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Efficiency of the Initiation Methods of Fruits in the Young Intensive-Type Apple Orchard

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ABSTRACT

The intensification of horticulture involves denser plantings, optimal provision with heat, light, moisture, and other life factors. Growing apples in intensive plantings require control and regulation of plant nutrition, the use of rational types of tree crowns, and pruning techniques. The study's main aim is to investigate the efficiency of the initiation methods of fruits in the young intensive-type apple orchard. An intensive-type unsupported apple orchard at the Agro centre Research and Production Complex of the Saratov State Agrarian University was planted in the fall of 2014 according to a 4x2.5 m scheme with 1000 trees per hectare. Rootstock - 54-118. The research was carried out in 2019 and 2020 on apple varieties of autumn (Zhigulevskoe, Orlik, Gubernskoe, Shafran Saratovsky) and winter (Kulikovskoe, Kutuzovets, Honey crisp, Berkutovskoe) ripening. On the example of 8 apple varieties (Zhigulevskoe, Orlik, Gubernskoe, Shafran Saratovsky, Kulikovskoe, Kutuzovets, Honey crisp, and Berkutovskoe), this article attempts to prove that green operations (June pruning of shoots more than 25 cm long for 4-6 buds) in a young intensive-type apple orchard leads to a decrease in the growth activity of plants, an increase in the specific foliage and the specific provision of branches with fruit formations. Foliar dressing of apple plants with an organic microelement complex during intensive growth provides an increase in plant foliage, the initiation of a more significant number of fruits, and the higher quality yield. Simultaneously, in the studied apple varieties, the significance of differences in changes in growth activity has not been proven. Based on the results, green operations and foliar dressing promote the formation of the potential for higher productivity of the apple tree.

KEY WORDS: APPLE TREE, VARIETIES, FRUITS, GREEN OPERATIONS, NUTRITION, PRODUCTIVITY.

INTRODUCTION

The successful growth and initiation of fruits require a balanced diet for apple trees, including various mineral elements, such as nitrogen, phosphorus, potassium, calcium, iron, magnesium, manganese, zinc, copper, boron, cobalt, molybdenum, etc. Each mineral element performs its function during the growing season of plants. Their reasonable combination is considered optimal. For example, the use of only phosphorus and potassium fertilizers without nitrogen is ineffective (Kondratiev and Eskov, 2017; Ryabushkin et al., 2020). The use of organic fertilizers alone is not always effective. In this regard, organometal fertilizers, which contain both organic substances and minerals, have become widespread in agronomic practice. They have no negative effect and can completely replace mineral fertilizing. Organo mineral fertilizers (for example, Raikat Razvitie, Aminokat) nourish plants without oversaturation with elements and do not pollute the environment (Khilko, 2017; Jia et al., 2020).

Recent studies have shown the promise of using trace elements with organic biologically active compounds (amino acids and their protein derivatives). These complex compounds (produced, for example, by Bioamid JSC, Saratov) can easily penetrate the cell walls and be absorbed by the body. Simultaneously, the increased strength of the bonds of the metal with amino acids significantly reduces the possibility of undesirable side processes with the participation of the microelement. At present, organic trace element complexes (OTEC) based on L-asparaginase are successfully used both in premixes for feeding farm animals and as fertilizers for growing cultivated plants. The fertilizer contains iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), cobalt (Co), molybdenum (Mo), and boron (B) (Williams et al., 2020).

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The role of iron (Fe) is significant in oxidative and energy metabolism in the formation of chlorophyll. Therefore, organic compounds, which include iron, are primarily important for the biochemical processes of plants occurring during respiration and photosynthesis (Sajjadi and Moosavi, 2019). With a lack of zinc (Zn), fruit crops have smaller, lighter leaves with scarce irregular fruits (Sheikhshoaie et al., 2018). Copper (Cu) makes possible the processes of respiration and photosynthesis, carbohydrate metabolism and synthesis of fats, and the formation of certain vitamins. Manganese (Mn) provides the normal course of photosynthesis, the accumulation of chlorophyll in the leaves, the synthesis of sugars, vitamin C. By participating in redox reactions, it contributes to the active development of plants, increases their productivity, regulates the water regime, and resistance to adverse factors. Cobalt (Co) in plants is necessary for the fixation of molecular nitrogen; it accumulates in pollen and accelerates its germination, stimulates plant growth processes (including stretching of cell membranes). This microelement is involved in cell reproduction of leaves. (Grace and Wilson, 2021).

Molybdenum (Mo) participates in metabolic, recovery, and energy processes, protein synthesis. It is part of the enzymes that regulate nitrogen metabolism, improves calcium nutrition of plants, participates in the formation of chlorophyll, in the development of the root system, as well as in exchange of phosphorus compounds and carbohydrates (Ibrakhimov et al., 2020). Boron (B) is necessary for plants throughout their life, participating in the transport of carbohydrates, in particular sugars, and the synthesis of cell walls. It affects the intensity of photosynthesis, improves hydrocarbon, nucleic and protein metabolism activates enzymes (Ryabushkin et al., 2020). This article provides data on the assessment of the effect of summer pruning of shoots and foliar feeding with a product made based on an organo mineral complex on the growth and initiation of apple tree fruits in the intensive garden of the Agrocenter Research and Production Complex of Saratov State Agrarian University.

MATERIAL AND METHODS

Soil maintenance system: the aisles - natural ramping with systematic mowing and leaving of grass as mulch, the near-trunk strip - herbicide-treated fallow. According to the fusiform type (new Russian spindle), formation of plants with the implementation of green operations in June (4-6 buds pruning of young growths more than 25 cm long). Drip irrigation: Treatment of plants with a product based on an organomineral complex was carried out twice during intensive plant growth (in June) with an interval of 10 days. The drug flow rate was 430 g/ha, the spray material flow rate was 1000 l/ha.

Experimental design:
Variant 1. – Control. Plants were not subjected to green operations or foliar dressing.

Variant 2. – Plants with fruit branches subjected to green operations (4-6 buds pruning of annual growths). Treatment with an organic microelement complex was not carried out.

Variant 3. – Plants with fruit branches subjected to green operations (4-6 buds pruning of annual growths) and treatment with an organic microelement complex.

Field experiment was taken as a methodological basis for research. The main surveys and observations were carried out in accordance with the program and methodological instructions for the various study of fruit, berry and nut crops (Grace and Wilson, 2021). The leaf surface area was determined by the method of carvings according to the method developed by Fulga, 1961. The analysis of the initiation of fruits was carried out on well-lit fruit branches located in the middle part of the crown on the eastern side.

RESULTS AND DISCUSSION

The objective of the research was to reveal the effectiveness of green operations and an organic microelement complex by Bioamid JSC (Saratov) on changes in growth activity and the initiation of fruits in intensive-type apple plantations. The studies have shown that significant changes in plant parameters occur under the influence of the studied objects. Gardeners largely form the shape and size of the crown during tree pruning, so these indicators were not considered when analyzing the growth parameters of apple trees under the influence of green operations and foliar fertilizers. More objective is the analysis of the annual growth of shoots and the diameter of the stem under the influence of the studied factors (measurements were taken at the end of the growing season in 2019 and 2020). The increase in the diameter of the stem over the year was characterized by the maximum values in the control variant, when part of the increased annual shoots was not removed and foliar feeding was not carried out (Table 1). This pattern can be traced for all studied varieties. Thus, in Zhigulevskoye trees (autumn variety), the increase in the diameter of the trunk during the growing season under the influence of the June pruning decreased by 2.2-2.6 mm (by 17.6-20.8%); in the Orlik variety - by 4.4 -4.7 mm (by 42.7-45.6%), in the Gubernskoe variety - by 6.2-7.7 mm (by 32.6-40.5%), in Safran Saratovsky varieties - by 4.2-4.8 mm (35.6 -40.7%).

This pattern is also typical for trees of winter ripening varieties: In the Kulikovskoe variety, under the influence of chasing, there is a decrease in the growth of the stem diameter by 4.0-3.9 mm (by 47.1-45.9%), in the Kutuzovets variety - by 4.4-4.1 mm (by 21.3-19.8%), in the Berkutovskoe variety - by 2.4-3.1 mm (by 24.0-31.0%), in Honey crisp - by 4.3-4.1mm (34.7-33.1%). No significant differences in the increase in the diameter of the stem with foliar feeding in the studied apple varieties have been proven (see Table 1). Observations of the formation of growths on model tree branches using June 4-6 buds pruning of shoots showed the following. 2-3 weeks after trimming the shoots, the length of which exceeded 25 cm, on the remaining parts of the shoots from the upper buds, new shoots develop, the size of which is significantly inferior to the control by the end of the growing season (Table 2). As a rule, the size of these increments corresponds to the size of fruit formations: dards (up to 25-30 cm), spurs (up to 15 cm), ringlets (up to 3 cm). There were no significant changes in the length of shoot growth under the influence of foliar dressing. Evaluation of the development of the leaf apparatus on model branches according to the variants of the experiment indicates some advantages of plants treated with an organic microelement complex (Table 2).

Table 1. Annual increase in the diameter of the trunk in apple trees under the influence of June pruning of shoots and foliar dressing with an organic microelement complex

Variety	Increase in the trunk diameter variant			HCP_{05}
	1	2	3	
Autumn ripening varieties				
Zhigulevskoe	12.5	10.3	9.9	1.4
Orlik	10.3	5.9	5.6	1.6
Gubernskoe	19.0	12.8	11.3	2.3
Shafran Saratovskii	11.8	7.6	7.0	1.9
Winter ripening varieties				
Kulikovskoe	8.5	4.5	4.6	1.6
Kutuzovets	20.7	16.3	16.6	1.8
Berkutovskoe	10.0	7.6	6.9	1.1
Honey crisp	12.4	8.1	8.3	1.3

Table 2. Growth and leafiness of apple shoots on model branches

Parameters	Variant	Autumn ripening varieties				Winter ripening varieties			
		Zhigu levskoe	Orlik	Gubern skoe	Shafran Saratovskii	Kuliko vskoe	Kutu zovets	Honey crisp	Berku tovskoe
Average shoot length, cm	1	30.3	51.3	52.7	42.7	57.0	65.7	40.7	47.3
	2	20.7	16.0	17.7	19.7	31.3	35.3	13.8	12.3
	3	17.0	16.9	16.7	17.3	32.0	40.3	13.0	12.2
	HCP_{05}	4.1	4.9	6.7	3.8	4.9	5.8	4.8	4.9
Number of leaves, pc.	1	21.7	29.0	19.0	19.0	25.7	31.7	25.3	20.7
	2	15.3	12.0	13.0	13.0	18.7	21.3	11.3	10.9
	3	14.7	13.2	12.7	9.7	18.3	20.0	11.3	12.5
	HCP_{05}	3.2	2.7	2.1	2.2	2.1	3.8	3.1	1.9
Leaf surface area, dm^2	1	11.6	15.5	11.4	11.2	12.9	11.2	8.7	8.9
	2	9.4	4.9	4.4	5.4	7.5	8.3	5.1	4.3
	3	8.8	5.6	5.1	5.0	8.1	8.8	4.9	4.9
	HCP_{05}	1.2	1.7	1.5	1.7	1.1	1.4	1.1	0.9
Leaf surface area per 1 cm shoot, cm^2	1	38.3	30.2	21.6	26.2	22.6	17.0	21.4	18.8
	2	45.4	30.6	24.9	27.4	24.0	23.5	37.0	35.0
	3	51.8	33.1	30.6	28.9	25.3	21.8	37.7	40.2
	HCP_{05}	4.0	3.7	3.2	2.7	2.1	2.8	3.9	3.7
Lamina area, cm^2	1	53.5	53.4	60.0	58.9	50.2	35.3	34.4	43.0
	2	61.4	40.8	33.8	41.5	40.1	39.0	45.1	39.5
	3	59.9	42.4	40.2	51.5	44.3	43.8	43.4	39.2
	HCP_{05}	7.3	4.8	6.2	5.5	4.1	4.2	5.0	3.8

If the control variant shows a significant superiority of indicators in the number of leaves per one-year growth and the total leaf area on the model branch, then the analysis of the specific foliage of 1 cm of shoot growth and the average leaf size indicates a tendency towards an increase in these indicators after foliar treatment of plants with fertilizer. In autumn cultivars Zhigulevskoe, Gubernskoe and in winter cultivars Berkutovskoe, the significance of differences in foliage per unit of shoot growth under the influence of foliar fertilization was proved mathematically. In terms of the size of the lamina, significant advantages of the option with feeding with an organic microelement complex are noted in Gubernskoe, Shafran Saratovskii, and Kutuzovets. The fruits of an apple tree, as a rule, are formed on dards, spurs, ringlets, the presence of which determines the potential productivity of trees.

Horticulture uses various agricultural practices to initiate these fruits: selection of varieties, formation and pruning of plants, their nutrition. Studies of an earlier period indicate a high varietal specificity of the formation of fruit formations, especially at a young age (Ryabushkin et al., 2020). These studies have shown that there is a steady pattern of increase in the total number of fruit formations after green operations in all apple varieties (Table 3). A significant increase in the number of formed fruit formations under the influence of foliar treatment of plants with fertilizer is observed only for the Gubernskoe, Shafran Saratovskii and Berkutovskoe varieties. For the rest of the varieties, we can only talk about the tendency for the formation of a larger number of fruit formations under the influence of the studied fertilizer. This pattern can also be traced in the analysis of the specific load of fruit formations of one running meter of the fruit branch.

Table 3. Initiation of fruits on young apple trees

Variety	Variant	Number of fruits on a fruit branch				Fruit branch length, cm	Number of fruits per 1m of fruit branch, pcs
		Spurs, pcs	Dards, pcs	Fruit dards, pcs	Total, pcs		
Zhigulevskoe	1	6.0	1.7	0.7	8.4	139.0	6.0
	2	12.7	3.3	1.0	16.0	134.3	11.9
	3	13.0	3.6	0.8	17.4	136.1	12.8
HCP_{05}		1.5	0.3	0.1	1.9	-	1.4
Orlik	1	6.0	2.0	1.3	9.3	129.7	7.2
	2	8.7	2.3	0.3	11.3	143.3	7.9
	3	8.3	1.3	1.3	10.9	130.7	8.3
HCP_{05}		0.8	0.3	0.1	1.2	-	0.6
Gubernskoe	1	7.0	0.7	0	7.7	131.1	5.9
	2	9.0	2.0	0	11.0	130.0	8.5
	3	8.7	2.7	0	11.4	123.3	9.2
HCP_{05}		0.7	0.2	-	1.0	-	0.6
Shafran Saratovskii	1	10.0	1.0	1.0	12.0	138.0	8.7
	2	9.0	0.5	1.0	10.5	120.0	8.8
	3	7.7	3.3	0.7	11.7	123.3	9.5
HCP_{05}		0.7	0.3	0.1	1.1	-	0.5
Kulikovskoe	1	5.9	2.1	1.6	9.6	133.2	7.2
	2	6.5	1.6	2.0	10.1	125.1	8.1
	3	7.0	2.3	1.4	10.7	130.1	8.2
HCP_{05}		0.6	0.3	0.2	0.9	-	0.5
Kutuzovets	1	5.8	2.0	2.0	9.8	166.3	5.9
	2	6.0	2.2	1.8	10.0	150.2	6.7
	3	7.6	1.8	1.0	10.4	153.0	6.8
HCP_{05}		0.5	0.2	0.2	1.0	-	0.7
Honey crisp	1	6.8	1.7	0.0	8.5	111.3	7.6
	2	8.2	0.8	0.3	9.3	90.2	10.3
	3	7.7	1.5	0.7	9.9	92.3	10.7
HCP_{05}		0.8	0.2	0.1	0.7	-	1.1
Berkutovskoe	1	6.1	0.8	1.0	7.9	98.6	8.0
	2	5.3	1.8	0.0	7.1	78.1	9.1
	3	6.8	1.6	1.1	9.5	85.6	11.1
HCP_{05}		0.7	0.2	0.1	1.1	-	1.2

Additional plant nutrition, as a rule, improves the quality of the grown products. Our studies showed no significant increase in fruit weight after two-time treatment of apple trees with OTEC (Table 4). Based on the results obtained, most varieties (Gubernskoe, Shafran Saratovskii, Kutuzovets, Honey crisp, Berkutovskoe) tend to form larger fruits only, which confirms the relevant studies' results (Jia et al., 2020; Grace and Wilson, 2021). However, the exception is the Kulikovskoe variety, which had fruits in the fertilization variant (variant 3) 45% larger (on average 131.7 g) than in the variant without fertilization (90.9 g). Obviously, this is due to the fact that trees of the Kulikovskoe variety, under the influence of fertilizers, formed 10.5% larger leaves (see Table 2). In addition, Zhigulevskoe and Orlik, after foliar fertilization, show a slight decrease in fruit weight, which given the relevant studies, stands to reason (Ryabushkin et al., 2020; Williams et al., 2020, Grace and Wilson, 2021).

In conclusion, given the outcomes, it can be concluded that 4-6 buds pruning of shoots in June leads to a temporary stop in the growth of shoots and the subsequent formation of growths, the size of which is 2-3 times less than in the control variant. These increments are more consistent with the size of fruits (dards, spurs, fruit spurs) in terms of parameters. Simultaneously, the size of plants decreases due to a decrease in the size of annual increments, a decrease in the increase in the trunk diameter. And the specific provision of the tree crown with a leaf canopy increases. The total number of fruit formations on the tree, depending on the variety, increases by 2...90%.

Table 4. Influence of plant feeding with OMEK fertilizer on changes in average fruit weight

Variety	Average fruit weight, g		
	Variant		HCP_{05}
	2	3	
Autumn ripening varieties			
Zhigulevskoe	170.5	167.5	Ff<Ft
Orlik	120.7	111.6	Ff<Ft
Gubernskoe	119.6	124.3	Ff<Ft
Shafran Saratovskii	111.4	119.4	Ff<Ft
Winter ripening varieties			
Kulikovskoe	90.9	131.7	14.6
Kutuzovets	98.7	101.7	Ff<Ft
Berkutovskoe	135.0	143.7	Ff<Ft
Honey crisp	123.3	114.7	Ff<Ft

CONCLUSION

The significance of differences in the change in growth activity (increase in the diameter of the stem, increase in shoots) has not been proven when dressing the plants with OTEC in the studied apple varieties. There are tendencies to increase plant foliage, the initiation of a larger number of fruits, and the higher quality yield. In general, green operations and foliar dressing promote the formation of the potential for higher productivity of the apple tree. Similar studies need to continue to develop practical recommendations for the use of OTEC for apple trees.

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