Comparative study of plum cultivars belonging to different taxons during 1980–1996

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Summary: The program of the Research Institute of Cegléd, comprises the acclimation and selection of 7 *Prunus*-species and 39 cultivars grafted on Myrobalan C. 679 (*P. cerasifera*) seedling stocks. In addition two varieties have been investigated on three different rootstocks each: Myrobalan C. 174 (*P. cerasifera*), Bitter almond C. 449 (*P. amygdalus* var. *amara*) and Sweet almond C. 471 (*P. amygdalus* var. *dulcis*). Fruits of commercial quality are produced maroly on some cultivars of *P. salicina*-, *P. italica*- and *P. cerasifera* character. Authors explain the three possible causes of low yields experienced in non-European plums:
1/ unfavorable environmental conditions
2/ lack of irrigation and
3/ superficial information concerning the variety, rootstock and adequate traditions as well as growing practices.
A rather tight correlation has been stated between blooming dates and the main ripening period. However, the early blooming time alone cannot be considered as the cause of low productivity. The decay of plum trees is attributed to special ecological requirements and phytosanitary problems of the foreign plum cultivars. The analysis of regression revealed stochastic relations involving several other characters too, which facilitate the planning of cross-combinations in the breeding program.

Key words: plums, European and non-European plums, fructification, phenological and genetical traits

Introduction

Plum production of the world increases both in quantity as well as in quality. At the beginning of the 20th century, the research papers dealt with the large number of cultivars and the fertility relations (*Dahl*, 1935; *Röder*, 1940; *Tóth*, 1957; *Dermine & Liard*, 1957 and 1978; *Gautier*, 1977; *Tóth & Surányi*, 1980; *Brooks & Olmo*, 1980–1981; *Belmans*, 1986; *Szabó & Nyéki*, 2000). The wide diversity of varieties has been tested from the point of view of economic utility, so problems of rootstock and of cultivation could not be dealt with adequately. However, some classic pomologists, *Oberdick, Van Mons, Leroy*, the brothers *Simon-Louis*, or *Bereczki* and his contemporaries (*K. Glocker, J. Kovács, L. Unghváry* etc.) endeavoured the development of multiplication practices and the foundation of nurseries, as important aims (see *Surányi*, 1985a and 2002).

Plum research of the 20th century experienced the relative dominance of European plums due to their volume in research rather than in their importance in production. American development shifted the structure of cultivars on the both, western and eastern, sides of the continent, towards the Asian plums (first of all the Japanese, Chinese and from the territory of the late Soviet Union the Ussurian plum) and American endemic species as well as their hybrids. The eco-geographic classification of cultivated plum cultivars comprises, according to the statistics of the FAO (2004) registered European (27.47 %), Asian (59.35 %) and American (13.18 %) plums, that means the trend shifted to the Asian growers (*Childers*, 1969, *Cociu*, 1996, *Surányi & Erdős*, 1998).

The 5/6 part of the European plums is grown in regions of Europe, Central Asia and North America, whereas the data of masses represented by *P. salicina* and its hybrids indicate a 3/5 participation of the total world's plum production. The European blue-plum growing countries tended to widen the scale of their plum cultivars in ripening time as well as in physical and organoleptic characters. There is, however, a kind of „economic pressure" too, as revealed by the analysis of Sansavini (1996, referring to the dynamics of plum prices of the market. According to hím, European plums are sold at a price of 1343 LIT/kg, Japanese plums by 2145 LIT/kg, as a mean in 1995; the difference being around 60 %.

Plum varieties of non-European type were never accepted by the Hungarian growers so remained items of prunological collections only. *Bereczki* (1882–1887), and much later *Tóth* (1957 and 1968), *Surányi* (1985b and 1991), *Ramming & Cociu* (1992), *Surányi & Erdős* (1998) studied the assortment available in collections and stated that varieties of *P. americana* (e.g. Bonnie 221 and Weaver), or accidentally, some *P. salicina* types (Abundance, Burbank, Elephant Heart or Santa Rosa) or *P. besseyi*-, *cerasifera*- and *tomentosa* cultivars of the collection at Cegléd, moreover, items of a collection of Siófok (commercial cultivars of *P. salicina*) represent a particularly rich scale of potential varieties, and is to be followed up in several papers (cf. *Tóth*

& *Surányi*, 1980; *Surányi*, 1985b; *Surányi & Erdős*, 1998; *Szabó, Nyéki & Tóth*, 1987; *Szabó & Nyéki*, 2002).

It is due to E. Tóth, first of all that non-European plums appeared in some plum plantations, where the remained alive for 4–5 years at least on Myrobalan C. 679 rootstock as referred to in the present study (the year of plantation has been carefully registered). The taxonomic and genetic characters are presented in the chapter of *Materials and methods*. Data have been considered into Hedrick et al. (1911), *Knight* (1969), *Bellini* (1982), *Harsányi* (1979), *Yoshida* (1987), *Okie* (1996), *Sansavini* et al. (1996a and 1996b), and from a textbook (*Surányi & Erdős*, 1998).

Material and method

Grafts made on *Myrobalan* seedling stocks at 4 successive dates (1980, 1983, 1984, 1987) or in the case of the varieties *Laroda* and *Santa Rosa* on *Myrobalan C. 174*, *Bitter almond C. 499* and *Sweet almond C.471* seedling rootstocks (cf. Surányi, 1999). Most of the cultivars studied were also forms of different inter-specific hybrids, *P. domestica* (3) or *P. italica* (4), furthermore *P. cerasifera* (7) were represented by a number of cultivars indicated in brackets, whereas *P. salicina* (3), *P. americana* (2), *P. tomentosa* (3); these and *P. besseyi*, besides their mutually crossed hybrid varieties were represented by 19 cultivars.

Varieties taken from the collections were available by 5-5 trees: *Bonnie 221, De Soto* and *Weaver* (P. americana); *(Cherna Afkazka, Dzhanka 1, Dzhanka 3, Kometa, Nadezhda, Purpurovaya* and *Zlota Afkazka* (P. cerasifera); *Brompton, Chrudimer, De Maris* P. domestica); *Oktyabrskaya, Sentyabrskaya 21, Sentyabrskaya 23* and *Sopernitsa* (P. italica); *Burbank, Duarte, Elephant Heart* (P. salicina); *Yakima* (P. simonii?); *Drilea 473, Drilea W. 53* and *Drilea W. 54 (*P. tomentosa*)*.

The hybrid cultivars were as *Compass* (P. besseyi x P. hortulana mineri); *Oka* (P. besseyi x P. salicina); *Marianna 2624* (P. cerasifera x P. munsoniana); *KS 4, KS 9, KS 31, Methley, Santa Rosa* (P. cerasifera x P. salicina); *Goff, Laurie Wells* and *Redcoat (*=Burbank x Wolf) (P. salicina x P. americana); *Brookred* and *Winered* (P. salicina x P. besseyi); *Friar (*=Gaviota x Nubiana) (P. salicina x /P. cerasifera x P. salicina/) and *Laroda* (=Gaviota x Santa Rosa) (P. salicina x /P. cerasifera x P. salicina/) (cf. *Ramming & Cociu*, 1992, *Faust & Surányi*, 1999, *Surányi & Erdős* 1998).

In the list and the Tables, where no indication refers to the rootstock, the *Myrobalan C. 679* rootstock should be understood. Data applied to the evaluation of cultivars have been mised according the subsequent protocol: Dates of the beginning of blooming, as well as of the mass ripening are expressed in days counted from the first day of the year. Yields are expressed in kg per tree, the mass and size of single fruits is a mean of 5 x 20 measurements. Dry matter content and acidity are checked in laboratory as yearly means of three parallel samples.

The trees planted at four different dates died, gradually; therefore, in some cases interpolation of data was necessary in order to facilitate a statistical analysis. Regression analysis is performed on means obtained during a period of 6–12 years. Plum cultivars designed for acclimation in the collection were partially evaluated, only; therefore, phytosanitary and scion/rootstock relation could not be taken into consideration. The main causes of tree decline were the diseases *Xanthomonas pruni* (*Bucur* et al., 1961) and *sharka* (*V. Németh*, 1986) or *pseudo-sharka* (*Savino* et al., 1996) viruses, which should be studied in special plantations established for that purpose.

The main meteorological data are summarised in *Table 1*, where it is evident that also excesses occurred durrog the 18-year period. The mass proliferation of aphids as vector organisms of the sharka vírus or microclimatic conditions favouring bacterial or fungal (*Monilia*) epiphytotics could be traced by the results in yield, „only", not in *Table 1*. Excessive deviations from the means of the whole year (1980, 1991, 1994, 1995 and 1997) or of the vegetation period (1983, 1986, 1995 and 1997) bot first of all, the variation of precipitation of the whole year or of the vegetation period had a deleterious effect on all of the plum cultivars studied *(Table 1)*.

Table 1 The main meteorological data in the studies at Cegléd (No. 519 of Hungarian Meteorological Institute)

Year	Mean temperature, °C		Total precipitation, mm		
	Annual	In vegetation	Annual	In vegetation	%
1980	9.4	14.0	598.4	383.0	64.0
1981	10.8	15.8	422.2	305.6	72.4
1982	10.9	15.9	497.9	395.6	79.5
1983	11.7	16.6	337.0	252.8	75.0
1984	10.6	15.1	483.9	352.1	72.5
1985	10.0	15.0	490.6	284.5	58.0
1986	11.2	15.6	357.7	216.3	60.5
1987	10.3	14.9	598.7	395.5	66.1
1988	10.9	15.2	530.5	358.4	67.6
1989	11.6	15.9	513.5	432.9	84.3
1990	11.4	15.6	424.3	309.7	73.0
1991	10.9	15.0	638.9	526.6	82.4
1992	11.7	16.3	366.7	270.0	73.6
1993	11.0	15.8	427.7	289.9	67.8
1994	12.1	16.6	439.3	330.7	75.3
1995	10.9	15.0	668.8	435.6	65.1
1996	10.1	15.1	520.1	361.0	69.4
1997	12.1	16.6	378.4	262.6	69.4
Mean	11.0	15.6	483.0	342.4	71.0
CV, %	6.63	4.54	20.33	22.73	10.07

Results and Discussion

Table 2 summarises the pomological results referring to 39 varieties, or to altogether 43 combinations. Among the cultivars of the plantation of 1980, most of the Japanese varieties, whereas in the plantation of 1983, scion/rootstock relations, in the plantation of 1984, *P. besseyi*, *P. tomentosa* and their hybrids, furthermore, in the plantation of 1987, maroly the commercial cultivars of *P. cerasifera* are offering information.

Table 2 Comparison of examinated plum cultivars mostly on myrobalan rootsock between 1980–1996 (Cegléd)

Cultivars	Beginning of flowering days	Full of ripening days	Cropping kg/tree	Fruit size		Soluble solids %	Acid content %
				mm	g		
Planted in 1980							
Burbank	104.2	218.0	21.9	41.9	47.5	13.3	1.31
Duarte	89.8	223.0	10.1	35.4	36.0	12.5	1.34
Elephant Heart	105.8	227.8	6.6	44.7	59.0	14.5	1.33
Laroda	98.7	224.9	19.2	27.4	17.3	16.0	1.40
Methley	98.6	198.7	19.3	29.9	18.2	11.4	1.69
Oktyabrskaya	107.0	239.6	43.9	31.2	26.9	16.2	1.35
Sentyabrskaya 21	108.2	229.2	34.8	34.4	31.4	15.6	1.31
Sentyabrskaya 23	104.6	235.1	35.1	37.5	36.1	15.7	1.28
Sopernitsa	105.6	235.5	36.8	34.3	32.4	16.8	1.39
LSD 5	8.16	9.05	10.35	2.23	6.90	–	–
Planted 1983							
Chrudimer	107.6	219.0	13.1	33.3	27.9	17.4	1.29
Friar	102.5	226.5	1.7	23.4	35.7	15.1	0.85
KS 4	105.4	231.6	23.8	40.4	49.8	18.1	0.76
KS 9	105.1	230.0	31.7	32.7	27.4	16.0	0.67
KS 31	102.3	237.0	13.5	42.2	54.4	19.0	1.21
Laroda/ C. 174	98.7	212.2	7.1	19.3	23.6	18.6	1.41
Laroda/ C. 449	97.0	214.9	5.4	19.8	23.5	19.5	1.35
Laroda/ C. 471	99.6	216.1	2.8	18.9	22.0	19.2	1.33
Santa Rosa/ C. 174	98.1	215.0	6.3	18.9	23.6	18.4	1.34
Santa Rosa/ C. 449	98.8	216.6	7.2	18.0	20.0	18.5	1.22
Santa Rosa/ C. 471	99.0	219.3	2.9	19.0	22.7	19.0	1.21
LSD 5 %	0.87	17.05	18.44	4.01	7.21	–	–
Planted in 1984							
Bonnie 221	104.5	187.0	10.8	25.4	10.3	16.2	1.39
Brookred	102.1	220.3	2.0	29.6	20.7	17.0	1.53
Compass	109.6	219.0	5.4	22.2	7.9	17.0	1.51
De Maris	107.1	225.0	8.9	32.7	27.2	17.3	1.67
Drilea 473	95.9	166.0	31.3	14.2	12.0	17.1	1.40
Drilea W. 53	103.3	196.0	20.2	12.2	14.7	16.9	1.33
Drilea W. 54	98.9	188.5	30.6	12.1	15.4	16.5	1.44
Goff	107.1	242.0	8.6	36.1	28.8	17.5	1.62
Laurie Wells	100.9	202.0	12.8	35.1	28.7	17.3	1.72
Marianna 2624	96.6	194.8	22.2	24.5	19.9	14.2	1.74
Oka	110.0	203.0	0.3	30.6	17.9	15.4	1.46
Redcoat	101.4	221.0	27.1	33.8	27.8	16.9	1.64
Weaver	107.1	245.0	8.1	31.5	21.1	16.6	1.73
Winered	103.8	208.5	11.1	26.3	12.6	17.1	1.62
LSD 5 %	10.46	16.11	9.93	2.59	2.91	–	–
Planted in 1987							
Brompton	104.5	242.0	21.7	22.1	9.4	18.7	1.35
Cherna Afkazka	94.3	226.8	7.1	30.5	17.8	16.8	1.42
Dzhanka 1	92.2	215.0	16.0	22.5	12.0	14.4	0.87
Dzhanka 3	92.7	212.6	20.1	21.3	13.9	16.21	12
Kometa	97.2	202.0	13.7	35.2	26.7	12.6	1.,55
Nadezhda	100.8	189.7	7.0	37.8	31.9	13.7	1.59
Purpurovaya	95.6	194.2	21.6	30.4	19.5	12.6	1.76
Yakima	105.5	214.0	13.6	37.9	31.3	18.2	1.13
Zlota Afkazka	94.3	193.8	11.4	30.9	19.2	13.9	0.85
LSD 5 %	11.20	13.40	14.90	5.01	7.61	–	–

In blooming time, some 3 weeks of difference have been observed, as *Duarte* started blooming as a mean of 9 years at April 1, whereas the latest over many years was *Oka*.

The variety *Drilea 473* proved to be the earliest in blooming as well as in ripening (in 70.1 days), and *Weaver* took the longest time to ripening (137.9 days), that means October 3 of full maturity. As an interesting detail, in the same plantation, President ripened earlier than *Weaver*, regularly.

The time of planting and the decline of trees offer keys to interpret the large differences in yield as well as the very low yields themselves (1.7 · 43.9 kg/tree). E.g. the *Friar* trees died after a short time, their replanting ensued twice during that period. In *Table 2*, the variation in fruit size is evident, which are expressing maroly the origin of varieties and genotypes because cultivars and hybrids derived from *P. salicina* and *P. italica* develop larger fruits than those of other species. Small seeds (stones) are typical for some cultivars (*Compass, Brompton, Marianna 2624, Bonnie 221, Dzhanka 1, Drilea 473, Winered* and *Dzhanka 3*), which are potentially principally used as rootstocks unless their germination potential is satisfactory. Correspondingly, the gene bank may serve for the purpose of acclimation. Thus different purposes are to be envisaged separately. That was approved by different research papers (*Bellini & Nencetti* 1993, 1997a and 1997b; *Sansavini* et al. 1996a and 1996b, *Okie* 1996, *Bellini* et al. 1997, *Liverani* et al. 2001, *Bellini* et al. 2002, *Zivondov & Dyuvinov* 2002); furthermore, results of breeding rootstocks published earlier (*Nyujtó*, 1987 and *Surányi* 1999) and later (*Okie* 1996, *Nyujtó* 1987, *Liverani* et al. 2001).

Soluble solids ranged between 11.4 and 19.5 %, but it was stated that the means of fruit mass (weight) data in *Laroda* and *Methley* were not conform with those found in the most known papers, e.g. *Laroda* should produce 64 g/fruit (*Sansavini* et al. 1996b), whereas it was around 25 g at Cegléd. For the problem of acclimation we shall note that foreign cultivars perform quite differently under the changed ecological conditions, especially relations of fertilisation as well as fruit size are affected (e.g. self-fertility of *Stanley* or *Santa Rosa* depends on the geographic conditions as stated by *E. Tóth*: in *Tóth & Surányi*, 1980). Acidity of plums may vary between wide limits, as *KS 31* fruits produced extremely low acidity, which impairs the market value of this variety with large fruit *(Table 2)*.

The genetic origin of the varieties could be considered as an indication of their ecological preferences and alteged phytosanitary requirements (*Watkins*, 1976, *Yoshida*, 1987, *Faust & Surányi*, 1999, *Ramming & Cociu*, 1992). In crosses

Table 3 relative valucs (%) to the *C. 174 Myrobalan* in two salicina-like cultivars

Traits	cv. *Laroda*			cv. *Santa Rosa*		
	C. 174 MY[1]	**C. 449** BA[2]	**C. 471** SA[3]	**C. 174** MY[1]	**C. 449** BA[2]	**C. 471** SA[3]
Beginning of boom, days	100	98.3	100.9	100	100.7	100.9
Full of ripening, days	100	101.3	101.8	100	100.7	102.0
Yield, kg/tree	100	76.1	39.4	100	114.3	46.8
Fruit size, mm	100	102.6	97.9	100	95.2	100.5
Fruit weight, g	100	99.6	93.2	100	84.8	96.2
Soluble solids, g	100	104.8	103.2	100	100.5	103.3
Acid content,	100	95.7	94.3	100	91.0	90.3

Note: [1]**MY**= myrobalan (*P. cerasifera*)
[2]**BA**= bitter almond (*P. amygdalus* var. *amara*)
[3]**SA**= sweet almond (*P. amygdalus* var. *dulcis*)

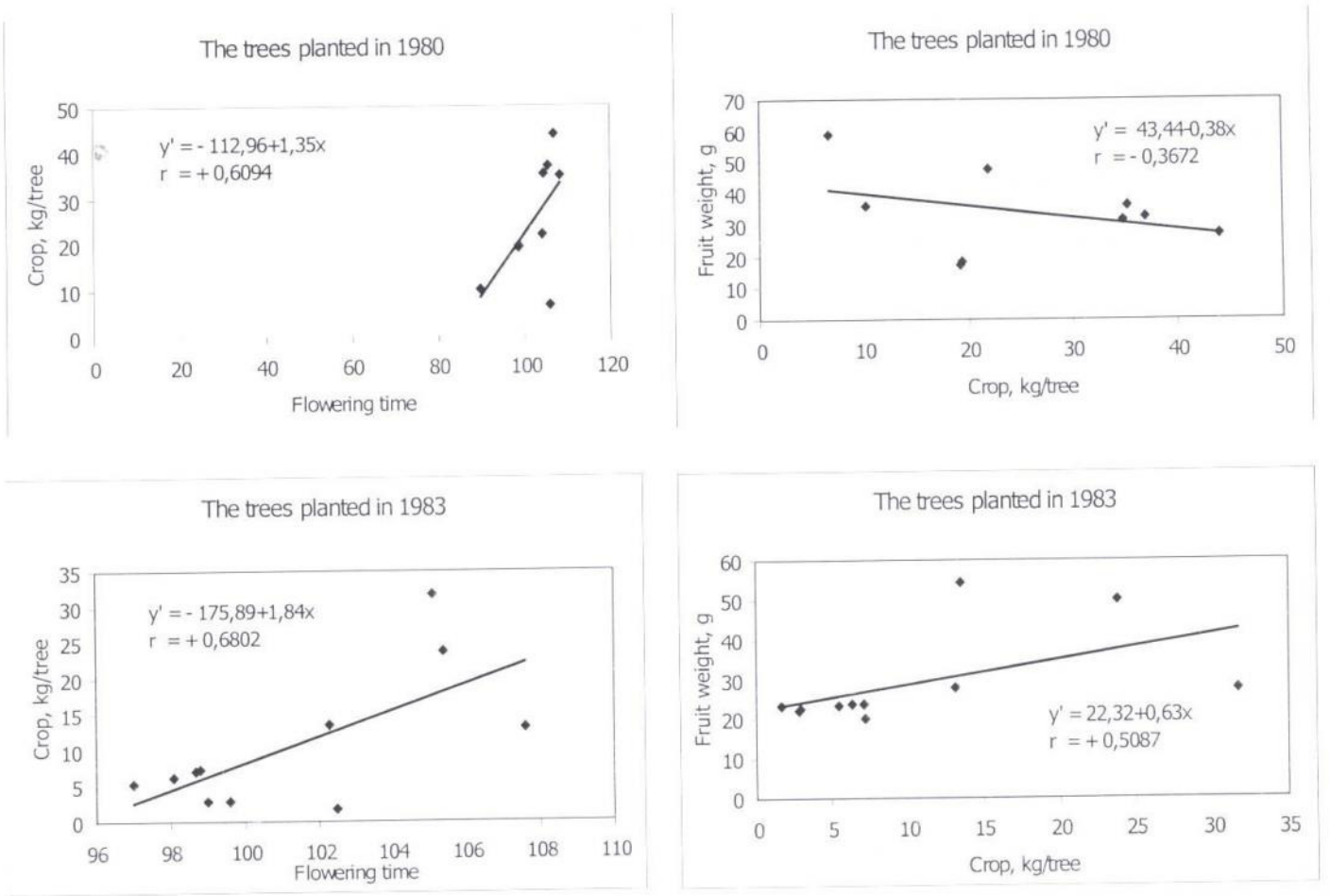


Figure 1 – The blossom and ripening time from first day of every year (in days)

of plum cultivars, it seems that blooming dates of the parents may result in intermediate dates of the offspring as being expected in breeding attempts (*Tóth & Surányi*, 1980, *Bellini* et al., 1987).

In case of varieties belonging to the *salicina* group, it is reasonable to consider the use of alternative rootstocks differing in their ecological requirements. On rootstocks approved under dry un-irrigated conditions two cultivars performed according to *Table 3*, remarkably, in comparison with *Myrobalan C. 174*, which was taken as 100. The preliminaxy experiment did not justify any reasonable trend, although some differences of 30–60 % could be taken as significant ones. *Laroda* and *Santa Rosa* proved to perform best as grafted on *Bitter almond C. 449* under un-irrigated conditions *(Table 3)*.

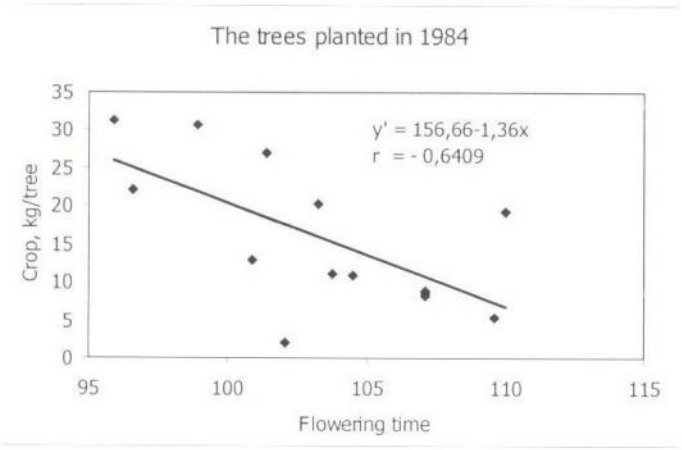
In cases when results are difficult to interpret, a stochastic relation should be explored carefully. In *Table 4*, results of correlation analyses are summarised by presenting the r-values raised on the experimental data of earlier research attempts (*Surányi*, 1978, 1985b and 1991). There were, however, some trends worth wile to be mentioned: early blooming dates anticipate early ripening, generally *(Figure 1)*, a negative relation between blooming date and yields per tree was less evident, which would mean that the low productivity of Japanese plums is not the consequence of spring frosts, but rather the opposite trends of yield forming (number and size of fruits), on the one hand and the trend of accumulate organic matter into the fruits, on the other *(Figure 2)*.

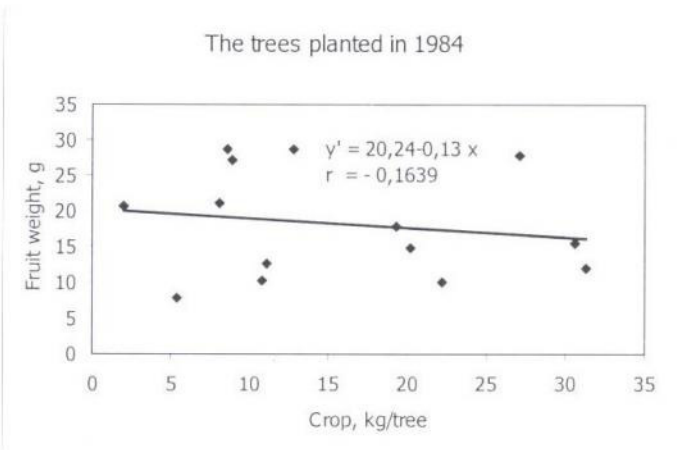
Further conclusions drawn from the observations made at Cegléd involve the valuation of outstanding results, which are attributed to three factors, maroly: the adverse environmental conditions, the lack of watering and the insufficient

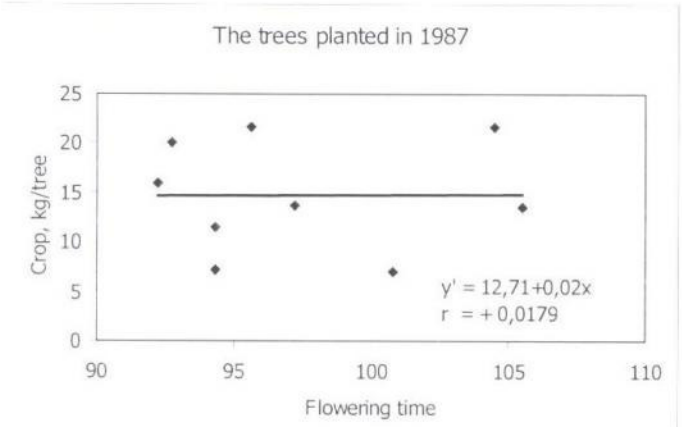
Table 4 – Some correlations between examinated data of plum cultivars

Relationships	Planted in				
	1980	1983	1984	1987	Together
Beginning of flowering and Full of ripening	+0.0692	*+0.8736*	*+0.6140*	–0.1766	*+0.3924*
and Cropping of tree	+0.6094	*+0.6802*	*–0.6409*	+0.0179	+0.2138
Cropping of tree and Fruit size	–0.3672	+0.5087	–0.1639	–0.5730	+0.1232
and Dry matter	+0.2419	–0.2422	*–0.7444*	–0.5338	*–0.7937*
Fruit size and Fruit weight	*+0.9897*	*+0.9168*	*+0.6898*	*+0.9939*	*+0.8294*
Dry matter and Acidity	*+0.6667*	*+0.7669*	+0.0944	–0.3194	+0.1518
r-value and p=5 %	0.6664	0.6021	0.5324	0.6664	0.3044

Note: sloped is significant







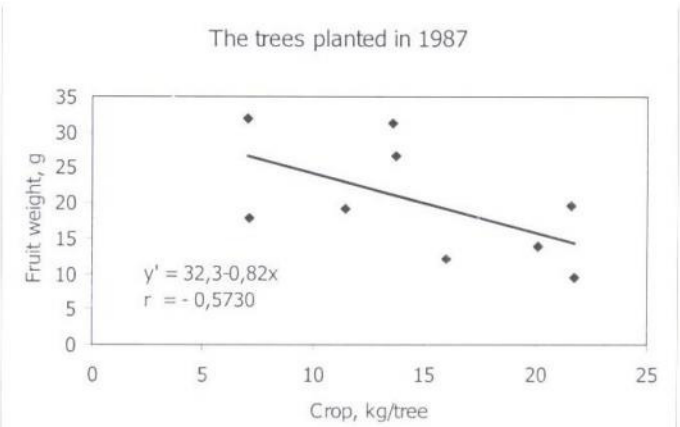
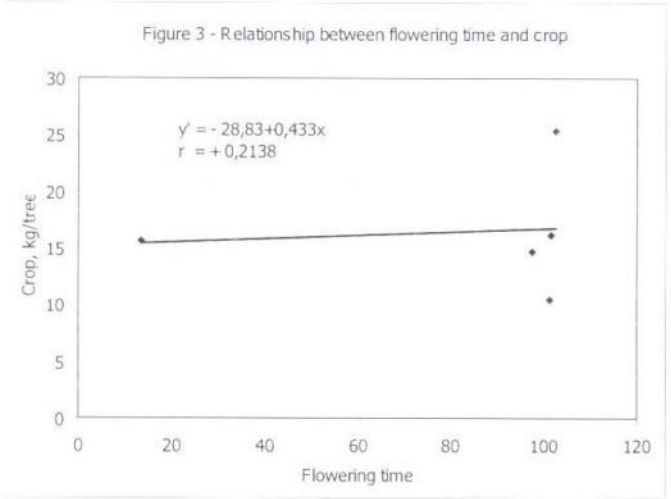


Figure 2 – The correlations of the main traits (flowering time, crop and fruit size)



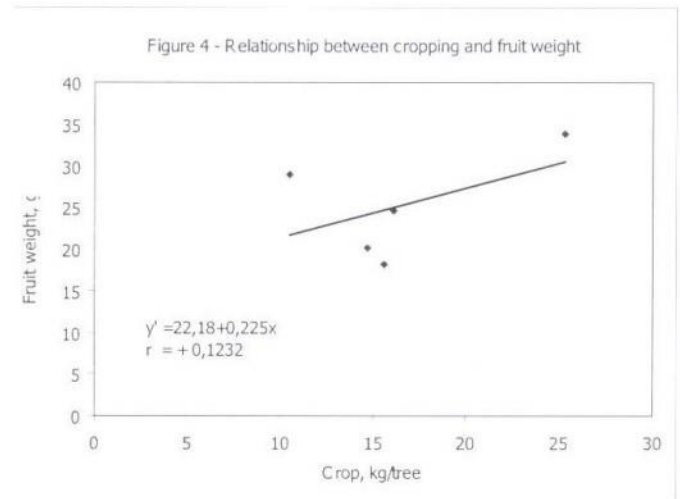


Figure 3 Relationship between flowering time (days) and cropping (kg/tree)

Figure 4 Relationship between cropping (kg/tree) and fruit weight (g)

information upon scion/rootstock interactions. Pollination studies of *Szabó & Nyéki* (2002) prove that in the experiments with 9 Japanese plum varieties the ecological conditions prevented a normai process of fruit set (cf. *McGregor*, 1976, further in the handbook edited by *Nyéki*, 1980) because several problems could not be solved, at that time.

Referring to the results presented in *Table 4* and *Figure 2*, the dates of blooming and the yield per tree or the relations between yield and fruit mass (weight), in *Figure 3* and *Figure 4*, the results of the analysis are grouped according to the dates of planting, the differences in the means have been merged and weighed out the deleterious effects of the repeated frost damages, sometimes seemingly outright harmful.

Summing up the results, following consequences have been drawn from the research program lasting 18 years:

1. Successful comparison of plum varieties with Japanese, Chinese and American genetic background cannot be made except under favourable ecological conditions, i.e. optimal soil moisture – possibly supplied by watering – and with selected cultivars, only.
2. Varieties grown for fresh consumption giving marketable fruit are: *Burbank, Duarte, Elephant Heart, Friar, KS 4, Sentyabrskaya 21* and *23*, as well as *Kometa, Nadiezhda, Purpurovaya* and *Yakima*.
3. The colour of fruit flesh and low sugar content renders the purplish-red and dark purple cultivars as important sources of vitamins, and the denomination of "Sandwich" plums is suggested (e.g. *Brookred, Burbank, Duarte, Goff, Kometa, Oka, Redcoat, Weaver, Winered* etc.).
4. The variety *Dzhanka 1* and *3* offer a taste of musk melon, or in some years muscat (e.g. *Brompton, Santa Rosa*) or with a pleasant bitter after-taste (*Methley*, less frequently *Laroda*) represent special values, just to widen the scale of the assortment.
5. The cultivars with especially small fruits (*Bonnie 221, Compass, Drilea 473, W. 53* and *W. 54*, furthermore *Dzhanka 1* and *3, Marianna 2624, Winered*) – compared with others as *Brompton* and *Marianna 2624*, are also recommended as seedling rootstocks for varieties of *non-domestica* or even *domestica* type.
6. *Laroda* and *Santa Rosa* produced the largest fruit and the highest yields as grafts made on *Bitter almond C. 449* compared with two other rootstocks.

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