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THE INFLUENCE OF PROPER VINE PRUNING TECHNIQUES ON CROP FORMATION AND QUALITY OF THE GRAPES

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Abstract

We have established the importance of proper vine pruning techniques depending on individual grape variety characteristics and its influence on crop formation and quality of the grapes. The technique of studying the influence of the length of the vine pruning on the qualitative indices of the fruit of the grapes has been proposed. Field research was carried out in 2014-2016. Agricultural technology in the experiment is commonly used for forest-steppe. The vines are planted on the plot without irrigation, the shape of the shrubs is harp multy sleeved with a knot of substitution, sheltered on a vertical trellis of 1.5 m heigh. The methods that can be used to increase the yield of grape varieties in the Poltava region (Ukraine) have been analyzed. It has been established that the coefficient of fructification of apical buds predominantly correlates with the actual yield, which allows to use this link to predict yields by grape varieties. The justification and characterization of the selected methods of vine pruning, which would ensure the obtaining of high sustainable yield and fruit quality, as well as the economic efficiency of growing grapes, have been given.

Keywords: pruning method, fruit vine, yield formation, fruit quality, fertility of the central buds, economic efficiency of cultivation.

PROBLEM DEFINITION

The problem of vine pruning methods remains disputable until now. It is known that perennial parts of the vine are constantly replaced with young ones, as a result, the plant retains the same form, vigour and fruiting for many years. Enormous experimental materials have been accumulated by now, making it possible to establish clear patterns of influence of various methods of vine pruning on the formation of the harvest and quality of the grapes, which, however, vary widely in various grape varieties. In modern conditions, the main direction in viticulture is the search for effective ways to increase the yield and quality of the regional grape varieties.

ANALYSIS OF BASIC RESEARCH AND PUBLICATIONS, WHICH INITIATED A SOLUTION TO THE PROBLEM

The accumulated world experience and the obtained results suggest that viticulture in Ukraine is becoming one of the most profitable crops, which makes it possible to significantly improve the agro-industrial complex overall state.

Pruning has been the long-standing, most important and most difficult event to care for a grape bush. A number of rules that form the basis of pruning have been developed over thousands of years. Due to pruning, up to 35% of pliable substances are used to form clusters (Reynolds 1989, Williams 2000, Dikan *et al* 2001).

At insufficient light, most nutrients are used for the growth of leaves and shoots, instead of the grapes bunches. When excessive thickening the leaves bush, the assimilation surface is not used enough. In this regard, the photosynthesis energy decreases, a significant part of plastic substances goes to the shoots growth and development, and not to the formation of clusters. Therefore, as a consequence, there is a decline in yields with a short pruning method (Wermelinger and Koblet 1990, Coombe 1995, Lovisolo *et al.* 2009).

The grapes have the ability to high yield with different ways of pruning, thanks to a wide range of changes in the shoots size. The purpose of pruning the vine is to increase the yield and improve the quality of berries, taking care for the proper plant growth. (Howell 2001, Smart *et al.* 2017). Correct pruning has a positive effect on the growth, grapes fruiting and quality, while the wrong one is negative.

Each bush, depending on its development, the agricultural machinery level and varietal characteristics, withstands a certain load of shoots and crop (Jackson and Lombard 1993, Volovik 2009). The proper bushes loading is ensured the balance in the development of vegetative and productive organs. An incorrect pruning is disturbed the balance in the direction of strengthening one process and

weakening another. When the bushes are overloaded, the shoots will be weak, wintering buds will be poorly developed, and this will lead to a sharp fall in harvest quality next year. In this case, the ripening of the harvest is delayed, the sugar content in the berries decreases (they do not reach the optimum size), the vines stability to diseases and low temperatures decreases. The art of the vinegrower is the ability to balance the yield of the bush, the quality of the crop and its normal annual growth in equilibrium, and this is achieved by a properly crafted pruning.

Summing up the literature review, we can conclude that there is no consensus among scientists on the impact different ways of pruning on the formation yield and grape quality.

The main aim of the research was to select the methods pruning the vines, which would provide a high sustainable yield and fruit quality, as well as the economic efficiency growing grapes.

MATERIALS AND METHODS OF RESEARCH

Field research was carried out in 2014-2016 on the private plots of land that is located on the territory of the Reshetylovka district of the Poltava region. The soil of the experimental site is typical low-humus black soil. Agrochemical indicators (0-30 cm): humus according Tyurin: 4.37-4.65; pH (salt): 6.5-7.1; capacity of absorption 45.1-46.3 mg-eq. per 100 g of soil. Total nitrogen: 0.25-0.28%, phosphorus: 0.15-0.18%, potassium: 2.3-2.5% is contained in a layer 0-20 cm (Lyashenko 2017).

Agricultural technology in the experiment is commonly used for forest-steppe. The vines are planted on the plot without irrigation, the shape of the shrubs is harp multy sleeved with a knot of substitution, sheltered on a vertical trellis of 1.5 m heigh. The living area of the bush is 3.0 × 1.5 m.

In order to study the effect of the length of the vine pruning on the yield and quality of the fruit of the grapes on the experimental plot, in 2014-2016 field and laboratory experiments were carried out according to the generally accepted methodology of field experiment of Dospehov (1985).

Scheme of the experiment provided the following options:

1. 3-bud vine pruning.
2. 6-bud vine pruning.
3. 9-bud vine pruning.
4. 12-bud vine pruning.
5. 15-bud vine pruning.

Studies have been carried out on varieties of different ripening terms – Muscat steady (white, very early), Arcadia (early), Talisman (late) – a method of rendering repetitions three times repeated, for 10 bushes each (Grape variety 2017).

During the experiments the following tasks were set:

- to find the value of the index of fecundity, percentage of fruitful and barren shoots, the percentage of non-developed and dead buds based on the obtained data on agrobiological counting;
- to determine the correlation between the intensity of growth of shoots and clusters under the influence of different length of pruning according to the generally accepted method;
- to determine the density of the clusters using the density factor;
- to determine the yield by weight method in each repetition of the five variants;
- to determine the concentration of sugar and titrated acids in the wort by chemical-technological analysis;
- to conduct organoleptic analysis of clusters and berries.

RESEARCH RESULTS

The conducted studies indicate that the main index of the potential fetal growth of the central buds lies in two factors: coefficient of fecundity of the central buds on well-differentiated rudiments of inflorescences, as well as the coefficient of fecundity of the central buds in the sum of good and slightly differentiated rudiments of inflorescences. A characteristic feature is the fact that (Table 1), in the basal part of the shoots (first to third buds), in all experimental varieties, in the central buds, a small number of well-differentiated inflorescences were found, in most cases the buds had slightly differentiated rudiments, resulting in the coefficient of fruiting them is much smaller than in the buds of higher-placed nodes.

The data of Table 1 show that for the short cut, the lowest value of the coefficient of fruiting (the Muscat steady 0.83, Arcadia 0.98 and Talisman 0.51). Its maximum value in the Muscat steady variety, it is achieved when pruning on 12 buds – 1.27; Arcadia variety – on 9 buds – 1.32; in the Talisman variety – on 12 buds – 1.08. Further, with an increase in the length of the fruit shoots to 15 buds, the fertility factor is slowly decreasing. The same pattern is observed in the changes in the coefficient of fecundity by the sum of rudiments of inflorescence (Table 1).

In light of the above we can draw conclusions:

- the fecundity of the central buds of the grape shoots is determined by the number and quality of inflorescence rudiments formed in them;
- the fecundity of the central buds along the axis of grape shoot is accompanied by increase in the coefficient of fruitfulness from basal to its middle part (for the Muscat – 9^{th} bud, for the Arcadia– 9^{th} bud, for the Talisman – 12^{th} bud), and then it decreases to its top (15^{th} bud).

- grape harvest is determined not only by the formation of inflorescences in the previous vegetative year, but also by the conditions of awakening and differentiation in the spring of the next year.

Table 1. Influence of methods of pruning on the fecundity factor of the central buds for well-differentiated rudiments of inflorescences and the sum of the rudiments of inflorescence (average for 2014-2016)

Length of pruning, number of buds	Fertility coefficient of the central buds for well differentiated rudiments inflorescence	Fertility coefficient of the central buds for the sum of the rudiments of inflorescence
Variety Muscat steady		
3	0.83	1.76
6	1.02	2.05
9	1.22	2.26
12	1.27	2.29
15	1.18	2.20
Variety Arcadia		
3	0.98	1.63
6	1.12	1.95
9	1.32	2.21
12	1.23	2.22
15	1.11	2.15
Variety Talisman		
3	0.51	1.16
6	0.64	1.43
9	0.91	1.65
12	1.08	1.77
15	0.98	1.65

During agrobiological research (Table 2), it was found that the greatest number of green shoots develop in the bushes with a length of pruning in the Muscat steady variety on 12-15 buds, which is fundamentally different from the previous variants. In the Arcadia variety, the variation in the number of developed shoots in the study variants is not significant. The Talisman has a completely different dependence – a large number of developed shoots is observed for a short cut.

In general, according to the varieties, it was found that the Muscat steady and Arcadia have a number of fruiting shoots almost independent of the length

of the pruning. In the Talisman variety, the number of fruit-bearing shoots on long vines is to a large extent prevailing their number on a short vine. It is clearly evident that the short cut method leads to a significant decrease in the number of fruitful shoots that have evolved from the lower branches, as compared with the method of long pruning. The number of fruit-bearing shoots of the variety at trimming for three and six buds decreased by approximately 1.5 times (Table 2).

Table 2. Influence of vine pruning methods on the number of shoots on the bush (average for 2014-2016)

Length of trimming, number of buds	Shoots that have developed, pcs.	Percentage of fruit shoots per bush,%
Variety Muscat steady		
3	29.2	47,5
6	28.8	51,7
9	28.7	53,2
12	31.7	51,7
15	36.2	49,7
Variety Arcadia		
3	32.3	55,6
6	31.5	56,7
9	30.5	57,2
12	31.5	54,8
15	33.7	50,9
Variety Talisman		
3	34.7	26,6
6	36.1	28,4
9	31.5	35,4
12	28.7	44,4
15	29.8	40,4

The varieties Muscat steady and Arcadia have more fruit shoots formed by cutting on nine buds of 53.2% and 57.2%, respectively, of the Talisman variety – on 12 buds, which is 44.4%. These data support the hypothesis of the need to develop varietal pruning.

Summarizing the foregoing, it can be concluded that:

- actual fruitfulness of shoots in spring decreases in comparison with the fecundity of the central buds;

- the length of the pruning of the vine is an active tool for controlling the fecundity of the shoots.

The fruitfulness of buds is entirely variable value and depends not only on the varietal characteristics, but also on various environmental factors and agricultural technology. Its correction takes place in the spring period in the first phase of vegetation of a subsequent year and depends on the existing conditions.

As a result of our research, it was established (Table 3) that the fruiting of shoots in spring decreased compared with embryonic one.

The data of Table 3 indicate that the maximum value of the coefficient of embryonic fetal growth of the shoots during the years of observations on the Muscat – 1.48 and Talisman – 1.45 reaches at the trimming on 12 buds, to the Arcadia variety – 1.33 reaches at the trimming on 9 buds.

Table 3. Influence of the vine pruning methods on the coefficient of embryonic fruiting of the shoots, and the coefficient of fruiting of shoots in spring (average for 2014-2016)

Length of pruning, the number of buds	Coefficient of embryonic fruiting of the shoots	Coefficient of fruiting of shoots in spring
Variety Muscat steady		
3	1.34	0.78
6	1.39	0.81
9	1.47	0.84
12	1.48	0.81
15	1.38	0.73
Variety Arcadia		
3	1.19	0.77
6	1.30	0.83
9	1.33	0.89
12	1.25	0.79
15	1.21	0.71
Variety Talisman		
3	1.14	0.33
6	1.21	0.37
9	1.32	0.52
12	1.45	0.62
15	1.25	0.55

The coefficient of fruiting of the studied shoots increases its meanings to the middle part of the vine.

Nevertheless, the average value of this indicator for various types of trimming increases to a maximum in the Muscat steady – 0.84 and Arcadia – 0.89 on 9 buds, Talisman – 0.62 on 12 buds.

Obviously, for these varieties, this is the length of the trimming, which will help increase the fertility of the buds and shoots in the spring period.

Summarizing the foregoing, it can be concluded that:

- regardless of the variety, the shoots formed from the branches of the lower part of the vine are characterized by the lowest level of fecundity. And the longer the trimming, the wider the zone of low fruiting shoots;
- short pruning stimulates the differentiation of the rudiments of inflorescences in the buds of the basaltic part of the vine in the early spring period of the vegetation, and as a consequence, increases the fecundity of the shoots that developed from them. The shorter the pruning, the better and more complete implementation of the coefficient of fetal growth of the buds in the coefficient of fruiting shoots is.

Scientists have proven that the growth processes of the vegetative organs of the vine plant are controlled. Changing the length of the trimming of the fruit vines, you can purposefully regulate the growth and fruiting of the vines. Thus, the length of the trimming is an active regulator of the overall growth force of the bush, as well as its generative parts and their interconnection.

It has been established that at the extension of the vine pruning, the intensity of the growth of the clusters increases to a certain limit. In Muscat steady and Arcadia the largest clusters were marked by trimming on 9 buds – 358.9 grams and 722.4 grams respectively, in the Talisman variety – 12 buds – 1050.5 grams. Further extension of the pruning also negatively affects the intensity of the cluster growth (Table 4).

It is possible to plan a crop with a given density of clusters in advance on the basis of the established pattern, applying the appropriate length of the pruning of the vine. Muscat steady has a dense cluster as a varietal trait in which the density factor does not exceed 0.600 g/cm^3. Thinning is achieved by execution of extended pruning.

Variety Arcadia as a whole does not have a dense cluster, except for cutting on 3 buds, the density factor is 0.305 g/cm^3. When cutting 6 buds, the density factor reaches 0.278 g/cm^3. Applying a longer prune method, for example, on 9 buds, it is possible to reduce its density to 0.250 g/cm^3, which corresponds to significant dilution. The Talisman variety does not have a dense cluster in general, but with a short prune method, it becomes dense (density factor is 0.341 g/cm^3). Taking into account the fact that not a dense cluster for table varieties is the most acceptable, in this case it is necessary to extend the pruning. As a result, we can draw the following conclusion: the density of clusters can be regulated, applying a different length of pruning of the fruit vines. A short cut method helps to increase their density, long cut method helps them to get thinned.

Table 4. Change in the density of clusters under the influence of the vine pruning in table grape varieties (2014-2016)

Length of pruning, the number of buds	Average weight of clusters,g	Average volume of clusters, cm^3	Coefficient of fruitfulness of the cluster, g/cm^3	Estimation of the cluster density
Variety Muscat steady				
3	268.1	678.7	0.395	dense
6	353.8	953.6	0.371	dense
9	358.9	1097.6	0.327	dense
12	307.1	997.1	0.308	dense
15	185.1	621.1	0.298	not dense
Variety Arcadia				
3	673.2	2207.2	0.305	dense
6	705.4	2537.4	0.278	not dense
9	722.4	2889.6	0.250	not dense
12	611.7	2517.3	0.243	not dense
15	572.7	2406.3	0.238	not dense
Variety Talisman				
3	925.0	2712.6	0.341	dense
6	987.7	3382.5	0.292	not dense
9	990.4	3695.5	0.268	not dense
12	1050.5	4218.9	0.249	not dense
15	852.2	3838.7	0.222	not dense

Important indicators of grape clusters are their mechanical properties. The conducted analysis revealed that the nodes of the axis of the vine change all the indicators characterizing the mechanical composition of clusters and grapes. It was found that the weight of the cluster and its size increase as the distance from the base of the vine with all variants of the pruning gets longer. At that, it was noticed: the longer the cutting, the more the cluster of lower nodes reduces its weight. These figures are directly related to the number of conditioned berries. It was mentioned above that the clusters of the lower nodes contain the least amount of well-developed berries. Obviously this affects negatively the weight of the clusters in general (Table 5).

If the weight of the clusters of the variety Muscat steady when pruned on 3 buds in the 1st node was 268.1 g, then, when pruned on 15 buds in this node, it has a weight of 185.1 g. In the Arcadia variety, the weight of the clusters decreases from 673.2 g to 572.7 g, in the Talisman variety – from 925.0 to 852.2

g (Table 5). In general, in all studied varieties, the weight of the clusters with a shortcut method in any of the three nodes is greater than the weight of the clusters of these nodes in the long cutting method.

Table 5. The mechanical composition of grape clusters at different lengths of fruit vine pruning

Length of pruning, the number of buds	Weight of clusters, g	Weight of berries in clusters		Weight of the crest in the cluster		Weight of 100 berries, g
		g	%	G	%	
Variety Muscat steady						
3	268.1	249.8	93.2	18.3	6.8	379.7
6	353.8	338.6	95.7	15.2	4.3	339.9
9	358.9	346.6	96.6	12.3	3.4	380.0
12	307.1	293.4	95.5	13.7	4.5	332.2
15	185.1	174.2	94.1	10.9	5.9	295.4
Variety Arcadia						
3	673.2	652.0	94.3	42.4	11.4	905.4
6	705.4	691.8	96.6	27.2	6.8	844.6
9	722.4	707.0	96.4	30.8	7.2	883.7
12	611.7	597.7	95.5	28.0	9.0	827.4
15	572.7	559.5	95.2	26.4	9.6	814.4
Variety Talisman						
3	925.0	901.4	95.5	59.6	6.4	999.4
6	897.7	875.7	95.6	55.0	6.2	924.6
9	990.4	974.0	97.2	41.4	4.2	964.8
12	1050.5	984.3	96.5	53.2	5.0	975.1
15	852.2	823.1	93.6	72.8	8.5	885.4

The average values of the mechanical composition of the grapes show that the largest weight of clusters recorded in the Muscat variety at the cutting on 9 buds and is equal to 358.9 g, Arcadia variety – 9 buds – 722.4 and the Talisman variety in the cutting on 12 buds – 1050.5 g respectively. In percentage terms, in all studied varieties, the most complete clusters were marked with a cutting on 9 buds. Muscat steady and Arcadia clusters contain 96.6% berries of the total weight, Talisman variety contains 97.2% on 12 bud cuttings. With further lengthening of the cutting, the average weight of the clusters, the weight of berries in it and the weight of 100 berries in all varieties is reduced due to inferior clusters of lower nodes.

As a result of the research conducted, the highest percentage yield of the marketable harvest in the Muscat varieties and Arcadia is observed at the length of the pruning of the vine on 9 buds. The Talisman is on 12 buds (Table 6).

Table 6. Grape harvest and its quality at different lengths of fruit vine prunings (2014-2016)

Length of pruning	Crop capacity		Weight Concentration	
	kg/bush	t/ha	Sugar, g/cm^3	Titrated acids, g/100 cm^3
Variety Muscat steady				
3	11.34	24.94	21.0	7.0
6	14.14	31.42	21.5	7.3
9	15.52	34.46	22.1	7.2
12	14.92	33.16	21.3	7.7
15	12.48	27.72	20.3	8.0
HIP_{05}	0.25	0.27		
Variety Arcadia				
3	12.61	28.00	14.2	7.1
6	15.53	34.36	14.6	6.8
9	16.60	36.88	15.0	6.8
12	13.74	30.54	14.8	7.0
15	11.44	25.42	14.0	7.4
HIP_{05}	0.17	0.35		
Variety Talisman				
3	15.93	35.40	13.2	7.4
6	18.30	40.65	13.5	7.1
9	22.29	49.53	14.1	7.0
12	24.75	54.99	14.3	7.2
15	18.78	41.71	13.8	7.4
HIP_{05}	0.21	0.71		

The data in Table 6 indicate that the best quality of the variety Muscat steady on the basis of indicators of weight concentration of sugars – 22.1 g/100 cm^3, titrated acids – 7.2 g/100 cm^3 were received when pruned on 9 buds. For a similar method of pruning of Arcadia variety, the indicator of the weight concentration of sugars was – 15.0 g/100 cm^3, titrated acids – 6.8 g/100 cm^3.

But the Talisman variety had the best crop quality in terms of weight concentration of sugars – 14.3 g/100 cm^3, titrated acids – 7.2 g/100 cm^3 when cut on 12 buds.

Based on the foregoing, it can be concluded that the mass concentration of sugars and titrated acids in juice in five variants showed a slight change in all studied varieties. However, the best correlation was noted in the varieties when cut on 9 buds.

It should be noted that the increase in yield and its quality are not fully accompanied by its commercial qualities. (Fig. 1).

The given data allow us to formulate the following conclusion: the length of pruning of vines in table grape varieties Muscat, Arcadia and Talisman has a significant impact on the yield of marketable grapes.

Organoleptic (tasting) assessment of table grapes was carried out with the participation of 30 tasters on the following indicators presented in Table 7.

The total score for the three indices determines the overall grade of the variety. The maximum grade of the variety is 10 points.

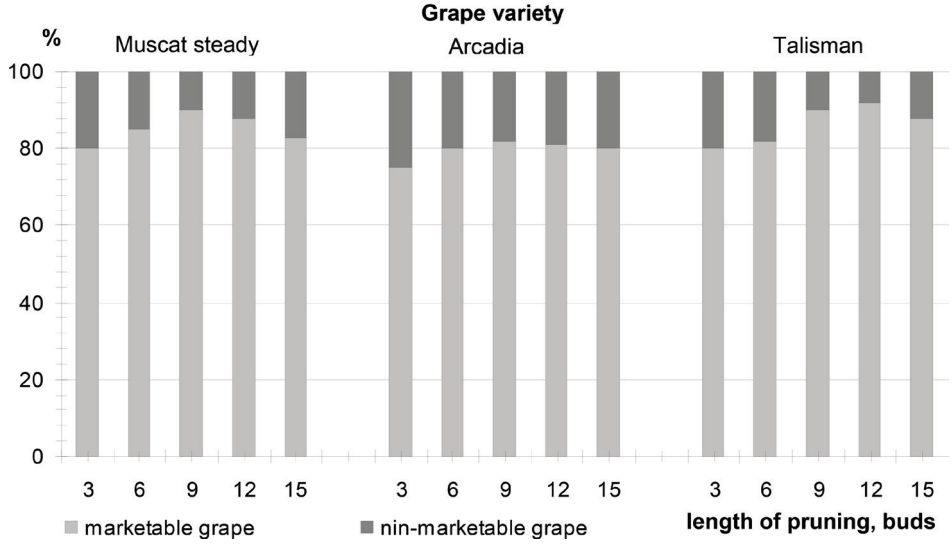

Figure 1. The ratio of marketable and non-marketable grapes with different length of vine pruning (average for 2014–2016)

Consequently, the data in the table show that, according to the appearance with the maximum number of points 2 Arcadia received 1.67 points (the highest number of points among tasting varieties), the Muscat steady variety received 0.76 points (the lowest grade among tasting varieties). According to the taste and aroma of berries with the maximum number of 5 points Muscat steady confidently scored 4.07 points, Arcadia scored the minimum number of points – 3.43. And by the properties of peel and pulp consistency, with a maximum score

of 3 points, the Talisman variety was the leader – 2.10 points, and the Arcadia variety got the lowest grade of 1.59 points.

Table 7. Indicators of organoleptic assessment of table grape varieties (in points)

Indicator	Assessment in points		
	Variety Muscat steady	Variety Arcadia	Variety Talisman
Appearance of clusters	0.76	1.67	1.58
The taste and aroma of berries	4.07	3.43	3.67
Peel properties and pulp consistency	1.80	1.59	2.10
Sum	6.63	6.69	7.35

Table 8. Economic efficiency of cultivating studied grape varieties

Indicator	Variety Muscat steady	Variety Arcadia	Variety Talisman
Yield, t/ha	34.46	36.88	54.99
Price per unit of product, thousand UAH/t	7.0	16.0	15.0
Price of gross output from 1 ha, thousand UAH	241.2	590.1	824.9
Labor costs, man-hour			
per 1 ha	616.24	616.24	616.24
per 1 t	17.9	16.7	11.2
Production costs per 1 ha, thousand UAH	151.3	151.3	151.3
Prime cost 1 t, thousand UAH	4.4	4.1	2.8
Net profit, thousand UAH	90.0	438.9	673.6
The level of profitability, %	59.47	290.11	445.31

25,5 UAH ≈ 1 USA (average value in years of research)

As a result of the organoleptic assessment of varieties, it should be noted that the Talisman variety received the maximum number of points due to the appearance and properties of the peel and pulp consistency. The Arcadia variety obtained the second stage of tasting assessment at the expense of a better appearance. The last studied sample of Muscat was the leader among the taste qualities, it obtained the highest grade. When it came to the peel properties and pulp consistency it was the runner up in the evaluation.The unattractive

appearance of the cluster with the lowest rating did not give a chance to take a confident second position of the tasting rating.

The necessity of economical substantiation of research results allows to evaluate the optimal way of cultivating a grape variety more fully.

Consequently, the calculations of the economic efficiency of growing the studied grapes varieties have proved their economic efficiency of industrial cultivation. But taking into account previous research we recommended the Talisman variety for the industrial cultivation which, subject to compliance with the relevant agricultural techniques, leads to an increase in both the productivity of the variety and its level of profitability. It is a very important indicator for today.

CONCLUSIONS

1. The best variety for industrial cultivation in terms of the quality of berries (22.3% sugar content) and the ecological side is Muscat steady;
2. Growth of the crop in the varieties was observed in the Muscat steady and Arcadia variety at 9-bud pruning (1.74 t/ha and 2.52 t/ha respectively), Talisman varieties – on 12 buds 7.14 t/ha compared with a traditional pruning on 6 buds;
3. It has been established that the fertility of the central buds along the axis of the grape sprout is accompanied by an increase in the fertility coefficient from the basal to the middle part (the Muscat variety – the 9^{th} bud, the Arcadia variety – the 9^{th} bud, and the Talisman variety – the 12^{th} bud), and then goes down to its top (15^{th} bud).
4. The optimum pruning length was established by experiment, at which the crop weight, marketability (%), density coefficient, were most successfully combined. That is 9 buds for the Muscat steady and Arcadia varieties, 12 buds for the Talisman variety.
5. Length of pruning of fruit vines in table grape varieties Muscat steady, Arcadia and Talisman has a significant impact on the output of products suitable for transportation over long distances.
6. The level of profitability turned out to be the highest on the varieties of experiment for growing the Talisman variety, where the indicator was 445.31% compared to Arcadia – 290.11% and Muscat steady – 59.47%.
7. Thus, taking into account the results of the research, the economically advantageous Talisman variety, characterized by a rather high level of profitability is recommended for the industrial cultivation.

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