Breeding Advances in Tuberous-Rooted Chervil (*Chaerophyllum Bulbosum* L.), a New 'Old Vegetable' Among the *Apiaceae*

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Abstract

The rehabilitation of forgotten vegetables is one of the ways in which vegetable diversity can be broadened. It also contributes to the genetic resource conservation of minor vegetable crops. This R&D theme has been developed by our laboratory since 1975. Tuberous-rooted chervil (*Chaerophyllum bulbosum* L.), belonging to the *Apiaceae*, is one of the main vegetables that have been studied. Tuberous-rooted chervil is a wild biennial, native to Central and Eastern Europe. Since its introduction in agriculture in France in 1846, this winter root vegetable has not undergone any real development until 1984, the year in which our work began. The tuberous root, with an ochre skin and white flesh, is edible and similar to a short carrot. Although the roots are harvested in July, their edibility becomes effective only at the end of the autumn when root reserves have undergone a biochemical change favoured by cold temperature. Because of its biochemical composition and its delicate flavour, tuberous-rooted chervil is considered a gourmet vegetable. Considering that genetic progress is the first step for a significant economic revalorisation of tuberous-rooted chervil, an important breeding programme was undertaken. The main objective was the reduction of the seed embryo dormancy, which normally is removed by the natural winter conditions in the field. At the same time considerable attention was paid to the improvement of root morphology and an increase in yield. After 'Altan', obtained in 1986 by mass selection, two new varieties - 'Véga' and 'M_4.10' - , mainly characterised by a low seed embryo dormancy, have been proposed for plant breeders' rights according to UPOV in 2000. Thanks to these achievements the crop development of tuberous-rooted chervil is starting up in France, mostly in the Loire Valley and the north of Brittany.

INTRODUCTION

Tuberous-rooted chervil (*Chaerophyllum bulbosum* L.) (Fig. 1), belonging to the *Apiaceae*, is a biennial native to Central and Eastern Europe (Fig. 2). Its tuberous root is edible for humans. Because of its biochemical composition (Billot et al., 1989; Ayala-Garay et al., 2001) and its delicate flavour (Péron, 1986), tuberous-rooted chervil is considered a gourmet vegetable. Since its introduction in French agriculture in 1846 this winter root vegetable has not undergone any real development. Until 1986 tuberous-rooted chervil was produced only in three or four market gardens (Péron, 1986). Our laboratory investigated this species in order to improve its commercial development and, in this way, to broaden the vegetable range (Péron, 1989, 1990) and, at the same time, to contribute to the genetic resource conservation of minor vegetable crops (Péron, 1992).

As a result, considering that plant genetic progress is the first step towards a significant economic revalorization of tuberous-rooted chervil, an important breeding programme has been carried out since 1982. It was aimed at improvement of root morphology, increases in yield and, mainly, the reduction of the seed embryo dormancy, which was the greatest problem to be resolved (Péron, 1989). This paper describes the most important results, which have been obtained in the breeding programme.

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MATERIAL AND METHODS

Material

In 1983 and 1984 three landraces, cultivated by traditional French growers, were collected. INH first carried out a preliminary study on the morphological, physiological and agronomic aspects of the plant and then investigated a breeding programme. The three landraces were:

- 'C', landrace from the Châteauneuf-sur-Loire region (Department of Loiret) near Orleans
- 'D', landrace from the Dôle region (Department of Jura) near the Swiss border
- 'E', landrace from the Etampes region (Department of Essonne) south of Paris.

From 1985 until 2000 the collection was supplemented with wild populations collected in the east of France (Rhine and Ill valleys), in Germany (Elbe, Lahn, Neckar, Saale, Vera, and Rhine valleys) and in Romania (region of Voronetz).

Methods

Conventional plant breeding methods were used:

- mass breeding
- self-pollination or half-sibling pollination to obtain inbred lines offering characteristics such as low embryo dormancy, globular root form or light-coloured roots. For these operations we used individual insect-proof cages in which flies were introduced for pollination.
- hand-made hybridisation between different lines.

Each generative phase for plant breeding (flowering, pollination and seed production) was carried out in the open field, with or without insect-proof plant protection. According to the biennial character of the plant, a new generation was obtained every two years.

For selection against the strong embryo dormancy the experimental progenies were sown on different dates, from 15 November - the traditional sowing date - to 15 March.

For all the progenies to be examined from seedling to mature tuberous-root stages, sandy soil and large well-ventilated plastic greenhouses were used. Two replications of 180 seeds each (distance of 1.5 cm from seed to seed and 30 cm from sowing row to sowing row) were performed. The harvesting of the root was carried out on 1 July, when the leaves were completely dry. The harvested roots were stored in a ventilated chamber under controlled conditions (4°C, 90 % air humidity) until 15 December, the date for root planting. The flowering period occurred in May.

In parallel to the investigations on embryo dormancy reduction, the genotypes were evaluated for foliage characteristics (leaf division and colour, foliage width), root characteristics (size, shape, epidermis colour, smoothness, shoulder shape,…), physiological behaviour and yield.

RESULTS AND DISCUSSION

The most important results are shown in Fig. 3. Each year, from 1985 to 2000, about 50 to 60 progenies were examined and submitted to screening in October. Selected genotypes were conserved for the next generation.

General Leaf and Root Morphological Tendency for all the Selected Progenies in the Cultivated Material

According to market demand, a morphological ideotype for the root was proposed in 1986 (Fig. 4):

- obovate or obtriangular shape
- blunt or rounded end shape
- low shoulder width
- superficial and short-surfaced lenticels
- bright brown skin

- optimal root diameter between 3 cm and 5 cm (weight from 15 to 70 g)
- intermediate or large root ratio length (L)/diameter (∅) [L = 1.3 to 2.5 ∅].

Selection and Performance of Material Issued from Mass Breeding

In 1986 two genotypes were obtained by mass breeding from C and D, the original populations. As the genotype issued from D was the most attractive for the market (more globular root and brighter skin), it was selected as a commercial variety at the beginning of our plant breeding programme. It was called ‘Altan’ and was used as a control during the entire second part of the breeding programme.

Selection and Performance of Material Issuing from a Series of a single Plant Selfing

In general, self-compatibility was observed during successive generations, and inbreeding did not have a significant effect on root weight, plant height or flavour. This means that selfing lines could be used as commercial varieties and it was not necessary to resort to hybrids in order to recover hybrid vigour.
The number of generations to obtain stabilised lines for some characters, such as embryo dormancy time and root shape, was limited to 3-6 (Table 1).

Selection for the Reduction of Embryo Dormancy Time

Normally the embryo dormancy can only be broken by stratification - low temperature and high soil humidity during a minimum of eight weeks (Augé et al., 1989). Thanks to the breeding pressure, which consisted of sowing the best genotypes selected for root morphology and yield later and later, numerous lines showing a low seed embryo dormancy were obtained. They can be sown in February for immediate germination. Seed stratification is no longer required. Two of them were selected in 1998: 'Vega' and 'M_4.10' (Fig.5). The description of these genotypes is given in Table 1.

Evaluation of the Hybrid Vigour Effect and the Inheritance of Some chAracters

The cross between wild material, characterised by a small and dark brown root, and a selected S6 progeny from Population ‘D’ shows that the effect on hybrid vigour was not very marked and that the characteristic dark brown colour of the root was dominant and appeared as monogenic.

CONCLUSION

Our plant-breeding studies resulted in the conservation in our laboratory of about 60 accessions and the development of nearly 200 progenies. A large collection of wild populations and strains of *Chaerophyllum bulbosum* has been established. All this material contributes to the enlargement of the genetic variability of *C. bulbosum.* Moreover, genetic distance, using molecular markers, was studied on all the conserved material **(**Briard et al., 2000).

‘Véga’ and ‘M4.10’ have been proposed for plant breeders' rights according to UPOV in 2000. These two varieties can be sown in February and not in November like ‘Altan’ (Fig. 6). According to their performance in reduction of the culture time and in root shape, they will be offered to the growers of tuberous-rooted chervil, who are mostly located in the Loire Valley. Thanks to these achievements we hope the crop of tuberous-rooted chervil will undergo a significant development in France.

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Tables

Table 1. Characterisation of 'Vega'and 'M4. 10'cultivars, proposed for plant breeders'rights to UPOV in March 2000 (Peron, 2000).

	Vega	**M4.10**
Genetic form	Self line	Self line
Origin	'D' (=landrace from Eastern France)	'D' (=landrace from Eastern France)
Collecting date of origin	1984	1986
First breeding objective	Root morphology and high yield	Low embryo dormancy
Pedigree	7 selfing generations	3 selfing generations + 2 half sibling generations
Main characteristics	- Low embryo dormancy -Leaf with dark green colour, very fine division and fine insertion crown - Long root with an obtriangular longitudinal form, flat to rounded shoulder, light external colour, slightly pointed to pointed tip and smooth surface.	- Low embryo dormancy -Leaf with medium green colour, medium to fine division and fine insertion crown - Root with medium length, an obovate longitudinal form, flat to rounded shoulder, light to medium external colour, blunt to slightly pointed tip and smooth surface.

Figures

Fig. 1. End of tuberization phase of a cultivated genotype in June.

Fig. 2. A wild plant of tuberous-rooted chervil growing on sandy soil of Ill's river, Alsace, France.

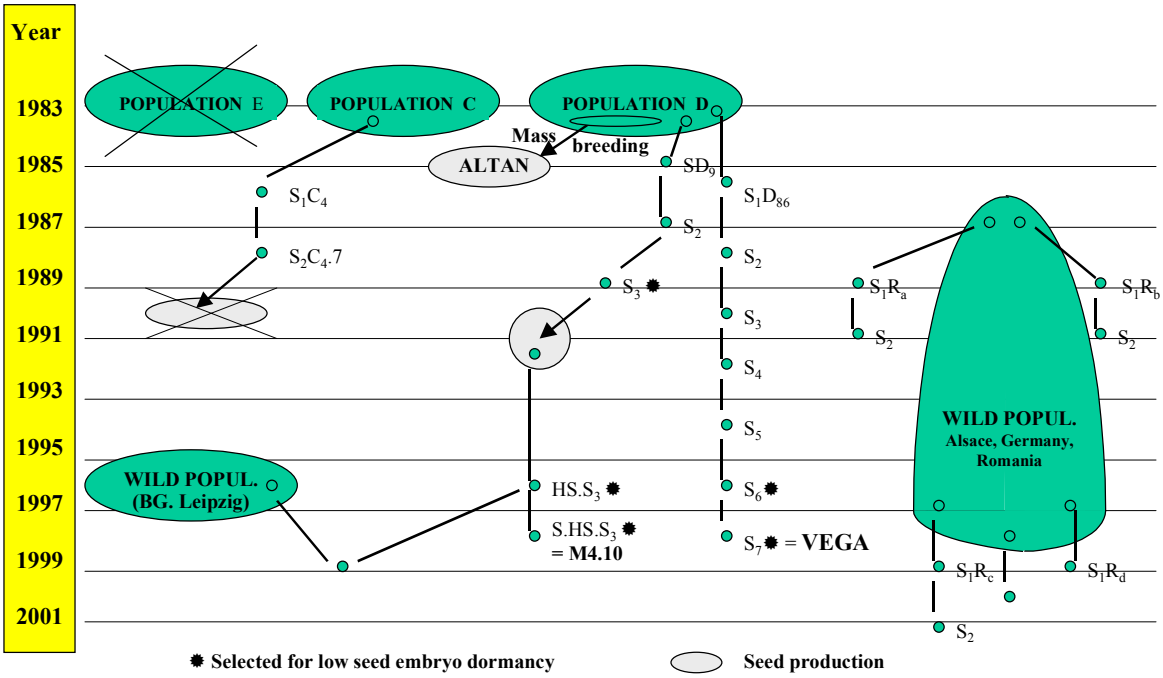

Fig. 3. Pedigree of tuberous-rooted chervil progenies obtained in INH's Vegetable Crop Laboratory during the period 1983-2001.

Fig. 4. Root morphological tendency.

Fig. 5. Root shape of Vega and M4.10 varieties obtained in 1998 and selected for a low seed embryo dormancy.

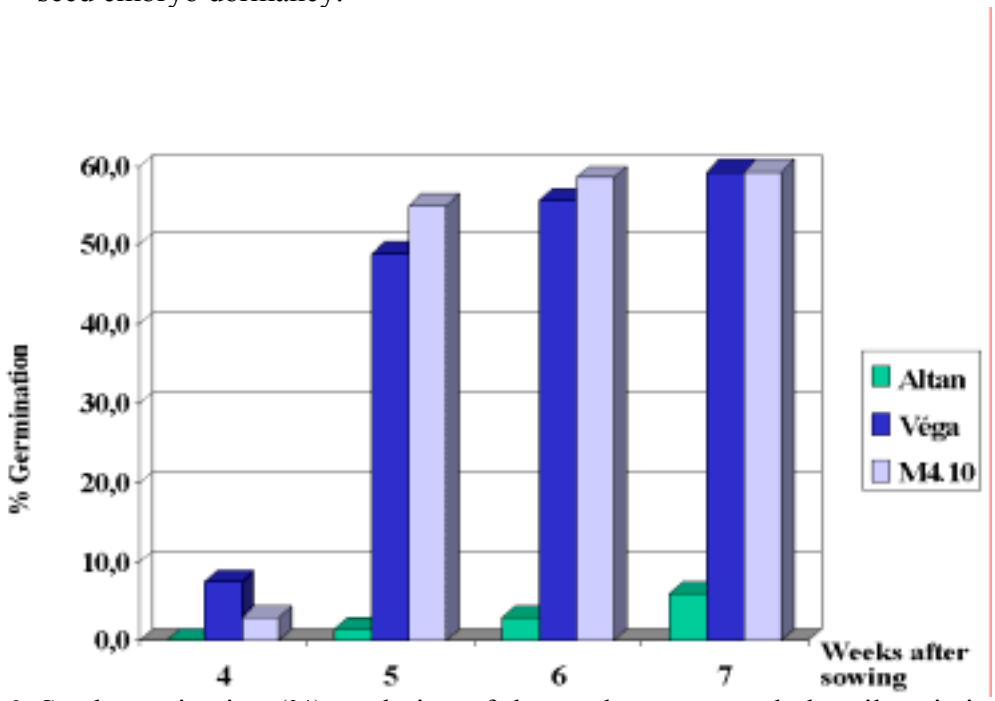

Fig. 6. Seed germination (%) evolution of three tuberous-rooted chervil varieties from 4 to 7 weeks after sowing. 'Altan (control) – characterized by a strong seed embryo dormancy-, 'Vega' and 'M4.10' –both characterized by a low dormancy-, were sown on February 20th 2000.

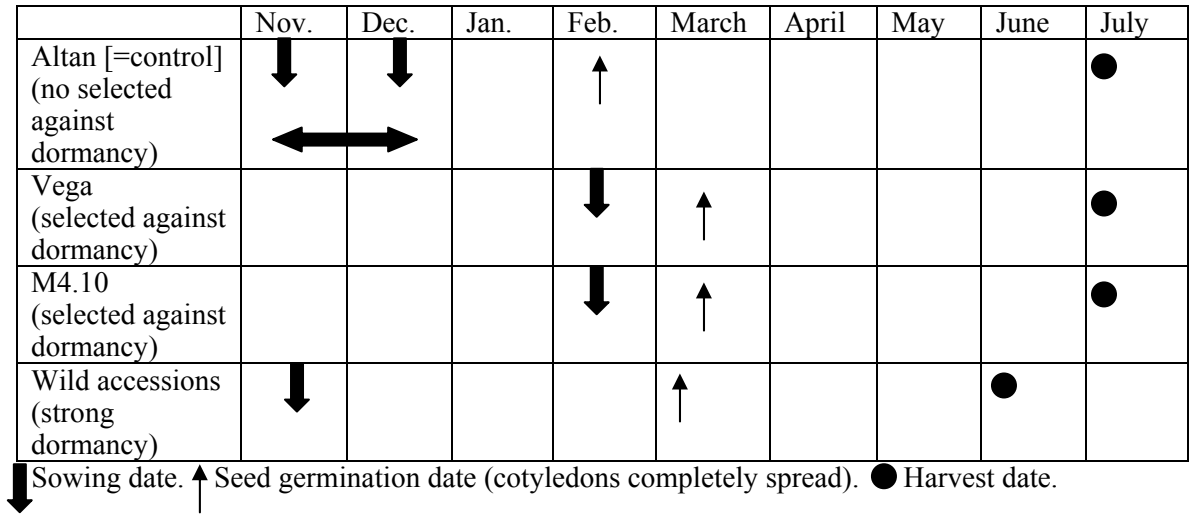

Fig. 7. Growing phases duration for 'Vega and M4.10' selected against seed embryo dormancy, compared to other materials.