Inheritance of blooming time in walnut, with regard to the property of reproductional autoregulation of species

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Summary: A great number of crosses have been made with Hungarian and foreign varieties as partners to breed improved varieties. This species shows a particular trait, namely the autoregulation of fruit set, which affects considerably the productivity of commercial orchards. Thus the inheritance of the blooming time of the male and female flowers has been explored for several years in the progenies.
It has been stated that
- the feature of the partners does not turn up predictably in the progeny,
- it is most important to take into consideration the blooming time class of both, male and female flowers in planning associations of varieties for commercial orchards.
- in years of irregular spring weather the stability of the blooming time of the variety or in other words the deviation of the actual blooming time of variety from its characteristic blooming-time class is also very important.

Introduction

The fruit production of the trees in a closed stand of a commercial walnut orchard was reduced by the abortion of female flowers due to the increased pollen release in comparison with the solitary trees traditionally planted into sporadic- and home-gardens.

One of the main principles in choosing and associating the varieties is to have good coincidence of the blooming times of the varieties, male and female flowers, respectively. Earlier, the trouble of flower abortion has not been recognised as the first clone-varieties of the national variety list: Alsószentiváni 117, Milotai 10 and Tiszacsécsi 83 are all protogyneous. They didn't cause considerable flower abortion in most of the years even in neighbouring plantations. To prevent flower abortion, later showing up is mixed populations, a systematic determination of blooming time was initiated as necessary when the new varieties obtained by breeding and precious foreign varieties are introduced in the plantations.

Presumably, the new Hungarian varieties will spread on a larger scale than the foreign ones due to the weak adaptability of the latter to low temperature minima in the Carpathian region.

Using more varieties in extended commercial orchards has a great economic importance. As a consequence of the extension of the ripening period makes a better utilisation of the harvesting and fruit processing capacity, moreover, the reduction of the risk of production is possible.

It is expected that some of the new varieties will be compatible with those main new varieties involved in the recent variety list considering blooming time. There is a higher demand for the ability to train seedlings having compatible blooming times. It would be advantageous too in extensive, forestry-like plantations and in those of double-use – both, fruit and industrial wood producing – as in case of high-density forestry plantations. It is prohibitive to use in forestry nursery trees of the expensive grafts as cloned varieties.

For the sake of meeting the demands of the growers mentioned above we have studied the blooming compatibility between our candidate varieties derived from the breeding activity and the main varieties involved in the national variety list. Furthermore we tried to find information about features of the inheritance of walnut using the data of large populations on blooming time. These populations belonged to the F1 generation derived from crosses between varieties

Materials and methods

During the walnut breeding program surveys of blooming time of male and female flowers were carried out in populations from the F1 generation derived from identified parents.

The following conclusions were drawn for both, male and female flowers:

- Start of bloom – when the lobes of stigma were divided in the first flowers of the tree, or when the pollen release of the earliest opening catkins started.

- Full blooming – when 70% of the flowers of the tree were open.

- End of blooming – when the pollen release stopped, or the stigmas were totally open.

The determination of E. Germain (1989) and G. H. Granahan et al. (1993) was taken into consideration when the blooming time classes were established.

To determine the variety to be associated with the two main varieties - Alsószentiváni 117 (A 117) and Milotai 10 (M 10) – they were compared with Pedro (as a standard variety) and 6 new varieties as results of recent breeding programs.

Investigations were based on 6 years observations noting the start and the end of blooming of both sexes.

From the A 117 x Pedro combination 136, the Pedro x A 117 combination 133, the M 10 x Pedro combination 34 and from the T 2 x Pedro combination 17 F1 progenies were involved into the investigation of the inheritance of blooming time characteristics.

Comparisons were based on full blooming time.

Results

Each of the 8 varieties studied as well as the standard (Pedro) belong to the 4th class (medium early) up to the 7th class (late) within the 9 flowering time classes proposed for walnuts.

Due to the seasonal differences of spring weather of the years observed the flowering time lasted in the earliest leafing year for 40 days (between April 9 and May 20) and in the latest leafing year for 20 days (between May 6 and May 25). Some difficulties and inaccuracies may appear in classification on the basis of full blooming time because the start or the end of blooming overlapped the neighbouring classes of flowering.

The blooming times of the 6 new varieties derived from two protogyneous female parent (A 117 and M10) and a protandreous male parent (Pedro) are shown in the *Table 1*. Data are based on the 6 years observed.

As shown by the results there is a significant difference between the varieties considering the stability over years in flowering time. Out of 6 years observed only two varieties (A117-15 and M 10-21) and only their female blooming times remained in the same class. Most instability was shown by the female blooming time of M 10-14 as it spread over three classes.

Table 1 Changes of blooming time of Hungarian walnut varieties in 6 years (according to the UPOV time classes: 1-9)

Variety	Dichogamy	Male flower		Female flower	
		Class No.	Years	Class No.	Years
A 117-15	Pa	6	4	7	6
		5	2	–	–
A 117-31	Pg	6	5	6	4
		7	1	5	2
M10-9	Pg	6	3	5	5
		5	3	4	1
M10-14	Pa	5	4	7	4
		6	2	6	1
		–	–	5	1
M10-21*	Pa	4	3	5	6
		5	1	–	–
M10-37*	Pa	4	3	6	5
		5	1	5	1
A 117	Pg	5	5	5	3
		6	1	4	3
M 10	Pg	5	4	4	5
		4	1	5	1
		6	1	–	–
Pedro	Pa	4	4	6	5
		5	2	5	1

* = catkins were killed by frost in two years
Pg = Protogyneous, Pa = Protandreous
Blooming class number: 4 = medium early, 5 = medium, 6 = medium late, 7 = late

We also studied the utility of several years' average blooming data for the purpose of combining varieties according to a common practice and it is shown in the following example. On sites endangered by spring frosts for the sake of extending the ripening time it would be advantageous to associate the two varieties having late leafing time: in this example the A 117-31, an early ripening variety and the M 10-14 a later ripening variety. Comparing the female flowering time of A 117-31 with the time of pollen release of M 10-14 we have obtained the results shown in *Table 2*.

Table 2 Changing of deviation of the blooming time

Years	Female blooming time of A 117-31	Male blooming time of M 10-14	Deviation in days
1	11 May	10 May	1
2	19 May	12 May	7
3	29 April	22 April	7
4	16 May	14 May	2
5	12 May	5 May	7
6	10 May	8 May	2
Average	11.16 May	6.83 May	4.33

Based on the average of 6 years the difference was 4.33 days, which would mean the associating compatibility of the two varieties in this aspect. But on the contrary in reality a high abortion would happen in the first, fourth and sixth years at the A 117-31 variety because in these three years the main pollen release time of M 10-14 differs from the female blooming time of A-117-31 only in one or two days. Consequently, it isn't a suitable association.

In case of varieties with more stable blooming time these relations can be more favourable. In order to sufficient security the variety associating compatibility can be determined only by the comparison of figures over several years.

In the F1 generation the distribution of the blooming time was studied as inherited from the parents in order to establish forest style, double-use walnut plantations. Results are shown on *Figure 1 and 2.*

The flowering time of walnut in the respective year occurred later and was shorter than the average. A total distribution of blooming time which is typical for the walnut can be found in the case of hybrid population originated from the protogyneous female parents A-117 or M 10 and the protandreous male parent Pedro.

In the case of protogyneous female parent and the protandreous male parent the occurrence of the higher frequency of protogyneous progeny is such a small difference that it couldn't be utilised in practice. As a result it isn't possible to establish safe fertile plantation from this plant material having such distribution of flowering time.

In case of Tiszacsécsi 2 (T-2) x Pedro – both are protandreous parents – in flowering time dominant early and medium variants were observed, while in female flowering time mostly medium to late ones were received. According to this

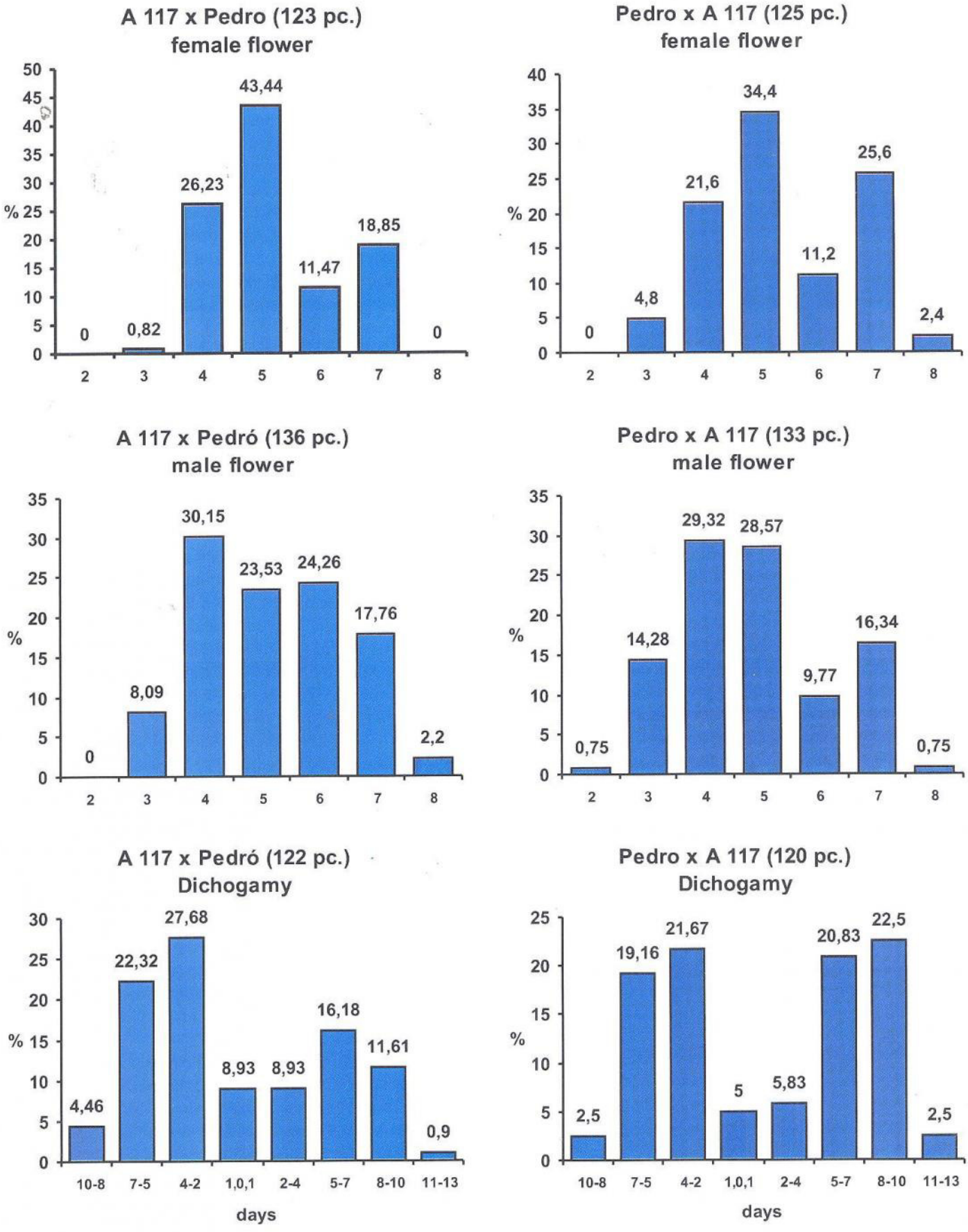

Figure 1 Distribution of walnut F1 population's blooming time and dichogamy by parents Alsószentiváni 117 (A 117) and Pedro

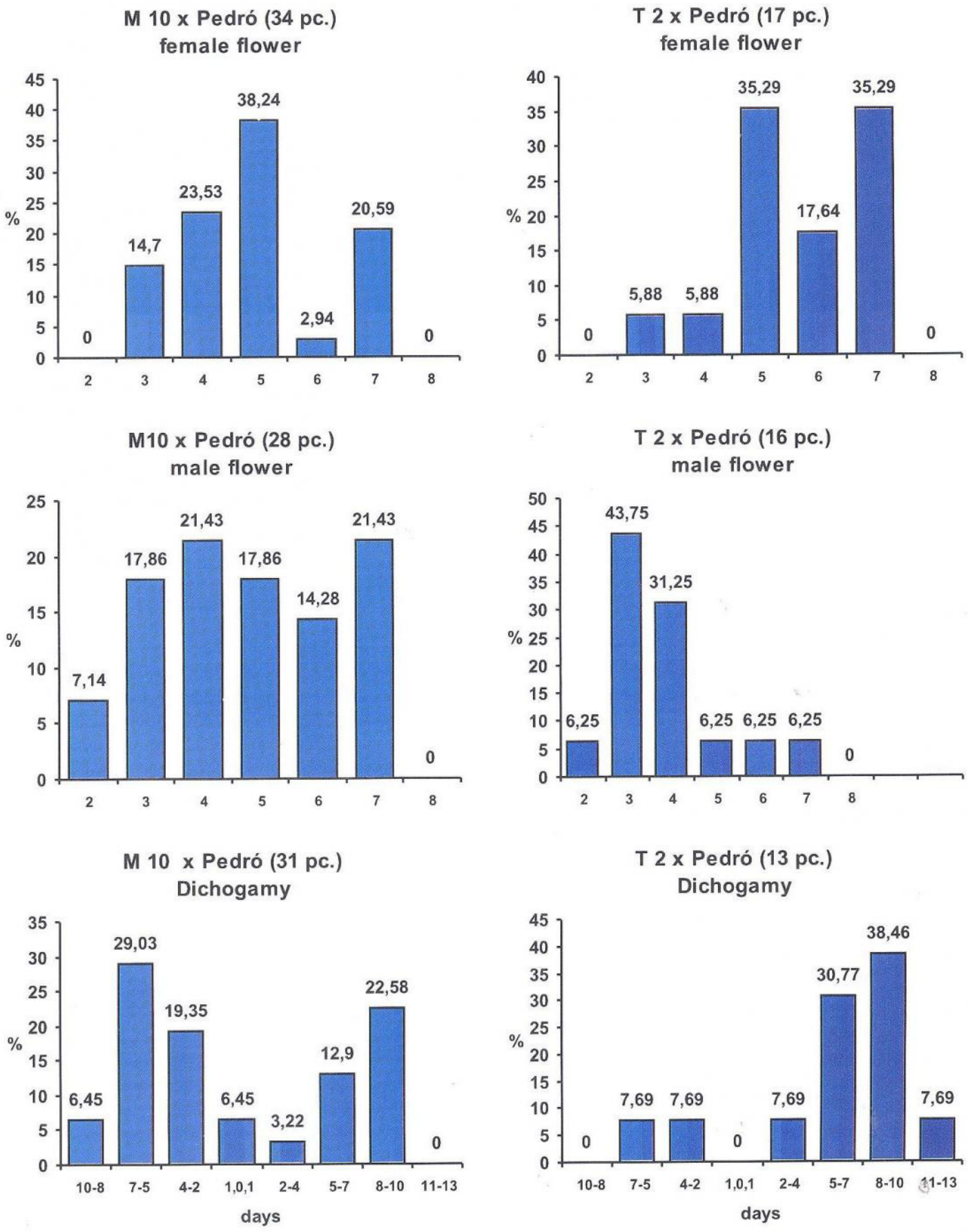

Figure 2 Distribution of walnut F1 population's blooming time and dichogamy by parents Milotai 117 (M10) or Tiszacsécsi (T 2) and Pedro

Table 3 Distribution of walnut F1 population's blooming time by parents (frequency %)

Date / Parents	2 very early 26-28 April	3 early 29 April-1 May	4 early med 2-4 May	5 medium 5-7 May	6 med. late 8-10 May	7 late 11-13 May	8 very late 14-16 May
A 117 x Pedro (123 pc.) Female	0	0.82	26.23	43.44	11.47	18.85	0
A 117 x Pedro (136 pc.) Male	0	8.09	30.15	23.53	24.26	11.76	2.20
Pedro x A 117 (125 pc.) Female	0	4.80	21.60	34.40	11.20	25.60	2.40
Pedro x A 117 (133 pc.) Male	0.75	14.28	29.32	28.57	9.77	16.34	0.50
M 10 x Pedro (34 pc.) Female	0	14.70	23.53	38.24	2.94	20.59	0
M10 x Pedro (28 pc.) Male	7.14	17.86	21.43	17.86	14.28	21.43	0
T 2 x Pedro (17 pc.) Female	0	5.88	5.88	35.29	17.34	35.29	0
T 2 x Pedro (16 pc.) Male	6.25	43.75	31.25	6.25	6.25	6.25	0

Table 4 Distribution of walnut F1 population's dichogamy by parents

	Protogyneus				Protandrous			
Parents / Days	10–8	7–5	4–2	0 ±1	2–4	5–7	8–10	11–13
A 117 x Pedro (122 pc.)	4.46	22.32	27.68	8.93	8.93	15.18	11.16	0.90
Pedro x A 117 (120 pc.)	2.5	19.16	21.67	5.00	5.83	20.83	22.50	2.50
M 10 x Pedro (31 pc.)	6.45	29.03	19.35	6.45	3.22	12.9	22.58	0
T 2x Pedro (13 pc.)	0	7.69	7.69	0	7.69	30.77	38.46	7.69

phenomenon this population appears as mainly protandreous. Unfortunately, this combination had such a small number in the hybrid plantations that the figures can only draw one's attention to further investigations of this kind. One difficulty is to be expected in forestry practice as the protandreous T-2 variety is very frequently pollinated by protogyneous varieties. In this way the population of the progeny will consist of protandreous and protogyneous individuals at a high percentage, consequently, high rates of female flower abortion is expected.

Conclusion

It is most important to take into consideration the blooming time class of both, male and female flowers when choosing the varieties to be associated.

The data of full bloom from the characteristics of blooming-time classes may be enough for variety description but the degree of coincidence in blooming times, as for a certain kind of "compatibility" cannot be decided sufficiently for variety associations.

Obviously the yearly blooming time differences make it necessary to determine the compatibility by the exact and detailed figures of many years.

In years of irregular spring weather the stability of blooming-time of the variety or in other words the deviation of the actual blooming time of the variety from its characteristic blooming class is also very important.

In the case of producing varieties of double use for the purpose of forestry, it creates difficulties that the feature of the parents doesn't turn up predictably in the progeny. It could be a further problem that the artificial pollination doesn't seem to be realisable for the purpose of growing seeds or seedlings.

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