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Vincent Beguier, E. Guillemot, Bernadette Julier

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# Alfalfa forage quality breeding in France: 30 years of common efforts from seed industry, dehydration industry and public research.\*

Béguier V. <sup>1,2\*</sup>, Guillemot E.<sup>3</sup>, Julier B. <sup>4</sup>

<sup>1</sup> Jouffray-Drillaud / GIE GRASS, <sup>2</sup> ACVF, <sup>3</sup> COOP de France Déshydratation, <sup>4</sup> P3F, INRA

\*e-mail : vbegquier@jouffray-drillaud.fr

**KEYWORDS:** Alfalfa breeding, forage quality, protein content, ADF, Dehydration

## ABSTRACT :

Alfalfa is an important forage crop in France, where a highly structured dehydration industry has developed in particular. The improvement of alfalfa genetics in France is very active, supported by a dynamic seed sector associated with the involvement of public research. 30 years of joint efforts had led to the improvement of the feeding value of alfalfa at the genetic level without altering genetic progress in yield.

## INTRODUCTION:

Alfalfa (Lucerne ; *Medicago sativa* L.) is a major forage crop in France. It is grown on around 600 000 ha (300 000 ha of pure alfalfa, at least 300 000 ha of alfalfa-grass mixtures), with an average yield of 12 t/ha. From this area of production, a strong dehydration sector produce around 900 000 T of pellets and balls. This sector is well organized and its requirements are determined by Coop de France-Déshydratation. Dehydration plants establish contracts with farmers for forage production, and these farmers are paid as a function of their production tonnage. In 2017, 66752 ha of alfalfa have been contracted for dehydration.

INRA (Institut National de la Recherche Agronomique), the french public organisation in charge of research for agriculture in France, has long time established research program on Alfalfa, involving different labs on agronomy, crop physiology, ruminant nutrition genetics. The institute has also established long time research collaboration with the seed private sector (starting in the 1970's). Seed companies involved in Alfalfa breeding are organized in an association, ACVF (association des Créateurs de Variétés Fourragères) to develop pre-competitive research.

Alfalfa varieties must be listed in the EU catalog to be sold in France. In practice, registration in the french list is mandatory to be recommended by the dehydration sector. Evaluation and Registration of seed varieties in France is conducted by the CTPS (Comité Technique Permanent de la Sélection). CTPS comprise representatives (experts) from three sectors : public research, breeders and end-users, together with administrative staff from the GEVES (the body responsible for evaluation on behalf of the CTPS). The CTPS proposes to the Ministry of Agriculture the registration of valuable varieties, as well as changes to the registration regulations so as to adapt the catalogue to current uses and futur needs.

## Alfalfa forage quality breeding in France :

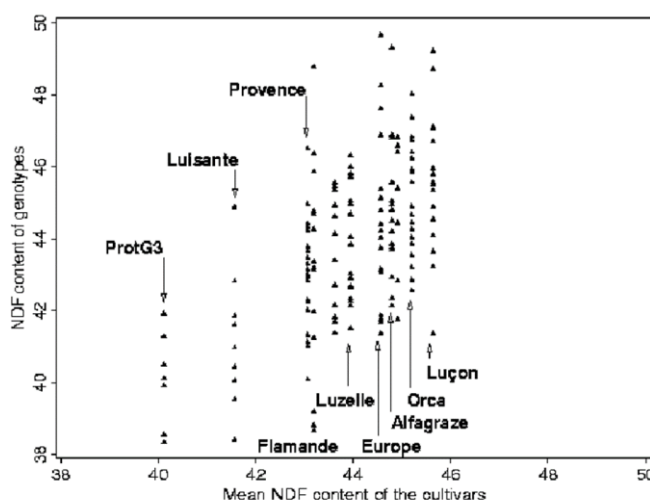
The French Ministry of Agriculture supports the agricultural sector by providing financing under contracts between the private sector and public research organizations. Therefore, given the strong relationship between INRA, seed companies and the dehydration industry, pre and non-competitive research partnerships were initiated in the 1990s to improve the nutritional value of alfalfa. The objective of this partnership research has been to improve the protein and energy value of alfalfa, while maintaining good levels of yield progress.

In 1994, INRA's Plant Biology and Breeding Division (BAP) start studies on Energy value trait following studies by INRA's Environnement and Agronomy Division (EA) (agronomy, crop physiology, 19080-1995) and Animal Physiology and Livestock Systemes Division (PHASE) (ruminant nutrition, 1995-2000) (Julier, 2015). Indeed, these studies have shown that dairy cows fed with alfalfa forage of good digestibility had milk production

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increased by 1 to 1.4 kg of milk per cow per day compared to cows fed with a forage of less digestibility (Emile et al., 1996). Therefore, from 1994 to 2003, different research contracts funded by the Ministry of Agriculture, involving INRA, ACVF and Coop de France déshydratation produced different knowledge and know-how that made it possible to take into account the improvement of feeding value in the seed companies alfalfa breeding programs.

The first achievement was the demonstration that a genetic variability exist within and among alfalfa varieties (Figure 1.), (Julier et al., 2000).



**Figure1:** Within- and among-cultivar variation for NDF content (%) observed for the harvest on 30 May 1996, for 7 to 20 genotypes per cultivar and 11 cultivars. Each value represents the average of three plots of five clones per genotype.

From this result, different studies have allowed to evaluate the genetic variability between varieties and populations regarding digestibility, genetic variability within varieties for digestibility and the most important for the dehydration industry and breeding companies, the development of NIRS equations and testing of their accuracy to predict the digestibility and protein content of dried forage in experimental studies designed to describe genetic variations. For feed value, the ADF (Acid Detergent Fibre) content, which correlates negatively to digestibility, was shown to be the most heritable trait and displayed the most genetic variation.

From the early 2000's, Seed companies involved in ACVF are using these knowhow and knowledge in their breeding program. The challenge to face is to improve feeding value (Energy and Protein) without losing yields and also improved disease resistance (Mainly Stem nemtode, Verticillium and Anthracnose). Genetic correlation is indeed negative between digestibility and forage yield but positive between digestibility and protein content (Julier et al, 2003). And lodging resistance, negatively correlated with digestibility, is particularly important in France where due to the harvest organization of the dehydration plan, the harvesting schedule is around 40-50 days between each cut.

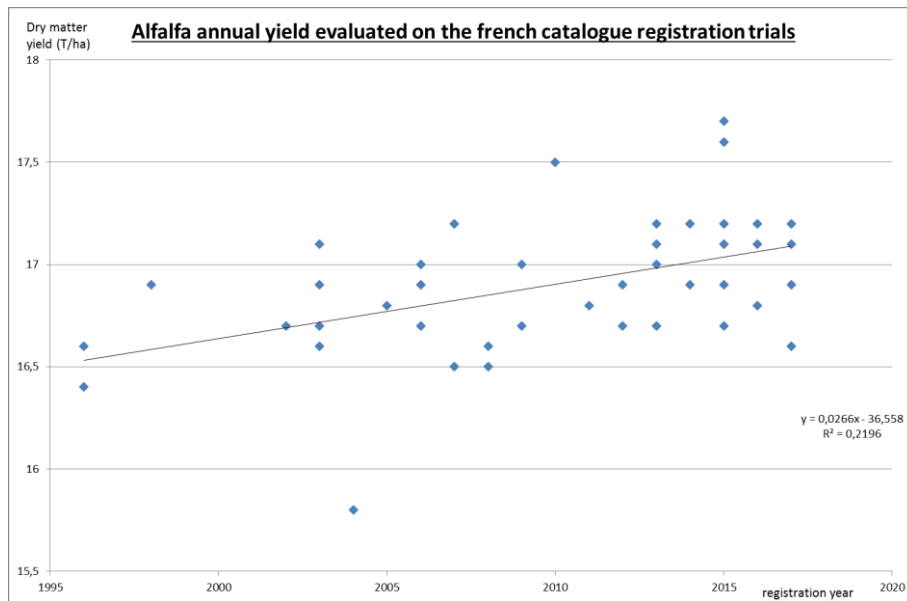
These different results has a direct impact on the regulatory. CTPS has established a list of traits of major interest for alfalfa varieties registration. Since 2000, protein content is measured and included in the score of each variety compared to control varieties, and since 2007, ADF (digestibility) has also been included.

At the same time, the seed industry and the dehydration industry have promoted the fruit of these collaborations by developing a variety assessment. Since 2001, Alfalfa varieties registered in the french catalogue are evaluated specifically for the dehydration sector and a recommended list is published to help farmers who have contracted with dehydration plan. This list is published based on a 2 locations – multiannual trials conducted by Coop de France-Déshydratation and the seed sector represented by their union (UFS – Union Française des Semenciers) ( Larbre, 2015 - <http://www.luzernes.org/?q=luzerne-et-agronomie/circulaires-agronomiques>).

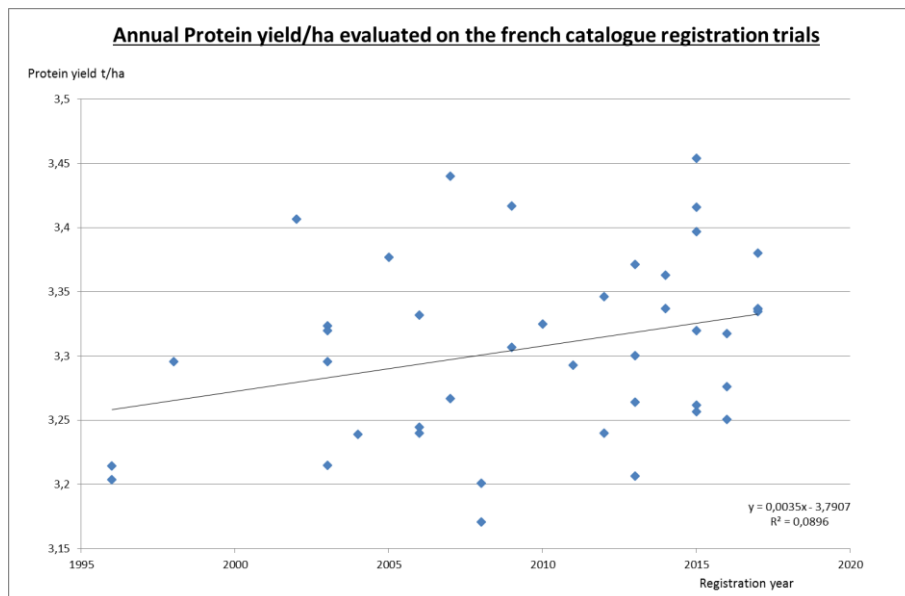
## ACHIEVEMENTS

What impact has this collaboration on varieties registered and marketed in France?

First, continuous genetic progress has been made on dry matter yield as it can be seen in Figure 2. At the same time, there has been a genetic advance in protein content that results in an increase in protein yield per hectare (Figure 3).

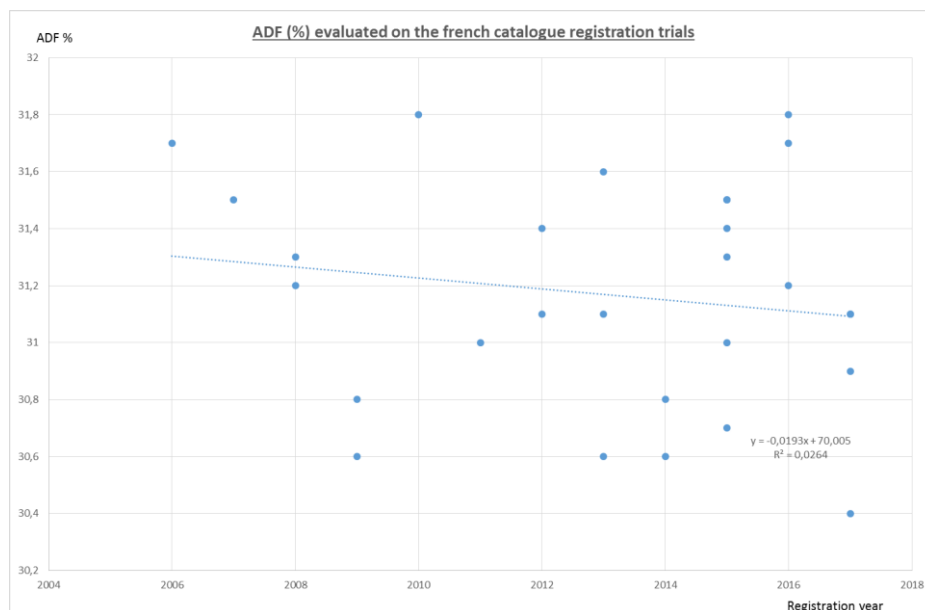


**Figure2:** Illustration of genetic progress in total annual dry matter yield obtained at the time of registration of alfalfa varieties in the French catalog.



**Figure 3:** Illustration of genetic progress in total annual protein yield obtained at the time of registration of alfalfa varieties in the French catalog.

Genetic progress on digestibility is less obvious (Figure 4). But we can see that among the most recent varieties, some have been improved in digestibility (reduced ADF content) while progressing in yield of dry matter.



**Figure 4:** Illustration of genetic progress in ADF content (Acid Detergent Fiber) at the time of registration of alfalfa varieties in the French catalog

At GIE GRASS, we implemented the tools developed during these collaborations and obtained good achievements. For exemple, we registered a variety in 2015 who illustrate these gains. During the registration trial, it displayed a protein content and ADF content at 104,5% and 98,6% versus the control varieties, respectively (A reduction in the ADF content constitutes a progress). This advance was achieved with a good forage yield (104,7 % of the control varieties).

## CONCLUSIONS :

30 years of collaboration and efforts from public research, the seed industry and the dehydration industry, with the financial support of the French Ministry of Agriculture, have led to the availability of alfalfa varieties to producers improved both in yield and quality (protein, digestibility). The partners of these collaborations are currently evaluating in a new program supported by the Ministry of Agriculture, the VARILUZ project, how these progress can be exploited optimally by the dehydration industry. The final results will be published in 2020.

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