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Evaluation of the Quantity of Flower Buds, Flowers, Fruits and Weight of Harvest, their Quantitative Relations and Variability on 24 Genotypes of Apricots in a 6-Year Period

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Abstract: Almost all analysed genotypes were able to form a number of flower buds sufficient for a potential regular harvest. When the conditions for the formation of flower buds on apricots were very good, the variability of the quantity of flower buds was very low. The correlation between the ranking of genotypes according to their percentage of flower buds which perished because of frost was proved to be significant only in the years with average damages due to frost. When damages due to frost were very important the differences between genotypes disappear. Genotypes with highly frost resistant flower buds were Vynoslivyj and Lemeda (LE-962). The lowest variability of quantity of flowers was observed in the years with a very rich flowering (in 1999 for example). Among all evaluated characters, the highest variability was obtained when studying the harvest weight in kilos per tree. The highest average harvest for the all evaluated period was observed on the species Vynoslivyj (20.39 kg per tree). When the weather conditions were good (in 1995, 1996 and 1999) highly significant coefficients of correlation were found out between the quantity of flower buds, the quantity of flowers, the quantity of fruits and the harvest weight per tree (r=0.53++ to r=0.99++).

Key words: apricots, quantity of flower buds, of flowers and of fruits, harvest weight

Introduction

Most scientific studies which have been published on the topic of apricot fertility evaluate the resistance of flower buds to frost, the harvest weight as well as pomological and qualitative characters of fruits (Onal, 1999, Nyeki et al., 1999,

Szalay et al., 1999, Tsoneva, 1998, Paunovič, 1999, Audergon et al. and others). However long term studies of the quantity of flower buds, evaluations of fruits in different phenophases, their cross-relations and the variability of larger collections of genotypes are still missing. Quantitative relations between the quantity of flower buds, of fruits and the fertility have been studied according to the periodicity of fertility on plums by Couranjou (1971, 1983). This author has evaluated the real number of flower buds per tree and per morphological parallel parts of the treetop in each year and on several species of plums. Therefore the goal of this work was to study and evaluate chosen quantitative characters of a larger collection of apricots genotypes and for a longer period of time. Chosen characters were the number of flower buds, the number of flowers, the number of fruits and the harvest weight. Our next aim was to evaluate their variability and cross-relations.

Material and methods

The tested orchard was planted in spring 1991 on the experimental fields of the department of fruit growing in Lednice. Used rootstocks were cultivated from apricots seeds (*Prunus armeniaca* L.). The most important part of genotypes was issued from the Czech Republic, but some came from the Slovak Republic, from Canada and from Ukraine. The numbers indicated after the names of the genotypes specify their clone or breeding number. Chosen crossbreeds (hybrids) are only denominated by their work number, where letters LE and M indicate that the genotypes come from the Faculty of Horticulture, Lednice, Mendel University of Agriculture and Forestry (MUAF) in Brno. The control species was Velkopavlovická LE-6/2. New genotypes (indicated only by their abbreviations M, LE, LE-SEO and numbers) were also included in the trial plantation because they had been evaluated as interesting on the cultivation point of view. Other species were chosen on the base of good references of foreign institutions that provided them.

The trial was organised in long blocs. Five plants of each genotype were planted. After they reached their economic cropping in 1994, each tree was individually evaluated for a six-year period. However the cropping potential after the natural falling down of fruits in June was calculated only in 2 years. In the final evaluation, we included 24 genotypes for which we gathered full data on all observed characters in all years and for all repetitions. The trial plantation was not irrigated and no thinning of fruits was provided even when the cropping potential was high.

The average annual temperature and total annual precipitations in Lednice for the last 80 years were favourables for apricot growing (9.9°C, 516mm). However temperature and precipitations during the observed period from 1994 to 1999 were quite different. The average annual temperature varied from 8.5°C to 10.8°C and precipitations from 480 to 626mm. Each year differed one from another mainly because of the course of temperature during the period of postdormance and flowering. Four years of the observed period were favourables for apricot cropping, these were 1994, 1995, 1996 and 1999. Very important damages of flower buds during the postdormance period were observed only in 1998. That year, 74.22% of flower buds of the all collection of genotypes died. The freeze of flower buds in 1994

(55.16%) and 1997 (26.20%) did not influence the harvest. (Tab. 2.). In 1995, 1996 and 1999, almost no deadly damages of flower buds were observed. On the point of view of temperatures, each single observed year can be characterised as follow: in the years 1994 and 1995, temperatures at the time of flowering were lower, but it never froze. We observed a fall of temperature to –1.1°C in April only once in 1995. In 1996, apricots flowered quite late (during the last 10 days of April) so that no damaging froze was observed. The year 1999 was particularly good for apricot growing and record harvest was reached. 1997 and 1998 were worse for apricot cropping, that was due to the colder weather, unfavourable to pollination and fertilization and also to the damaging frost which was observed during flowering period or just after it. In 1998, low temperatures from 3 to 6°C above zero which last several days during the flowering period badly influenced the process of pollination and fertilization. In 1997 temperatures measured 2 meters above the ground fell down to –3.2°C during the flowering period and that provoked important damages.

The methodology Vachůn et al. (1995), based on a scale of points (from 1 to 9), was used for the evaluation of the quantity of flower buds, of flowers and of fruits. Evaluation was always done by the same person. The highest number of points always corresponded to the highest positive level for the given character. The quantity of fruits was evaluated in the phenophases „H" and „I". For the phenophase „H", it was after the unfertilized or badly fertilized flowers fell down. That was the phenophase of the „small green fruit", when the fruit still had its perianth. The next evaluation of the quantity of fruits took place in the phenophase „I" (it means after the natural falling down of fruits in June), when the fruits had an average diameter of 15 mm ("big green fruit", "small fruit", "small nut"). The harvest weight was estimated in kilos for each tree. The coefficients of variability (r) were always calculated from the primary values, and not from average values.

Results and discussion

A sufficient **quantity of flower buds** is one of the main conditions for normal cropping. This condition had been completed on most apricot genotypes of the evaluated collection in the period from 1994 to 1999. When the weather is good during the flowering period and when a good pollination and fertilization is ensured, about 50% of the all possible quantity of flower buds is enough to ensure a normal harvest. Such a sufficient number is classified with 4 to 5 points. Only some genotypes approximated this limit and that, only in some years. Genotypes presenting a lower level of bud flower formation are for example LE-2267 (average 5.8 points), M-25 (5.1 points) and Sabinovská 220 (4.8 points). Most genotypes reached a quantity of flower buds rated with 7 to 8 points. The highest average quantity of flower buds in the 6-year evaluation was LE-1321 (8.73 points). Tab. 1. In the same conditions the ability to form more or less flower buds can be considered as a characteristics of the species. This corresponds to the results obtained for example on plums (Couranjou 1971 and 1983). However the level of this character can be modified a lot depending on the health conditions and on the weather conditions of the year when the

differentiation of buds takes place. But each genotype does not always react the same way to the same conditions. The positive correlation between the quantity of flower buds in points and the average temperature during the vegetation (r=0.55) was found out to be very important, but not significant. When analysing the total precipitations during the vegetation period, the coefficient of correlation was even higher (r=0.76), however this value did not reach the level of significance because the number of evaluated years (6 years) was too low. Fig.1.

Table 1. Values of chosen characters of 24 genotypes of apricots expressed by their average and by the mean error of average from 1994 to 1999

Genotypes	Quantity of flower buds in points	Quantity of flowers in points	Quantity of fruits in the phenophase "H" in points	Harvest weight per tree in kg
HARLAYNE	8.17 ± 0.43	7.63 ± 0.65	4.63 ± 1.14	7.19 ± 3.72
LE-392	7.25 ± 0.86	6.92 ± 0.87	5.20 ± 1.09	9.71 ± 6.39
PRIUSADEBNYJ	7.97 ± 0.73	7.40 ± 1.00	6.77 ± 1.05	14.19 ± 6.53
SEM. BADEMERIK	7.88 ± 0.57	7.34 ± 0.80	5.79 ± 0.86	11.00 ± 7.51
LE-2267	5.75 ± 1.02	5.62 ± 0.95	5.39 ± 0.80	9.77 ± 6.40
LE-390	7.60 ± 0.73	7.37 ± 0.73	5.37 ± 1.25	15.58 ± 8.07
LE-1917	6.97 ± 0.96	7.07 ± 1.11	4.83 ± 1.06	4.69 ± 1.79
NJA-1	7.53 ± 0.65	5.91 ± 1.01	4.69 ± 1.37	9.68 ± 5.94
ARZAMI AROMATNYJ	7.33 ± 0.99	7.23 ± 0.77	5.93 ± 1.14	16.99 ± 8.71
VOLŠEBNYJ	7.62 ± 0.78	7.33 ± 0.82	5.25 ± 1.12	18.51 ± 7.75
VYNOSLIVYJ	6.93 ± 1.09	6.83 ± 1.08	6.20 ± 1.16	20.39 ± 8.79
M-45	6.74 ± 0.60	6.21 ± 0.91	3.93 ± 1.12	6.86 ± 3.97
M-25	5.07 ± 1.14	4.60 ± 1.12	3.20 ± 0.55	4.08 ± 2.25
VELKOPAVLOVICKÁ LE-6/2	6.07 ± 0.89	4.93 ± 0.98	3.67 ± 0.98	5.44 ± 3.56
HAROGEM	7.37 ± 0.71	5.97 ± 0.99	5.30 ± 1.29	11.46 ± 6.93
LE-2185	7.27 ± 0.72	7.48 ± 0.69	5.14 ± 1.20	10.02 ± 4.82
LE-1580	6.94 ± 0.48	6.46 ± 0.67	4.21 ± 0.97	6.92 ± 3.54
SABINOVSKA 220	4.77 ± 0.74	3.90 ± 0.82	2.87 ± 0.63	3.34 ± 1.91
LE-1453	7.93 ± 0.36	6.53 ± 1.10	5.37 ± 1.44	13.85 ± 7.77
LEMEDA (LE-962)	7.63 ± 0.85	7.17 ± 0.96	4.60 ± 1.16	10.24 ± 6.02
LE-1321	8.73 ± 0.19	7.43 ± 1.09	5.33 ± 1.22	11.39 ± 6.66
LEDNICKÁ (M-90-A)	6.75 ± 0.66	5.88 ± 0.69	3.65 ± 0.81	5.02 ± 2.12
LE-SEO-118	6.98 ± 0.85	6.26 ± 1.02	5.62 ± 1.40	10.51 ± 6.15
LE-SEO-24	8.41 ± 0.40	6.63 ± 1.13	5.33 ± 1.27	9.10 ± 5.29
Average	7.15 ± 0.46	6.50 ± 0.55	4.93 ± 0.89	10.25 ± 5.24

The correlation between the quantities of flower buds on the different genotypes of apricots was always positive, but in most years, the coefficients were not significant ($r < 0.35$). Only the comparison of some years showed a highly significant correlation (for example when comparing the years 1995 and

1999, the coefficient of correlation was 0.71++). In the years with a very high quantity of flower buds, the differences in the quantity of flower buds between genotypes were smaller and the coefficient of variation for this character was also smaller (for example in 1998 we obtained v=10.21 and in 1999, v=9.96%). When the years were less favourable for the formation of flower buds, the coefficients of variability were twice as four times higher. Tab. 5. A very highly significant negative correlation (r=-0.98++) was calculated between the quantity of flower buds expressed in points and the coefficients of variability of these values. Fig. 2. In the years when an average number of flower buds died because of frost during the period of postdormancy (1994 and 1997), a significant correlation (r=0.58++) was found out between the percentage of their death. In the years with a very high level of damage of flower buds due to frost, differences between genotypes were smaller. This happened for example in 1998 when the average number of damaged flower buds reached 74.22% and the correlation with damages in the years 1994 and 1997 was indeed positive, but not significant (r=0.29 to r=0.38). The most frost resistant genotypes observed from 1994 to 1999 were LE-1917, Vynoslivyj and Lemeda (LE-962), the most sensitive to frost were LE-SEO-24 and Lednická (M-90A). Tab. 2.

Table 2. Percentage of frozen flower buds in postdormancy on 24 genotypes of apricot from 1994 to 1999 (there were not any damages due to frost in 1995, 1996 and 1999)

Genotypes	Frozen flower buds in %			Average and mean error of average
	1994	1997	1998	
HARLAYNE	59.20	15.20	66.40	46.93 ± 16.00
LE-392	57.00	10.00	78.00	48.33 ± 20.10
PRIUSADEBNYJ	72.80	23.20	92.00	62.67 ± 20.50
SEM. BADEMERIK	44.50	16.00	77.00	45.83 ± 17.62
LE-2267	34.67	9.60	68.00	37.42 ± 16.91
LE-390	28.80	10.40	77.80	39.00 ± 20.11
LE-1917	20.80	15.20	42.40	26.13 ± 8.29
NJA-1	67.20	17.60	98.40	61.07 ± 23.53
ARZAMI AROMATNYJ	64.00	13.60	55.20	44.27 ± 15.54
VOLŠEBNYJ	31.20	14.40	59.00	34.87 ± 13.00
VYNOSLIVYJ	50.80	10.40	26.40	29.20 ± 11.75
M-45	80.00	54.40	62.00	65.47 ± 7.59
M-25	69.60	40.80	64.80	58.40 ± 8.91
VELKOPAVLOVICKÁ LE-6/2	72.00	48.00	88.00	69.33 ± 11.62
HAROGEM	63.60	29.60	97.60	63.60 ± 19.63
LE-2185	46.00	9.00	68.00	41.00 ± 17.21
LE-1580	24.00	21.33	77.33	40.89 ± 18.24
SABINOVSKA 220	60.00	51.00	78.40	63.13 ± 8.06
LE-1453	82.80	4.80	96.00	61.20 ± 28.46
LEMEDA (LE-962)	42.40	12.00	46.40	33.60 ± 10.86
LE-1321	28.20	16.00	97.60	47.27 ± 25.41
LEDNICKÁ (M-90-A)	81.14	77.20	83.60	80.65 ± 1.86
LE-SEO-118	61.60	27.00	86.00	58.20 ± 17.12
LE-SEO-24	81.60	82.00	95.00	86.20 ± 4.40
Average percentage	55.16	26.20	74.22	51.86 ± 13.96
Coefficient of variability %	26.03	29.34	23.05	

Fig.. 1. Average quantity of flower buds of 24 genotypes of apricots and average temperature and total precipitations during the vegetation (IV-IX) of previous year in the period from 1994 to 1999

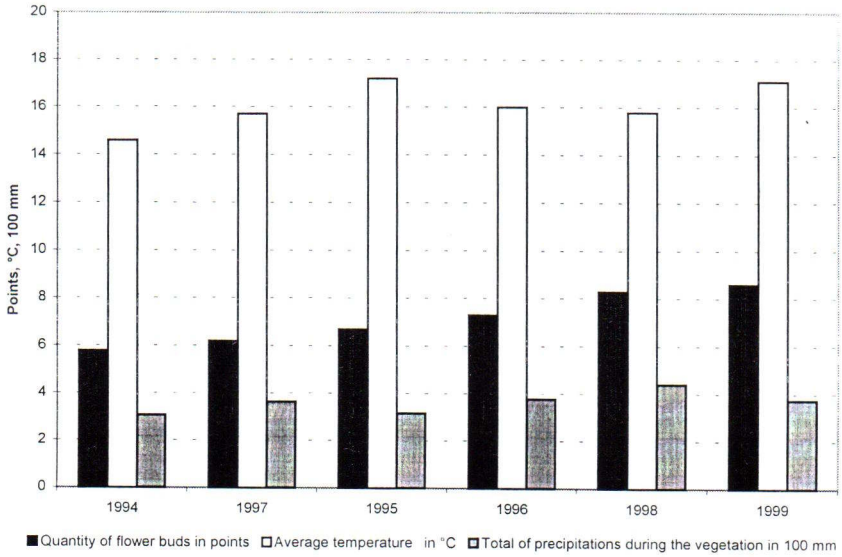
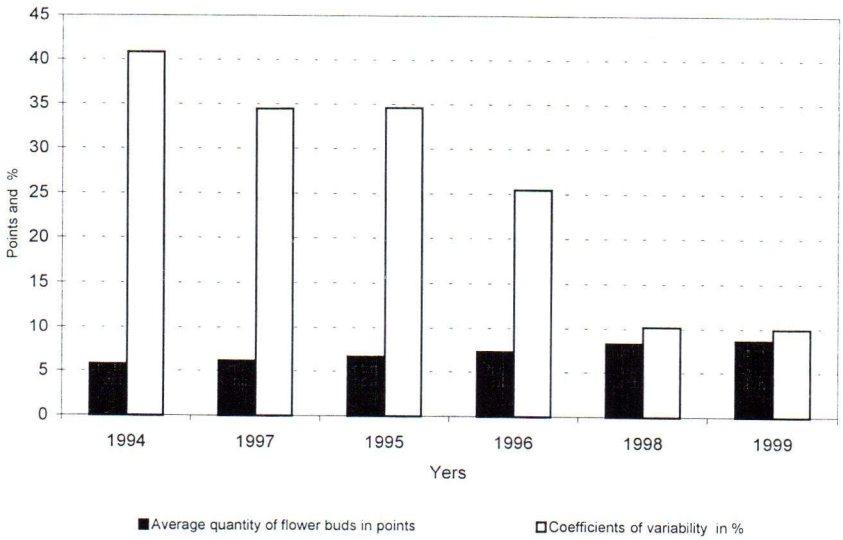


Fig. 2. Average quantity of flower buds in points and coefficients of variability in % in the set of 24 apricot genotypes in the six year period



A sufficient number of flower buds does not necessarily ensures a normal cropping, it is only one of its conditions. Even if the number of flower buds is sufficient, the formed flowers can be badly pollinated and fertilised, and they can be damaged when flowering because of spring frost. The potential for a normal cropping can so be reduced. In most years, the average **quantity of flowers** expressed in points was sufficient to ensure normal cropping. However 1997 was an exception because the number of flowers was medium and was not sufficient for most genotypes. This situation was partly due to the dying of flower buds at the time of postdormancy. Genotypes LE-2267, M-25 and Sabinovská 220 had the lowest evaluation (in points) of the number of flowers. The lowest variability of the quantity of flowers in all the collection of genotypes was reached in the years with the richest flowering (in 1999) and on the contrary the highest variability was obtained when flowering was very poor (1997). Tab. 5.

The **number of fruits** observed before the natural falling down in June in the phenophase „H" already signalled the level of the coming cropping. Low average numbers of fruits were observed in the years 1994, 1997 and 1998. In these years the highest values of coefficient of variability for the phenophase „H" were obtained. The lowest quantities of fruits were observed on Sabinovská 220 and M-25. Tab. 1. Most of the correlations between the quantity of fruits before the natural falling down in June in each year were positive but not statistically significant. This correlation was significant only between some years (r=0.45+ to r=0.50+). Even in this case, it was found out that the quantity of fruits during the phenophase „H" results from several factors and their cross-reactions. The highest average quantities of fruits for the 6 years in this phenophase were found out on the genotypes Priusadebnyj and Vynoslivyj. Tab. 1. The evaluations of the natural falling down of fruits in June were done only in 1998 and in 1999. In the year with a very large number of small green fruits (1999), the quantity decreased of 1 point because of the natural falling down of fruits in June. This approximately corresponds to a 10% reduction of cropping. In the year when the crop was not heavy, no falling down of fruits happened (1998). Tab. 3. The correlation between the number of fruits during the phenophases „H" and „I" was highly significant (r=0,88++) in the year with very good conditions for cropping. Only a few genotypes reacted to the very large number of small fruits by a more important natural falling down of fruits (for example M 45, M 1580 and LE-2158). This feature can be considered as a disposition of the genotype and this corresponds to Couranjou´s point of view (1971 and 1983). Fig.3.

The **harvest weight in kilo per tree** depending on the genotype and on the external conditions results from the other characters which have been mentioned above (quantity of flower buds, their resistance to frost, the quantity of flowers and the quantity of fruits before and after the natural falling down in June). Agricultural technology, nutrition, irrigation, plant protection also influence the cropping. These factors differentiate even more the final results and increase the variability of harvest weight of the evaluated genotypes in each year. The coefficient of variability of the harvest weight reached the highest value from all evaluated factors (from v=43.35% to 131.64%). Tab. 5.

Nevertheless significant coefficients of correlation (r=0.40+ to 0.67++) were found out for the character harvest weight in kilo per tree between some years. The lowest harvest weight was obtained in the years when flower buds froze and when flowers were damaged due to bad weather during the flowering period. The highest harvest weight in the six years observation was reached by the cultivar Vynoslivyj. Its average harvest weight per tree reached 20.39 kg. On the opposite the lowest average harvest was observed on the cultivar Sabinovská 220 and M-25. Tab. 1.

Table 3. Average quantity of fruits in the phenophase „I" (phenophase of the young fruit after natural falling down in June) in points on genotypes of apricot in 1998-1999

Genotypes	Quantity of fruits in the phenophase "I" in the year	
	1998	1999
HARLAYNE	1.2	7.4
LE-392	3.7	8.7
PRIUSADEBNYJ	5.2	8.8
SEM. BADEMERIK	4.5	8.8
LE-2267	5.0	8.3
LE-390	3.2	8.0
LE-1917	6.8	4.6
NJA-1	1.5	9.0
ARZAMI AROMATNYJ	5.0	8.0
VOLŠEBNYJ	6.3	5.8
VYNOSLIVYJ	6.8	7.6
M-45	1.8	4.5
M-25	2.0	3.0
VELKOPAVLOVICKÁ LE-6/2	2.2	6.2
HAROGEM	1.6	9.0
LE-2185	5.3	6.0
LE-1580	2.8	4.8
SABINOVSKA 220	1.4	3.4
LE-1453	1.6	9.0
LEMEDA (LE-962)	3.0	7.8
LE-1321	2.0	9.0
LEDNICKÁ (M-90-A)	2.0	4.0
LE-SEO-118	7.8	8.3
LE-SEO-24	3.3	8.7
Average	3.6	7.0
Coefficient of variability %	54.86	27.98

The correlation between the harvest weight in kilos and the quantity of flower buds expressed in points in the years with a normal course of vegetation was highly significant or closed to be significant (r=0.37n to 0.68++). An even higher dependence was observed between the quantity of flower buds and other evaluated characters (number of flowers, number of fruits during the phenophases „H" and „I"). In these cases, the coefficients of correlation observed in the years with a normal course of vegetation reached from r=0.41+ to r=0.99++. Tab. 4.

Table 4. Correlation between the number of buds and the number of flowers, the number of fruits in the phenophase "H", the number of fruits in the phenophase „I", the harvest weight on 24 genotypes of apricots in each year from 1994 till 1999

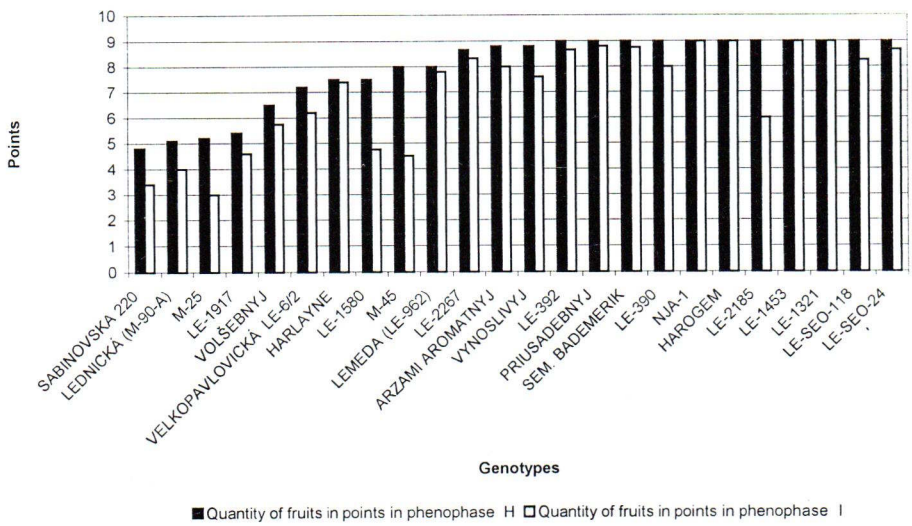
Relation between	Coefficient of correlation in the year					
	1994	1995	1996	1997	1998	1999
The quantity of flower buds and the quantity of flowers	0,82++	0,99++	0,98++	-0.32	0.39	0,99++
The quantity of flower buds and the quantity of fruits at phenophase "H"	0,41+	0,75++	0,86++	-0.31	0.29	0,77++
The quantity of flower buds and the quantity of fruits at phenophase "I"	x	x	x	x	0.33	0,67++
The quantity of flower buds and harvest weight	0,37n	0,53++	0,68++	-0.32	0.33	0,67++

x - was not evaluated; n- close to significance; + significant correlation; ++ highly significant correlation

Table 5. Coefficients of variability for the values of chosen quantitative characters on apricots genotypes in each year of the period 1994 till 1999

Character	Coefficient of variability in % in the year					
	1994	1995	1996	1997	1998	1999
Quantity of flower buds	40.82	34.63	25.48	34.49	10.21	9.96
Quantity of flowers	44.72	33.35	25.75	54.67	35.21	10.93
Quantity of fruits	58.88	37.97	25.20	45.33	62.08	18.44
Harvest weight per tree	131.64	90.86	46.91	114.10	132.33	43.35

Fig. 3. Quantity of fruits in phenophase "H" a "I" in 1999 on 24 genotypes of apricot



Conclusion

Chosen quantitative characters (quantity of flower buds, flowers and fruits as well as harvest weight), their relationships and variability have been analysed on 24 genotypes of apricots from 1994 until 1999 in South Moravian conditions (Czech Republic). Majority of analysed genotypes was able to form a number of flower buds sufficient for a potential regular harvest. The quantity of flower buds was so that it could provoke a lower harvest only on three genotypes (LE-2267, M-25 and Sabinovská 220) and only in some years. However the quantity of flower buds does not only depend on the genotype but also on the resultant interactions of several factors. This was showed by the analysis of the ranking of genotypes according to their quantity of flower buds which has been proved to be statistically identic only in some years (r=0.49+ to r=0.71++). When the conditions for the formation of flower buds on apricots were very good, the variability of the quantity of flower buds was very low. The correlation between the ranking of genotypes according to their percentage of flower buds which perished because of frost was proved to be significant only in the years with average damages due to frost. When damages due to frost were very important the differences between genotypes disappear. Genotypes with highly frost resistant flower buds were Vynoslivyj and Lemeda (LE-962). In most years, a normal harvest could still be expected at the time of flowering However in some years the probability to reach a normal harvest decreased because of bad weather conditions at the time of flowering (pollination and fertilisation). The lowest variability of quantity of flowers was observed in the years with a very rich flowering (in 1999 for example). In 1999 a very highly significant correlation was found out between the quantity of fruits in the phenophases "H" and "I" (r=0.88++). Among all evaluated characters, the highest variability was obtained when studying the harvest weight in kilos per tree. The highest average harvest for the all evaluated period was observed on the cultivar Vynoslivyj (20.39 kg per tree). Because of the different influences and interactions, the correlation of the harvest weight per tree was found out to be significant only between some years (r=0.40++ to 0.64++). When the weather conditions were good (in 1995, 1996 and 1999) highly significant coefficients of correlation were found out between the quantity of flower buds, the quantity of flowers, the quantity of fruits and the harvest weight per tree (r=0.53++ to r=0.99++).

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OCENA BROJNOSTI CVETNIH PUPOLJAKA, CVETOVA, PLODOVA I UKUPNOG PRINOSA, NJIHOV KVANTITATIVNI ODNOS I VARIJABILNOST 24 GENOTIPA KAJSIJE U ŠESTOGODIŠNJEM PERIODU

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Rezime

Skoro svi analizirani genotipovi su bili u mogućnosti da formiraju veliki broj cvetnih pupoljaka dovoljnih za potencijalno normalan prinos. Kada su uslovi za formiranje cvetnih pupoljaka kajsije bili veoma povoljni, njihova varijabilnost je bila veoma niska. Korelacija između rangiranja genotipova u pogledu mrazom oštećenih cvetnih pupoljaka čini se da je signifikantnija bila u godinama sa prosečnim oštećenjima od mraza. Kada su oštećenja usled mraza bila veoma velika, razlike među genotipovima nisu uočene. Genotipovi sa cvetnim pupoljcima veoma otpornim na mraz su Vynoslivyj i Lemeda (LE-962). Najniža varijabilnost brojnosti cvetova je zapažena u godinama sa izuzetno obilnim cvetanjem (npr. 1999.). Između svih ocenjivanih karakteristika, najveća varijabilnost je konstatovana u prinosu plodova po stablu. Najveći prosečan prinos za ceo period istraživanja je imao genotip Vynoslivyj (20,39 kg po stablu). Utvrđeni su visoko značajni koeficijenti korelacije u godinama sa veoma povoljnim klimatskim uslovima (1995, 1996 i 1999) između brojnosti cvetnih pupoljaka, brojnosti cvetova, brojnosti plodova i prinosa plodova po stablu (r=0,53++ do r=0,99++).