UDC 634.11:581.4(292.485)(477)

Features of formation of productivity of columnar apple-tree

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The purpose. To determine potential of productivity and efficiency of its implementation at different stages of organogenesis of *columnarity* of apple-tree depending on variety and age of trunk areas. **Methods.** Field, laboratory, comparative, generalizations. The study was spent in 2016 – 2018 in plantings of primary high quality probe of *columnar* varieties of apple-trees of 7-, 8- and 15-, 16-years old on a stock 54-118. Trees are grown under the scheme 4x1 m. Determination of stages of organogenesis and calculation of quotient of statistical assessment is realized according to procedure Isaeva I.C. **Results.** The probed *columnar* varieties on IIIrd, IVth stages of organogenesis differed by efficiency of differentiation of regenerative gemmas among themselves and on years. During Xth, XIth stages of organogenesis there were losses of potential productivity due to decrease of flowers, ovaries and fruits. As a whole the highest level of implementation of potential productivity was observed at varieties President, Valuta and Tantsovshchitsa which trees counting for 1 potentially generative gemma generated 0,41 – 0,58 fruits, the lowest — at variety Sparta — 0,12. **Conclusions.** In Forest-steppe in combination with good soil-climatic conditions and high agro techniques plants of columnar varieties form tall potential of productivity. Its successful implementation in 7-, 8-years trees secures yearly crop within the limits of 2 – 12 kg for 1 tree depending on variety. The greatest participation in formation of economic crop, for example at variety Valuta, take part the oldest 7-, 8-years old trunk areas, at variety Favorit — 2–5-years old.

Key words: *productivity, columnar apple-tree, fruit formations, elements of reproduction, organogenesis, differentiation of regenerative gemmas, reduction.*

DOI: https://doi.org/20.31073/agrovisnyk201906-4

According To the information of R.P. Kudriavtsia [1], A.A. Zamorskoho [12] and other scientists, the productivity of Apple-is the total of the whole organic substance, which is formed during photosynthesis process, and in the economic understanding is a part of biological Productivity, which is realized as a crop of fruit. The Biological process of plant transition of apple from a vegetative state in general is due to the differentiation of generative bud. This process is the key in the problem of creating with the planting regular fruit-bearing of apple trees [10]. Its Passing occurs during the III-IV stages of organogenesis [**Ошибка! Источник ссылки не найден.**], therefore, according to I.S. Isaievoi [2], the above mentioned stages are considered as critical, since the conditions of their passing depend on the possibility of transition of potential components of fruiting to real fruiting points [7].

During the IV-V stages as a result of formation of the germ flowers in generative bud is the sealing is is formed elements of potential yields. In the usual sortes at the expense of vegetative shoots, and in a columnar apple-tree (in most varieties) - the parts of vegetative buds on simple and complex kiltsivkakh, which do not undergo differentiation of generative buds (buds with unfinished cycle of organgenesis), the potential performance reduction is already in this period. **Analysis of the last researches and publications.** I. Kolomiitsem [4], F. Kobellem [5] and other scientists investigated a question of dependence of differentiation of generative buds on weather conditions. So, by results "five-year researches I. Isaieva [2] found that this process starts earlier in terms of warm and dry enough summer than cold and rainy, but, in view of the scholar, this difference in terms of early differentiation of generative in a variety of weather is insignificant and reaches the 7-14 days. Research T.Ye.

Kondratenko [9] the varietal difference in terms of the beginning of differentiation of generative buds is revealed, in the development stage of the last in the pre-winter period and in terms of the onset and duration of IX-X stages of organogenesis for traditional genotype of apple trees. Information on the organogenesis of buds in plants of a columnar apple-tree varieties, which would allow to establish the features of this process in a different complex kiltsivkakh, absent, as well as the causes of productivity and longevity of the latter.

The Purpose of our research is to determine the potential of plant productivity and the effectiveness of its implementation at different stages of organogenesis of the buds of fruit formations, located on different parts of the trunk of columnar apple-trees.

Materials and methods of research. Research of productivity potential and features of organogenesis of buds of different fruit formations of the columnar apple-trees in the conditions of Forest-Steppe Of Ukraine were carried out in the Department of Selection of Fruit and berry cultures of Institute of Horticulture of NAAS Ukraine (IH NAAS). Determination of the stages of organogenesis and calculation of statistical estimation coefficient was carried out by the method of I.S Iseva (1989)[2]. The Objects of the research were seven varieties columnar apple-trees of domestic and foreign selection in the plantings of Apple-tree NAAS (not irrigated), which were laid in 2002 and 2010. According to the methods of primary sorting. Trees on the rootstocks 54-118 planted in the circuit 4x1m. The Soil of the experimental area of dark gray is under the middle loamy on the carbonate lesi, typical for the right-bank part of the western Forest-Steppe. The System of soil retention in rows of the garden is dernovo-podsolic, near the trunk – herbicide pairs. Agrotechnical Care of plantations (without irrigation) was carried out in accordance with the zonal recommendations [6].

The Climate of the region location of investigated plantings is moderately continental. The Average annual air temperature is 7.3 C, annual rainfall-657 mm, the amount of active temperatures 2580 °c. During The investigation, weather conditions were not characterized by variability. The Thermal regime in general facilitated the good growth and development of plants. The Sum of active temperatures of 10 C and above substantially exceeded average perennial values and amounted to 3200 °c (2017) and 3681 C (2018). Conditions Winter 2016-2017 and 2017-2018 years were favorable for successful wintering plants. The Annual rainfall amounted to 385.5 mm (2017) and 360.0 mm (2018). In 2017 during flowering the frosts were observed (minus 2-4 C), and next year during the tying fruit-ice storm.

Research Results and discussion. Plantations of plants investigated by us a column-like grades in the II stage of organogenesis formed, depending on the grade, 0.3-2.5 mln. pieces. buds/ha. At III-IV stages of organogenesis of the grades differed by the efficiency of differentiation of generative buds both among themselves and on years (table. 1). In 2017 the most effective formation of generative buds took place in plants of grades of the President and Valiuta. In 2018 on the trees of a grade, the Tantsivnytsia of differentiation were 92% of buds. This happened due to favourable meteorological conditions during the preparation of plants before the transition of kidneys from II to III-IV stages of organogenesis. On average In two years of study the largest number of generative buds from the total of their number formed on the trees of the varieties Tantsivnytsia, the President and the Valiuta (52-58%), the smallest-in the Favoryt (20%).

Table. 1. Efficiency of realization of potential productivity of plants of columnar apple-trees on III-IV stages of organogenesis (statistical evaluation factor), IH NAAS

Stages of organogenesis / Sorts		* Tantsivnytsia	* Sparta	** President	**Valiuta	** vvoryt	** Snow Wite	* Bolero
II	The previous year	1,000	1,000	1,000	1,000	1,000	1,000	1,000
III-IV	2017	0,248	0,163	0,527	0,548	0,083	0,425	0,308
	2018	0,922	0,636	0,496	0,560	0,337	0,481	0,288
	average	0,583	0,395	0,517	0,555	0,205	0,453	0,302

Notation: * - 7-8-year-old trees
** - 15-16- year-old trees

According to T. E. Kondratenko [8], in the generative buds of fruit formations of different species formed a different number of flover. On sprout, terminal buds shoots and rings of usual grades of them more (5-7 pieces), on the fruiting and in the claws of buds of one-year increments – less (3-5). As a result, the participation of each type of fruit formations in the formation of productivity at the IV-VIII stages of organogenesis is changing. In The investigated columnar apple-trees the vast majority of fruit formations represented simple and complex rings, in the generative buds of which, depending on the variety, formed 5-7 flower: In the varieties of Bolero, Snow White and a Dancer on 7 flower, in Sparta, President, Currency and Favorit – 5.

At the V stage of organogenesis possible reduction of a significant number of reproduction elements as a result of the action on the germ of the flowers of low subzero temperatures. T. E. Kondratenko reports that on the V-VIII stages at winter-spring circumcision of ordinary grades is removed more than 35% of generative buds, that is artificially reduced potential productivity. Implementation of performance potential, which is in the form of flower (IX stage of organogenesis) depends on the success of pollination and fertilization, which influence meteorological conditions during flowering and presence of grades of pollinators [3]. In the rainy and cool weather, the fertilization is complicated. Not simultaneously, and the gradual blooming on the tree flower allows to write fertilization of the flowers. Thus, the asynchronous blooming is one of the adaptations for effective implementation of potential performance in the real crop.

Table. 2. Efficiency of realization of potential productivity of plants of columnar apple-trees on V-IX stages of organogenesis (statistical evaluation factor), IH NAAS

Stages of organogenesis / Sorts		* Tantsivnytsia	* Sparta	** President	**Valiuta	** Favoryt	** Bilosnizhka	* Bolero
II	The previous year	1,000	1,000	1,000	1,000	1,000	1,000	1,000
V-IX	2017	1,737	0,475	1,743	2,033	0,346	2,034	1,711
	2018	6,326	3,178	2,480	2,799	1,684	3,368	1,969
	average	4,084	1,770	2,142	2,459	1,001	2,701	1,862

Notation: * - 7-8-year-old trees
** - 15-16- year-old trees

In 2017, the plants of grades Bilosnizhka and the Valiuta in the calculation of one potentially generative buds formed two flowers (table 2), much the lowest amount of flowers are recorded on the trees of the varieties of Sparta and Favorit -100 potentially generative buds were 26 and 35 flowers were formed accordingly. Next year the plants of a sorte Tantsivnytsia distinguished the most intense flowering-on one potentially generative bud accounted for 6.3 flowers; The smallest number of flowers in the given year was formed on the trees of the Favoryt varieties and Bolero-1.7 and 2.0 flower respectively.

On average for 2017-2018 years the largest number of the formed Flowers in the calculation on one potentially generative buds observed in the plants of a grade of a Tantsivnytsia (57%)-four flowers on seven potentially possible, the smallest-in the Favoryt-20%. During the X-XI stages Organogenesis is determined by the efficiency of realization flowers in the fruit and the average mass of the latter, which in conjunction and determines the harvest. In Addition to the growth of fruits, the growth of unfruitful Zavyazok is often observed, which over time is reducing. The Duration of this process in early ripe grades is two weeks, in late-ripe-three. At the XI stage the formation of a hereditary conditioned for each grade of the fetus is formed; Depending on the conditions of a certain year, the magnitude may change. Thus, during the X-XI stages of organogenesis simultaneously with the formation of crop at the expense of a certain number of fruits and their average mass go and loss of its potential through the reduction of flower, knit and fruit. This process F. Kobel [5], E. Gareev [7] and others, are divided into two periods.

The First period lasts two weeks after flowering and corresponds to the X stage of Organogenesis (by ISAAC). In 2017 the smallest reduction of reproduction elements after flowering was marked by the grades of Valiuta and the President, plants of these grades reduced 57-59% of potential elements of the future crop (table 3). This year has been marked by considerable reduction flowers in grades Favorit and Snow White – up to 90%. The Cause of mass decay Flowers served as frosts (minus 2-4) in the first decade of May.

In favourable terms of weather conditions 2018, the reduction of flower and knit was less intense. The Coefficient of reduction of potential fruiting items was the smallest in the sortes of Valiuta and President. In the calculation of 100 potentially generative buds plants of these grades were formed 67-70 knit. The Biggest losses were observed in the varieties of Sparta and Bilosnizhka, the data tree of grades was reduced to more than 85% of the elements of reproduction. The Slightest loss of knit the X stage of organogenesis on average for two years is noted in the plants of grades of Valiuta and the President (43-44%), the biggest-Snow-white and Favoryt-to 87%.

Table. 3. Efficiency of realization of potential productivity of plants of columnar apple-trees on X stages of organogenesis (statistical evaluation factor), IH NAAS

Stages of organogenesis \ Sorts		* Tantsivnytsia	* Sparta	** President	**Valiuta	** Favoryt	** Bilosnizhka	* Bolero
II	The previous year	1,000	1,000	1,000	1,000	1,000	1,000	1,000
X	2017	0,326	0,173	0,407	0,424	0,105	0,099	0,274
	2018	0,470	0,148	0,670	0,699	0,176	0,152	0,377
	average	0,400	0,165	0,559	0,569	0,132	0,126	0,326

Notation: * - 7-8-year-old trees

** - 15-16- year-old trees

In The second period (X-XI stages of organogenesis) reduction is taking place in knit and matured fruits. In the calculation of one potentially generative kidney in 2017, the largest number of fruits was formed by the trees of the President and the Valiuta (table 4). Low level of realization of potential performance was observed in plants of varieties of Sparta, Favorit and Bolero, on 100 buds formed in accordance 6, 8 and 8 fruits.

For columnar apple-tree of grades of Valiuta, Tantsivnytsia and President in 2018 the low level of reduction of reproduction elements is inherent. Above mentioned grades were formed in the calculation of 100 potentially generative buds 40, 44 and 58 fruits respectively. The Variety of Sparta formed 12% of the fruit from potentially possible. The Highest level of implementation of potential performance on average for 2017-2018 years has been observed in the grades of the President, Valiuta and the Tantsivnytsia. Data Trees of grades on one potentially generative buds formed 0,41-0,58 of a fetus; The low level of realization of potential performance was observed in the sorte of Sparta – 0.12.

Table. 4. Effectiveness of elements of reproduction columnar apple-trees on XI stages of organogenesis (statistical evaluation factor), IH NAAS

Stages of organogenesis / Sorts		* Tantsivnytsia	* Sparta	** President	**Valiuta	** Favoryt	** Bilosnizhka	* Bolero
II	The previous year	1,000	1,000	1,000	1,000	1,000	1,000	1,000
X	2017	0,174	0,063	0,354	0,325	0,083	0,119	0,078
	2018	0,611	0,148	0,770	0,541	0,158	0,122	0,155
	average	0,405	0,104	0,584	0,445	0,115	0,120	0,116

Notation: * - 7-8-year-old trees

** - 15-16- year-old trees

According to T. E. Kondratenko coefficient of realization of potential productivity less than 0.100 testifies to serious violations in the technology of care of the quality, it is unsuitable for him climatic conditions of growing zone or influence of adverse weather Conditions of particular year. In 2017, the effectiveness of performance potential was influenced by May frosts. Subzero temperatures reduced 100% of the Knit located in the lower part of the trunk, which significantly influenced the real harvest. Thus, our research has shown that in the Forest-Steppe of Ukraine in combination of favourable soil and climatic conditions and high Agrotechnics investigated columnar apple-trees form a high potential of productivity. Successful implementation of it in 7-8-year-old trees on the average of the rootstocks 54-118 guarantees an annual harvest of 2-12 kg of fruit.

Anatomist-morphological analysis of buds of investigated columnar apple-trees grades showed that in the conditions of Forest-Steppe of Ukraine at the end of July they are in their development in the II stage of Organogenesis. This period corresponds to the formation of potential productivity, which is determined by the common number of buds, which reached this stage [11]. Separately taken the age parts of a tree trunk of a columnar apple-trees e species form different initial performance potential (tabl. 5).

Table. 5. Participation of the different parts of the trunk 7-8 annuals of grade Valiuta in the formation of performance at different stages of organogenesis (54-118, landing scheme 4x1m)

Number of reproduction elements (III-XI stages of organogenesis) on different parts of the trunk (% of the total number on the tree)										
The Age of the trunk, year	2016	2017	2017	2018	2017	2018	2017	2018	2017	2018
	Buds				Flower (V-IX)		Fruits			
	Vegetative (II)		Generative (III-IV)				(X)		(XI)	
1	6,8	8,9	-	1,3	-	1,3	-	1,1	-	1,2
2	12,6	6,7	6,0	6,0	6,1	6,0	12,8	6,2	12,4	7,1
3	7,6	8,2	8,4	10,2	8,6	10,2	23,1	10,5	24,4	10,9
4	15,3	7,6	20,3	10,5	21,2	10,5	39,2	10,9	35,5	11,5
5	20,5	10,9	30,3	14,5	31,8	14,5	25,0	14,2	27,7	9,1
6	25,2	13,9	25,9	15,1	26,6	15,1	-	17,1	-	15,6
7	12,1	20,3	9,1	19,7	5,7	19,7	-	21,6	-	22,4
8		23,6		22,7		22,7		18,4		22,3
Tree	100	100	100	100	100	100	100	100	100	100

In six-year-old trees (2016), the Valiuta in the II stage of organogenesis of the largest part in formation of potential productivity belonged to five-seven-year-old bodies of the Relationships stem-they were placed 57% of buds from the total quantity, which was formed on all Tree. There is the same pattern and in 2017, five-eight-year age plots formed 68% of all buds of fruit tree.

Six-Year-old trees of a grade Valiuta in the III-IV stages of organogenesis (mid-July-November, [9]) laid 200-224 thousand/ha of generative Buds, the largest number of them are located on four-six-year-old sites (76%). In the shoots-one-year no generative buds were formed. Next year planting of trees of this variety laid 290-305 Thousand/ha of generative Buds. Fruit formations six-year-old formed from 10 to 15% of flower buds from their total quantity on a tree. The Greatest differentiation of generative Buds has been held on complex of eight-year age, about 23%.

In 2017, due to the digestive frosts during the IX stage of organogenesis there was a complete reduction of Flower on six-seven-year-old fruit formations, the fruit was tied on fruit formations of two-year-old trunk areas. During the V-X stages of organogenesis in 2018 the year were observed favourable for flowering, fertilization and growth of fruit of meteorological conditions. The Smallest reduction of Knit took place in the oldest fruit formations. Six-eight-year age-based plots formed 57% of the total number of Knit on the tree; The youngest fruit formations retained the fewest number of reproduction elements (table 5).

At the End of XI stage of Organogenesis in 2017, the largest share of fruits from total their quantity on a tree is recorded on four-year fruit formations (35%). The next year the reduction in the XI stage was minimal. The Smallest proportion of the formed fruits with The total crop was observed in the of one-year increments (1.2%), the largest – on the fruit formations, which are located on seven-eight-year-old trunk sites (together with 44%), that is the greatest participation in the formation of a tree of a grade Valiuta the oldest part of the trunk.

Similar observations within two years for the formation of potential productivity and its implementation at different stages of organogenesis in a sort of Favorit showed that in the trees of this variety in the II stage of organogenesis 23% of Buds from the total quantity that formed on the whole tree, located on a four-year-old area, four of the youngest age areas form up to 62% of all Buds (table 6). During III-IV

stages of organogenesis of the sorte Favourite trees is from 20 to 200 thousand/ha of generative Buds; In annual increments, they were not formed altogether. The Most Effective differentiation of Buds took place on three-four-year fruiting-23.6 and 25.2%. The Smallest amount of reduced Flowers, Knit and fruit during the V-XI stages of organogenesis are accounted for in the youngest age areas of the stem, namely two-four-year. At the End of XI stage of Organogenesis 63% of the fruits from their total quantity on the tree was placed in two-four-year areas of a tree, that is the greatest participation in the formation of crop on the tree took the youngest fruit formations.

Table. 6. Participation of the different parts of the trunk 7-8 annuals of grade Favoryt in the formation of performance at different stages of organogenesis (54-118, landing scheme 4x1m)

Number of reproduction elements (III-XI stages of organogenesis) on different parts of the trunk (% of the total number on the tree)					
The Age of the trunk, year	Buds		Flower (V-IX)	Fruits	
	Vegetative (II)	Generative (III-IV)		(X)	(XI)
1	12,3	-	-	-	-
2	10,0	20,8	21,2	15,7	16,4
3	17,1	25,2	25,6	26,2	26,0
4	23,0	23,6	24,0	23,4	20,7
5	9,0	15,2	15,4	13,9	16,0
6	8,3	8,1	8,2	8,2	8,1
7	7,4	4,0	4,0	9,9	10,2
8	13,0	3,2	1,6	2,8	2,6
Tree	100,0	100,0	100,0	100,0	100,0

Conclusions

In the Forest-Steppe of Ukraine 7-8 and 15-16-year-olds the plants of investigated a columnar apple-tree grades form a high potential of productivity (0.3-2.5 million pieces of Buds /ha). At III-IV stages of organogenesis of the grades differed by the efficiency of differentiation of generative Buds both among themselves and by years. The Most effective performance potential at these stages is realized by the trees of a Tantsivnytsia, President and Valiuta (52-58%), less effective – plants Favoryt (20%).

During the X-XI stages of organogenesis are the losses of potential productivity through the reduction of Buds, Knit and fruit. The Smallest loss of Knit during X stage of organogenesis is observed in plants of grades of Valiuta and the President (43-44%), the largest-in Tantsivnytsia and Favoryt-to 87%. At the XI stage of Organogenesis of the grades of the President, Valiuta and a Tantsivnytsia on the basis of one Potentially generative Buds were formed 0,41-0,58 of the fetus; The low level of realization of potential performance was observed in the sort of Sparta – 0.12.

Separately taken age areas of the trunk of grades of the Valiuta at the II stage of organogenesis form different initial potential of productivity. The Most Efficient it is realized on the X-XI stages of organogenesis of complex fruit formations of seven-eight-year (the oldest) parts of the stem. In the plants of a variety Favoryt the largest part in the formation of the general crop of the tree take the fruit formationsof the younges (2-5-year).

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