Journal of Agricultural, Food and Environmental Sciences
UDC 634.23:539.166
Original scientific paper

MORPHOMETRIC CHARACTERISTICS ON SELECTED CHERRY PLANTS, A PRIMARY EFFECT PRODUCT OF GAMMA RADIATION (Cz137)

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Abstract
A study has been conducted on the rootstock cross area, trunk cross area and total growth with 195 selected plants, a primary effect product from Bigareau Burlat, Pobeda Krimska and Kozerska cherry varieties, during the first MV1 generation after the gamma radiation with Cz^{137}. Graft branches were exposed to dosages of 25Gy, 35Gy and 45Gy at the Institute of Radiobiology and Radiopreservation in Sofia. The graft was taken during dormant buds onto a Prunus mahaleb rootstock. The average values of all study parameters with the selected plants are 10 to 50% smaller in comparison with the controls (plants not treated with radiation). The highest reduction of total plant growth is noticed at Kozerska variety. The average value is 40% smaller in contrast to the control. The average values for this characteristic provide statistical significant differences for all radiation dosages with the selected plants in contrast to the control. The highest difference was noticed with the dosage of 25 Gy, where the total growth is 50% smaller than the control. A very high positive correlation is determent between the rootstock and trunk cross area, as well as between the rootstock and trunk cross area and with the total growth in all of the tested varieties. Negative correlation between the radiation dosage and the total growth is detected for Pobeda Krimska and Kozerska. This kind of correlation is not present in Bigareau Burlat.

Key words: Prunus avium L., gamma radiation, dosage, rootstock and trunk cross area, total growth.

Introduction

The radiation treatment with gamma rays is applied with the sole purpose of enhancing the frequency of the natural variability, shortening the process of selection, and enriching the gene-fund with new initial material for creating new gene- types (Popovska and Popovski, 2012). The efficiency of the ionization with the fruit species depends on the type and intensity of the radiation, radio-sensitivity of the variety, the part of the plant that is exposed to the radiation, the units stadium of development, the cells' physiological condition and their dynamism at the moment of treatment, the climate, the temperatures during the winter period above all, etc. (Kolesnikova, 1970; Ravkin, 1973; Milenkov, 1974; Lapins, 1983; Donini *et al*., 1991).

Appearance of the modification changes at fruit plants after radiation treatment with gamma rays, can be used as a diagnostic measure for somatic mutations (Nybom, 1961; Bishop,1967; Равкин, 1973; Миленков,1974; Donini, 1975, Lapins,1983). All of the changes are primary effect result of serious damage of the apical meristem of the leaf buds, as well as the secondary effect of the physiological disbalance which emerges in the affected cells (Guncle and Sparrow, 1961). The authors mention that the regeneration area of the affected cells emerges in the primary brunches with an atypical position of the buds, significantly fattened nodal regions, and an atypical brunch color, presence of furcations and fasciations and atypical leaves.

The changes which the radiation exposure causes over the DNA molecule, directly slows down its synthesis, as well as that of the RNA, proteins, ATR and the cell's mitosis (Gunchel and Sparrow, 1961; Borojević, 1976; Pearson

et al., 1975; Mišić, 1999).The occurrence of shortened internodes leads to a decreased growth in the plants and poses one of the most substantial modification changes which are a result to the radiation treatment (Ravkin 1973, Milenkov, 1974).

The aim of this paper is to analyze some morphometric characteristics of selected prospective cherry plants, as a primary effect product from radioactive treatment of three cherry varieties with three different dosages of Cz^{137}, and to compare them with the controls (plants not treated with radiation). The selected plants present a promising starting material for further selection and creation of new varieties or cherry rootstocks.

Materials and methods

Dormant buds from Bigareau Burlat, Pobeda Krimska and Kozerska cherry varieties were treatedwith radioactive Cz^{137} in doses of 25Gy, 35Gy and 45Gy. Graft branches were exposed to radiation at the Institute of Radiobiology and Radiopreservation in Sofia. Prunus mahaleb L. was used as a rootstock for grafting the buds, right after the treatment (30^{th} of August 2000 and 2001). Untreated buds from each variety were used as a control variant. Each variant was grafted onto two hundred rootstocks.

An early diagnosis of the primary effects of the radiation was made in the first MV_1 generation following the treatment. Basic criteria for first choice was made according to the appearance of plants with the following four characteristics: decreased vigorousness and irregularly positioned leaf buds, presence of furcations (bi-, three- and polyfurcations), atypical leaves (shape, size, color, edginess, deficiency of chlorophyll etc.) and expressive outspread of the plants (Popovska *et al*.,2011).

A study has been conducted on the rootstock cross area, trunk cross area and total growth with 195 selected plants, a primary effect product from radiation in the first year after the treatment of dormant buds. The measures were made in autumn, after falling of the leaves. The obtained experimental results were processed using t-test to prove the statistical significance of the differences between the controls and variants at levels of significance 0.05, 0.01 and 0.001 (Најчевска, 2002). The correlation between the different traits is established with a correlation analysis, determining the strength of the connection through a correlation coefficient, according to Snedecor (1959) (Најчевска, 2002).

The research was performed at the experimental field in the Institute of Agriculture in Skopje. The soil type is silt - clay loam, suitable for cherry production, with moderate alkaline pH according to its reaction in water and neutral according to its reaction in KCl, very carbonate, with a low amount of humus, with a good amount of hydrolyzing nitrogen and optimal amount of easily obtainable phosphorous and potassium. The trial was watered with a drop irrigation system.

Results and discussion

According to the basic criteria for early diagnostic of the effects of treatment with radioactive Cz^{137}, 195 or 46,9% of the total number of plants received after the treatment, have been selected in MV_1 generation (Popovska *et al*.,2011). The decreased vigorousness of the selected plants has the most participation of 29,3% from all present primary effects, followed by furcations (23%), then plants with atypical leaves (6,1) and then with expressive outspread (4,3%) (Popovska *et al*., 2011).Respective to the variety,88 plants are selected from Bigareau Burlat, 54plants from Pobeda Krimska and 53 are from Kozerska . Related to the dosage, 83 are selected from radiation of 25Gy, 58 from 35Gy and 54 from 45Gy (Popovska *et al.* ,2011).

The data about the tested morphometric parameters are presented in Tables 1-3 and Figures 1-3. The control Bigareau Burlat has the lowest values for the three tested traits, compared to the controls of the other varieties, while Pobeda Krimska has the highest values for rootstock cross area. Kozerska has the highest values for trunk cross area and total growth.

Almost all of the average values for the three tested traits among the selected material are lower than the control values, from 10 to 50%, depending on the variety and the dosage. This is expected, because the trait *lower growth* is the most determined among the selected material. Exception is established for the variety Bigareau Burlat for the dosage of 35 Gy, where the values for rootstock cross area and total growth are higher for 10-20%

compared to the control. The reason for this result is found to be in the highest number of plants with expressive outspread selected from this variety.

The average rootstock cross area is 339.9 mm^2 (Table 1). The smallest deviation from the control value is determined at Bigareau Burlat, which represents 10%. The differences between the tested variants and the control are statistically insignificant. Higher dissimilarities are established for the varieties Pobeda Krimska and Kozerska. For the both varieties the total average is 40% smaller than the control value and the difference is statistically important at the level of significance of 0.01. Statistically significant differences are established among all of the variants, but the highest differences and very statistically significant are for the average values of the 45 Gy dosages. Analyzing the tested dosages, significantly smaller rootstock cross area is determined for the dosages of 25 and 45 Gy. Overall, the rootstock cross area from the whole selected material is lower for 30% and the difference is statistically significant at the level of significance of 0.01.

The average trunk cross area of the selected plants is 214.9 mm^2, which is 30% smaller than the control values (Table 2). Because the rootstock and the graft branches are directly connected, they influence each other's growth. A very strong positive correlation is determined between the rootstock cross area and the trunk cross area. The correlation coefficient for Bigareau Burlat is 0.896 and is statistically significant at the level of significance of 0.05, according to Snedecor (1959). For the varieties Pobeda Krimska and Kozarskaa complete positive correlation is established between the two traits. The correlation coefficients are 0.969 and 0.961 accordingly and are statistically significant at the level of significance of 0.01.

Table.1. Rootstock cross area of selected plants

Variety	Dose	Rootstock cross area (mm^2)	Index	T	CV %
Bigareau Burlat	Control	441.0 ± 35.4	1.0		31,5
	25Gy	350.0 ± 49.5	0.8	1.495	60,2
	35Gy	440.8 ± 72.9	1.0	0.002	57,9
	45Gy	383.9 ± 78.1	0.9	0.666	68,0
	25-45	391.6 ± 66.8	0.9	0.654	62,0
Pobeda Krimska	Control	575.4 ± 51.3	1.0		32,6
	25Gy	372.8 ± 42.6**	0.6	3.040	44,4
	35Gy	364.1 ± 72.7*	0.6	2.684	65,9
	45Gy	261.3 ± 52.8***	0.5	5.491	67,0
	25-45	332.7 ± 46.8**	0.6	3.493	59,1
Kozerska	Control	534.1 ± 48.9	1.0		34,8
	25Gy	326.8 ± 55.2*	0.6	2.813	41,1
	35Gy	326.2 ± 71.4 *	0.6	2.403	54,3
	45Gy	232.9 ± 26.3***	0.6	5.425	37,8
	25-45	295.3 ±` 50.9**	0.6	3.382	44,4
Average of controls		516.8 ± 45.2	1.0		32,9
Average 25 Gy		349.9 ± 49.1*	0.7	2.503	48,6
Average 35 Gy		377.0 ± 63.0	0.7	1.796	59,3
Average 45 Gy		292.7 ± 43.2***	0.6	3.584	57,6
Average 25- 45 Gy		339.9 ± 55.2**	0.7	2.490	55,2

Again, the smallest deviation from the control value is determined for Bigareau Burlat, which represents 10% and the differences between the tested variants and the control are statistically insignificant. The highest difference is observed for the variety Pobeda Krimska. The average value is 40% smaller than the control value, which represents statistically significant difference. The value is the smallest for the 45 Gy dosages and the plants have 50% smaller trunk cross area than the control and the differences are statistically highly significant. The smallest trunk crosses area for the variety Kozerska is established for the plants treated with 45 Gy dosages. The trunks have 40% smaller cross area and the

difference from the control value is statistically highly significant. The average value is 220 mm^2, which is 30% smaller than the control. Analyzing the tested dosages, statistically significant smaller trunk cross area is determined for the 45 Gy dosage.

Table.2. Trunk cross area of selected plants

Variety	Dose	Trunk cross area (mm^2)	Index	t	CV %
Bigareau Burlat	Control	285.4 ± 22.8	1.0		36,0
	25Gy	216.8 ± 41.0	0.8	1.462	80,3
	35Gy	324.1 ± 49.5	1.1	0.712	73,5
	45Gy	211.2 ± 62.7	0.7	1.112	88,8
	25-45	250.7 ± 51.1	0.9	0.620	80,8
Pobeda Krimska	Control	286.5 ± 36.6	1.0		47,5
	25Gy	172,0 ± 28.7*	0.6	2.465	52,8
	35Gy	203.7 ± 57.7	0.7	1.212	89,6
	45Gy	146,4 ± 25.3**	0.5	3.152	67,0
	25-45	174,0 ± 37.2*	0.6	2.156	69,8
Kozerska	Control	314.5 ± 35.0	1.0		40,3
	25Gy	240.3 ± 72.6	0.8	0.922	98,6
	35Gy	248.3 ± 70.4	0.8	0.842	62,9
	45Gy	171,3 ± 26.3**	0.6	3.272	37,8
	25-45	220.0 ± 56.4	0.7	1.424	66,4
Average of controls		295.5 ± 31.4	1.0		41,3
Average 25 Gy		209.7 ± 47.4	0.7	1.508	77,2
Average 35 Gy		258.7 ± 59.2	0.9	0.548	75,3
Average 45 Gy		176,3 ± 38.1*	0.6	2.413	64,5
Average 25- 45 Gy		214.9 ± 48.2	0.7	1.399	72,4

The average total growth of the selected plants is 224.5 cm and is 20% smaller compared to the control average value (276.8 cm) (Table 3). For the Bigareau Burlat, the highest number of plants with expressive outspreadis determined, which resulted with the highest average total growth from all of the tested varieties. The average is 10% higher than the control. Most of these plants are established among the 35 Gy dosage. Accordingly, for this dosage the highest total growth is measured, which is 20% higher compared to the control. Deviations were established, but the t-test did not show statistically significant differences in any of the variants for this variety. For the variety Pobeda Krimska, a statistically very high significant difference for the total plant growth is established for the 45Gy dosage. The tested plants have 40% smaller total growth than the control. The biggest deviations are determined for Kozerska. That is a variety with the most branched crown. The control has the highest total growth from all of the tested varieties (334.8 cm). The radiation effect gave a high number of plants with decreased vigorousness, which also resulted in high deviations in the total growth from the control. The differences are statistically significant for all of the dosages. In the other variants, the plants have 40 to 50% smaller total growth. The highest difference, statistically significant at the level of significance of 0.01 is established for the 45 Gy dosages.

Table.3. Total growth of selected plants

Variety	Dose	Total growth (cm)	Index	t	CV %
Bigareau Burlat	Control	243.9 ± 24.2	1.0		37,1
	25Gy	240.1 ± 45.4	1.0	0.074	86,9
	35Gy	303.8 ± 65.7	1.2	0.857	72,9
	45Gy	232.9 ± 50.0	1.0	0.198	70,3
	25-45	258.9 ± 53.7	1.1	0.256	76,7
Pobeda Krimska	Control	251.8 ± 22.9	1.0		33,2
	25Gy	198.9 ± 39.3	0.8	1.163	57,4
	35Gy	195.9 ± 42.4	0.8	1.162	70,2
	45Gy	139.6 ± 25.3**	0.6	3.291	67,0
	25-45	178.1 ± 35.7	0.8	1.739	64,8
Kozerska	Control	334.8 ± 39.7	1.0		43,7
	25Gy	183.6 ± 41.1*	0.5	2.645	73,4
	35Gy	211.0 ± 50.7*	0.6	1.921	55,7
	45Gy	188.5 ± 26.3**	0.6	3.070	37,8
	25-45	194.4 ± 39.4*	0.6	2.510	55,6
Average of controls		276.8 ± 28.8	1.0		38,0
Average 25 Gy		207.5 ± 41.9	0.7	1.361	72,6
Average 35 Gy		236.9 ± 52.9	0.9	0.662	66,2
Average 45 Gy		229.0 ± 33.9	0.8	1.074	58,4
Average 25- 45 Gy		224.5 ± 42.9	0.8	1.012	65,7

A statistically significant positive correlation between the rootstock and trunk cross area, and the total plant growth is established. The correlation coefficients between the rootstock cross area and total growth, as well as the trunk cross area and total growth, for Bigareau Burlat are 0.597 and 0.849, accordingly. These coefficients show strong correlation between the traits, statistically significant at the level of 0.05. Stronger and complete correlation is determined for the other two varieties. For Pobeda Krimska, the correlation coefficients are accordingly 0.971 and 0.927 and for the variety Kozerska are 0.945 and 0.839. The correlation coefficients are statistically significant at the level of significance of 0.01.

Also, complete and very strong negative correlations between the height of the dosages used and the total growth for the varieties Pobeda Krimska and Kozerskaare determined. The correlation coefficients are accordingly -0.952 and -0.882 and are statistically significant at the level of significance of 0.05. This kind of correlation is not established for the variety Bigareau Burlat. The correlation coefficient r is 0.170. The reason for this is that most of the plants with furcations are determined in the variant with 35 Gydosage, which led to higher total growth for this variety.

The degree of variation for these three traits is measured through the values of the coefficient of variation (CV), given in Tables 1-3. Overall, the tested traits in the selected plants vary in much higher ranges, than in the control variants. The highest variation is observed in all of the varieties for the trait trunk cross area (CV=72.4%), while the smallest variation is monitored for the trait rootstock ross area (CV=55.2%). Analyzing the varieties separately, the three traits vary the most in the variety Bigareau Burlat, in average from 62% for rootstock cross area to 80.8% for trunk cross area. The traits vary the least in the variety Kozerska, from 44.4% for rootstock cross area, to 66.4% for trunk cross area.

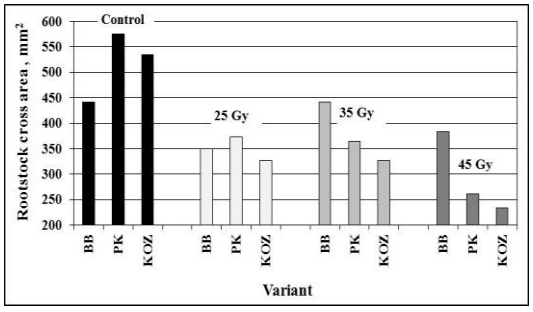

Figure1. Rootstock cross area of selected plants

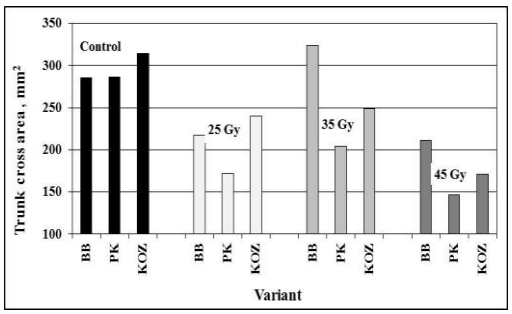

Figure 2.Trunk cross area of selected plants

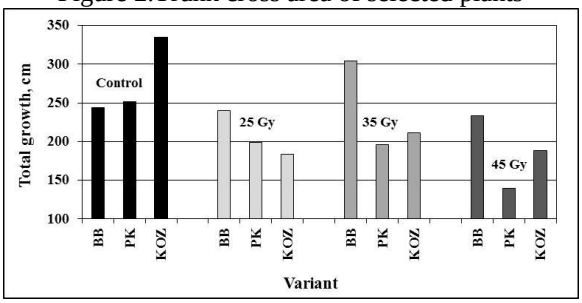

Figure 3. Total growth of selected plants

Analyzing overall, according to the height of the dosages used, the rootstock cross area varies the most for the dosage of 35 Gy, while the trunk cross area and total growth for 25 Gy. The rootstock cross area varies the least for the dosage of 25 Gy, while the trunk cross area and total growth for 45 Gy.

Conclusions

The morphometric characteristics of the selected cherry plants, as a primary effect from the treatment with gamma rays, depend from the traits and the number of plants who according to the basic criteria were chosen in the first MV_1 generation following the radiation treatment.

Most of the selected plants have decreased vigorousnes, which leads to that, that the selected material has in average 10-50% lower values for all of the tested traits in comparison with the control, depending on the variety and the rootstock. Exception represents Bigareau Burlat for the dosage of 35 Gy, where the values for the rootstock cross area and total growth are higher for 10-20% than the control, because of the highest number of plants with expressive outspread, selected from this variety.

A very high positive correlation is determent between the rootstock and trunk cross area, as well as between the rootstock and trunk cross area and with the total growth in all of the tested varieties. Negative correlation between the radiation dosage and the total growth is detected for Pobeda Krimska and Kozerska. This kind of correlation is not present in Bigareau Burlat.

All of the tested traits vary in much higher degree in the selected plants than in the control variants. The trunk cross area is the trait with highest variation, while the rootstock cross area with least variation.

The three tested morphometric characteristics vary the most in the variety Bigareau Burlat, while they vary the least in the variety Kozerska. The rootstock cross area varies the most for the dosage of 35 Gy and the least for 25 Gy, while the trunk cross area and total growth vary the most for 25 Gy and the least for 45 Gy.

The selected 195 plants present a promising starting material for further selection and creation of new varieties or cherry rootstocks.

References

1. Bishop C.J. (1967). Radiation induced mutations in vegetative propagated fruit

trees. Proceedings of the XVII International Horticultural Congress, Vol 1,pp. 83-95.
2. Borojević S., Borojević K. (1976). Genetika. Poljoprivredni fakultet. Novi Sad.
3. Donini B. (1975). Improvement of vegetative propagated plants through induced mutations. Proceedings of Research Coordination Meeting, Tokai, Vienna. IAEA, Vol1, pp. 35-51.
4. Donini *et.al*. (1991). Mutation breeding programmes for the genetic improvement of vegetative propagated plants in Italy. Proceedings of an International Symposium on the Contribution of Plant Mutation Breeding to Crop Improvement. Vienna. IAEA., Vol.1, pp. 237-254.
5. Gunchel, J.E. Sparrow A.H. (1961). Ionizing radiations:biochemical, physiological and morphological aspects of their effects on plants. Encyclopedia of Plant Physiology, 16, pp. 555-611.
6. Колесникова А.Ф. (1970). Индуцированный мутации вишни. Селъскохозяйственная биология., No 4. Москва.
7. Lapins K.O. (1983). Mutation breeding. Methods in fruit breeding. Edited by James N. Moore and Jules Janick. Purdue University Press West Lafayette. Indiana.
8. Миленков М.М. (1974). Индуцированный мутагенез у черешни. Диссертация на соискание ученой степени кандидата биологических наук. Академия наук СССР, Сибирское отделение. Обединенный ученый совет по биологическим наукам. Новосибирск.
9. Mišić P. (1999). Genetika. Partenon. PKB INI Agroekonomik. Beograd.
10. Nybom, N. (1961).Theuse of induced mutations for the improvement of vegetative propagated plants. Symposium on mutation and plant breeding. Washington, pp. 252-294.
11. Најчевска Ц.(2002).Експериментална статистика применета во земјоделските и биолошките истражувања. Бона.Скопје.
12. Pearson O.W., Sander C., NilanR.A. (1975). The effect of sodium aside on cell processes in the embryonic barley shoot. Radiation Botany, 15, pp. 315-322.
13. Поповска М.(2007).Ефекти од гама зрачењето кај некои сорти цреши. Докторска дисертација. УКИМ, Факултет за земјоделски науки и храна - Скопје.
14. Popovska M., Popovski B., Gjamovski V. (2011). Criteria for early diagnostics of primary effects of the treatment with gamma rays (Cz^{137}) at some cherry varieties. Plant Science No 48, pp. 47-52.
15. Popovska M., Popovski B. (2012). The influence of the treatment with different gamma rays (Cz137) doses on bud sprouting at some sweet cherry varieties. Journal of Mountain Agriculture on the Balkans, Vol. 15, 3, pp. 634-642.
16. Равкин А.С.(1973). Исполъзование ионизирующей радиации и химических мутагенов в селекции плодовых и ягодных култур. Москва.