around France, evaluated them at Versailles, and classified them using these criteria. Three main groups were proposed: 1. lucerne from Provence (Mediterranean region); 2. western lucerne with two sub-groups: lucerne from Poitou and lucerne from Marais; 3. 'Flamande' with a related type of lucerne from Ormelong. These types were also defined according to their geographical origin (Figure 1). This classification was later revised by Demarly (1957) with few changes (Table 1). Within western lucerne however, three types were identified: lucerne from Poitou, lucerne from Marais de Luçon and lucerne from Marais de Challans. The fact that the landraces were distinguished by the percentage of plants with certain characters implies in fact a very large within-landrace diversity. For example, Clavier (1964) underlined the heterogeneity of 'Provence' landrace. Seed production of western lucerne and of 'Provence' lucerne did not meet any problems because their native regions usually have suitable climatic conditions. Seeds of 'Flamande' were mainly produced in the Beauce, a region south of Paris (Mayer, 1950).

In 1950, these main landraces were registered on the official list of varieties as 'Commercial marks' except the population from Ormelong which was registered as the variety Du Puits. Within 'Flamande', four commercial 'marks' (or cultivars) were registered (by four breeders): 'Chartrainvilliers', 'Flandria', 'Soucheville' and 'W 268'. Progressively, synthetic populations were bred and registered. In the agronomic evaluation that followed the first steps of scientific breeding, only the main types were used. In 1970, by a decision of GNIS (Groupement National Interprofessionnel des Semences) and CTPS (Comité Technique Permanent de la Sélection), all the landraces were removed off the list of varieties. It was also decided to maintain these landraces, under the responsibility of the breeders gathered in ACVF (Association des Créateurs de Variétés Fourragères). As they represent interesting genetic resources for breeding, it can be said that most of the modern varieties bred in northern Europe are of 'Flamande' germplasm, and most of those bred for the Mediterranean climate are of 'Provence' type.

The main problem set by the classification is that landraces originating from other French regions were considered as intermediate between two or more types.

Table 1. Morphological traits of the six main French lucerne landraces (from Mayer et al., 1951 and Demarly, 1957)

Landrace	% of plants with variegated[1] flowers	% of plants with a tap root	% kidney-shaped seeds	Average number of pod coils[2]	Frost tolerance[3]
Flamande	< 15	< 40	> 40	2.15	+++
Ormelong	< 15	> 50	> 40	2.00	+++
Poitou	> 15	> 40	< 40	2.30	+
Marais de Luçon	> 15	< 40	< 40	2.45	+
Marais de Challans	< 15	> 40	> 40	–	-
Provence	< 8	> 50	> 40	2.85	- -

[1] Variegated flowers are violet with traces of yellow. The other flowers are violet.
[2] The average number of pod coils is 2.5–4 in pure spp. *sativa*.
[3] +++, + are for high and good frost tolerance, - and - - are for low and very low frost tolerance, respectively.

Although these landraces belonged to the range of variation covered by the five main types, they show other valuable combinations of agronomic traits (Y. Demarly, comm. pers., 1995). They were progressively replaced, from 1950–1960, by registered varieties and disappeared. We can now consider, with no doubts, that, except for the five main landraces, the other French populations are definitively lost, as they are no more cultivated and are not in genebanks.

It is especially difficult to evaluate the effect of the imported varieties in the evolution of the French local landraces. As early as 1935, Alabouvette & Méneret questioned the use of unadapted landraces from North and South America for seed production. Intercrosses between local landraces and imported populations probably occurred. But as genes from unadapted varieties induced a poor multiplication rate, the effect of these foreign populations on the French landraces is probably limited.

Acknowledgements

Y. Demarly and P. Guy are thanked for their efficient searches, in both their memory and in their archives, for the early steps of lucerne breeding.

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