

REMOVAL OF BASIC NUTRIENTS (NPK) BY APPLE TREES USING VARIOUS TYPES OF POTASSIUM FERTILIZERS IN THE CONDITIONS OF AZERBAIJAN

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Abstract

In the experiment field on irrigated meadow - brown soil was found that at low soil provision of exchangeable potassium in apple orchards applying of different types of potash on a background of organic fertilizer (20 t ha⁻¹ of manure), significantly increases the accumulation of the main nutrient elements in leaves and fruits, and also takeaway NPK with apple harvest (classical orchard - 'Golden Delicious' variety and intensive orchard - 'Fuzhi' variety). The best variant was the sharing of organic fertilizer system (20 t ha⁻¹ of manure - as background) with the high dose of potassium sulphate (K₁₆₀): compared with the control variant (without fertilizers), the yield was higher by 9.9 t ha⁻¹ or 7.87%, and the removal of nitrogen, phosphorus and potassium from the soil - by 69.0 kg ha⁻¹, 46.3 kg ha⁻¹ and 120.4 kg ha⁻¹, respectively; and compared with the background + K₁₆₀ potassium chloride variant, these indicators were higher by 0.95 t ha⁻¹, or 4.2%, respectively: 6.2 kg ha⁻¹, 7.1 kg ha⁻¹ and 14.2 kg ha⁻¹. This variant was also effective in relation to the accumulation of nitrogen, phosphorus and potassium in the leaves and fruits of the apple trees, as well as the removal with harvest in classical orchard. Similar results were obtained using organo - mineral system fertilizer - 20 t ha⁻¹ manure + K₁₆₀ potassium sulphate also in intensive orchard.

Key words: forms of potash fertilizers, NPK removal, apple yield, irrigated meadow-forest soils, fertilizer system.

INTRODUCTION

In orchards, the removal of nutrients is determined by the magnitude of the vegetative mass of trees. With the entry into the fruiting season and a significant decrease in tree growth strength, the takeaway is determined mainly by the fruit yield. Changes in the nutritional conditions have a significant effect on the absorption and alienation of nutrients from the soil. Knowledge of apple growing conditions, meteorological conditions of the year, type of soil, degree of fertilizer allows you to get a more complete picture of the quantitative changes in the alienation of nutrients from the fruit harvest (Akhmedov, 1989; Vitovskaya, 2015; Volodina et al., 2014).

Establishing the nature of the impact of growing conditions on the change in the ratio and amount of nutrients alienated from the soil, including nitrogen, phosphorus and potassium, provides information on the alienation of nutrients. This makes it possible to obtain a more complete picture of the nutrient

requirements of trees, which is important for solving the problems of building fertilizer systems in tree orchards. The removal of chemical elements from the soil by plants depends on the intensity of their entry into plants and the growth rate of biomass. It is known that this indicator varies widely depending on the species, varietal characteristics and growing conditions of the crops. The accumulation of chemical elements by plants, in addition to species and varietal characteristics of plants, depends on the phase of their development, on the soils buffering ability, the properties of chemical elements and the forms of their presence in the soil (Krivoruchko, 1978; Kushnirenko, 1978; Kushnirenko & Razumnaya, 1978; Rubin & Moiseenko, 1970). The growth rate of plant biomass depends significantly on the content of nutrients in the soil. Fertilizers application affects the productivity of crops, increasing both biomass and the removal of chemical elements by the crop (Rubin & Moiseenko, 1970; Semchenko & Sinitsin, 1977; Vitovskaya, 2015).

A significant number of studies carried out in various regions are devoted to studying the influence of various fertilizers systems, as well as species, doses and forms of mineral fertilizers on the productivity and quality of apple trees (Akhmedov, 1989; Lapa et al., 2009; Volodina et al., 2014; Yakimenko, 2017). The difference in the results obtained is probably due to differences in the soil-climatic and agrotechnical conditions of the experiments.

The aim of the reserches is to study increasing doses of various forms of potash fertilizers (against the background of organic fertilizers 20 t ha⁻¹ of manure) on the yield of the apple tree and on the accumulation of essential nutrients (NPK) in the fruits and leaves of the apple tree, their removal from the plant (crop) under conditions of the irrigated meadow-brown soils of Azerbaijan. The relevance of these works has recently been increasing due to the low and unbalanced use of increasing doses of mineral fertilizers in the region's agriculture (Akhmedov, 1989; Mammadov, 1980; Mammadov et al., 2012).

MATERIALS AND METHODS

The studies were carried out on the irrigated meadow-brown soil of the dry subtropics of the north-eastern part of the Greater Caucasus within Azerbaijan, in the experimental base of the Research Institute for Fruit Growing and Tea Production of the Ministry of Agriculture of Azerbaijan, village Zardobi, Guba district.

Climate of Guba - Khachmaz zone differs sufficiently of aridity: the average annual precipitation - 350 mm, the average temperature - 13.8⁰C, the amount of active air temperature > 10⁰C - 4000. In the experimental variants were used the following types and fertilizers system: mineral - N_{aa},P_{sp},K_x,K_s; organic - cattle manure semi-rotted, 65% of humidity (Dosphehov, 1985; Guidance..., 2008).

The test was performed in the classical orchard - old planting for 30 years, apple variety 'Golden Delicious' (scheme 8 m x 4 m) and intensive orchard - planting recent 4-year-old, apple variety 'Fuzhi' (scheme 4 m x 1 m). The total area of the classical orchards - 9600 m², intensive orchards - 1200 m². The experiments were performed in triplicate variants.

Soil characteristics of the experimental plot (irrigated meadow-brown soils) before laying the experiment: soil reaction - slightly alkaline (pH-7.8), low content (16.8 mg kg⁻¹) of mobile forms of P₂O₅ (according to Machigin) and an average content of exchange forms K₂O - 238 mg kg⁻¹ of soil. The amount of humus in the arable layer is 3.25%. The amount of ammonia nitrogen (N-NH₄) - 17.5; nitrate nitrogen (N-NO₃) - 9.62 mg kg⁻¹ of soil (Agrochemical..., 1975; Arinushkina, 1970; Dosphehov, 1985).

The following fertilizers were used: nitrogen fertilizers - ammonium nitrate NH₄NO₃ (N-34%); phosphate - simple superphosphate - Ca(H₂PO₄)₂ (P₂O₅- 18%), and from potassium - potash chloride KCl (K₂O-46%) and potash sulphate K₂SO₄ (K₂O-52%). Organic fertilizer - the semi-rotted manure cattle (humidity 65%), the average content of nitrogen - 0.5%, P₂O₅ - 0.25% and K₂O - 0.58%.

The entire annual rate of organic fertilizers (100%) was ploughed in the soils. Mineral fertilizers were applied in three periods during the growing season of the apple trees in the following phases of plant development: during shoot swelling; after flowering; when setting fruits (Dosphehov, 1985; Vitovskaya, 2015).

In field studies, according to the experimental design, the following mineral, organic, and organo - mineral fertilizers systems were used:

1. Control variant (without fertilizers);
2. Cattle manure 20 t ha⁻¹ - Background or Fond - organic fertilizers system;
3. Background + K₁₄₀ (KCl) - organo - mineral fertilizer system;
4. Background + K₁₄₀ (K₂SO₄) - organo - mineral fertilizers system;
5. Background + K₁₆₀ (KCl) - organo - mineral fertilizers system;
6. Background + K₁₆₀ (K₂SO₄) - organo - mineral fertilizers system;
7. N₁₀₀P₅₀K₁₂₀ - mineral fertilizers system.

Before laying the experiment, an agrochemical examination of the arable soil layer of the experimental plots was carried out. For this purpose, the following analyses was determined: the humus content according to Tyurin in the modification (GOST 26213-91), the nitrate nitrogen - ionometric method, the ammonium - colorimetric method with reagent

Nessler, mobile forms of the nutrients - in an extract Machigin: phosphorus - colorimetric method, potassium exchange - flames hydrochloric photometry method (GOST 27207-91). The pH of the water determined potentiometrical method - GOST 26483-85 (Agrochemical..., 1975; Arinushkina, 1970). Accounting the crop yield and leaves was carried out by the gravimetric method - fresh and air-dry (Derzhavin, 1999; Dospehov, 1985; Guidance..., 2008).

In plant samples (leaves and fruits), the content of total forms of nitrogen, phosphorus and potassium was determined by Ginzburg G.E., Scheglova G.M. and Wulfius E.V. (Arinushkina, 1970). Plant samples were taken from each plot from all variants at the time of selection of soil samples (Derzhavin, 1999). Effect of different doses of mineral and organic fertilizer, as well as their combined application to the takeaway of macro elements by apple tree, was studied in 2017-2019 years in the conditions of stationary field experience.

RESULTS AND DISCUSSIONS

Currently, one of the possible reserves for increasing soil fertility and cultivation is organic fertilizers. Numerous researchers have provided the high efficiency of manure and its positive role in the increasing of soil fertility, however, comprehensive studies on the effect of various types of organic fertilizers in comparison with mineral fertilizers are not enough (Ermakova & Novikov, 2019; Merzlaya, 2006; Volodina et al., 2014).

Identification (clarification) of factors affecting the ratio of nutrients alienated from the crop and contained in fertilizers is of great importance when choosing a fertilizer system in a crop rotation. The issue of doses and ratios of mineral and organic fertilizers, in connection with the thickened methods of growing apple trees and intensifying gardening, continues to be one of the central issues in the fertilizer system of orchards (Kushnirenko, 1978; Kushnirenko & Razumnaya, 1978; Semchenko & Sinitsin, 1977). One of the mandatory factors for the effective and sustainable functioning of agrocenoses is the rational use of mineral fertilizers, which allows to obtain at least 30-50% of additional yield increase with good

quality while preserving and increasing soil fertility (Volodina et al., 2014).

In addition, the preservation and increase of the fertility of irrigated meadow-brown soils is directly related to the use of organic, organo-mineral and mineral fertilizers, which have a significant impact on its agrochemical properties. In most cases, their effect on the soil properties is positive and contributes not only to its stabilization, but also for improvement the fertility parameters (Ermakova & Novikov, 2019; Nikitishen & Demidov, 1987).

The research scheme provided for the establishment of a possible depletion or enrichment of this soil with basic nutrients, the study of the comparative effect of mineral and organic fertilizers, as well as their joint application, the use of mineral fertilizers in quantities equivalent to the content of basic nutrients in manure or half the nitrogen content of manure, as well as the effectiveness of the joint application of manure and mineral fertilizers in apple orchards, supplementing manure with individual nutrient exists (Guidance..., 2008; Mammadov et al., 2012; Merzlaya, 2006; Semchenko & Sinitsin, 1977).

An analysis of data conducted by various authors of the studies shows that the use of different types of potash fertilizers in the mineral, organic, and organic-mineral fertilizer systems play a significant role in the accumulation of nitrogen, phosphorus, and potassium in individual organs of the apple tree plant (Krivoruchko, 1978; Shafran et al., 2012; Yakimenko, 2017).

The effect of two types of potash fertilizers on the accumulation of the main nutrient elements (NPK) of apple trees under irrigated meadow-brown soils was studied. The average data for 3 years is shown in Figure 1.

The figure shows that the use of various types of potash fertilizers in the mineral and organic systems had a different effect on the accumulation of basic nutrients in the above ground organs (leaves and fruits) of apple trees. It was found that increasing the doses of various fertilizer systems and the intensity of using different types of potash fertilizers according to the experimental variables correspondingly affected the fertilizer efficiency in accumulating nutrients in the leaves and fruits of the apple tree.

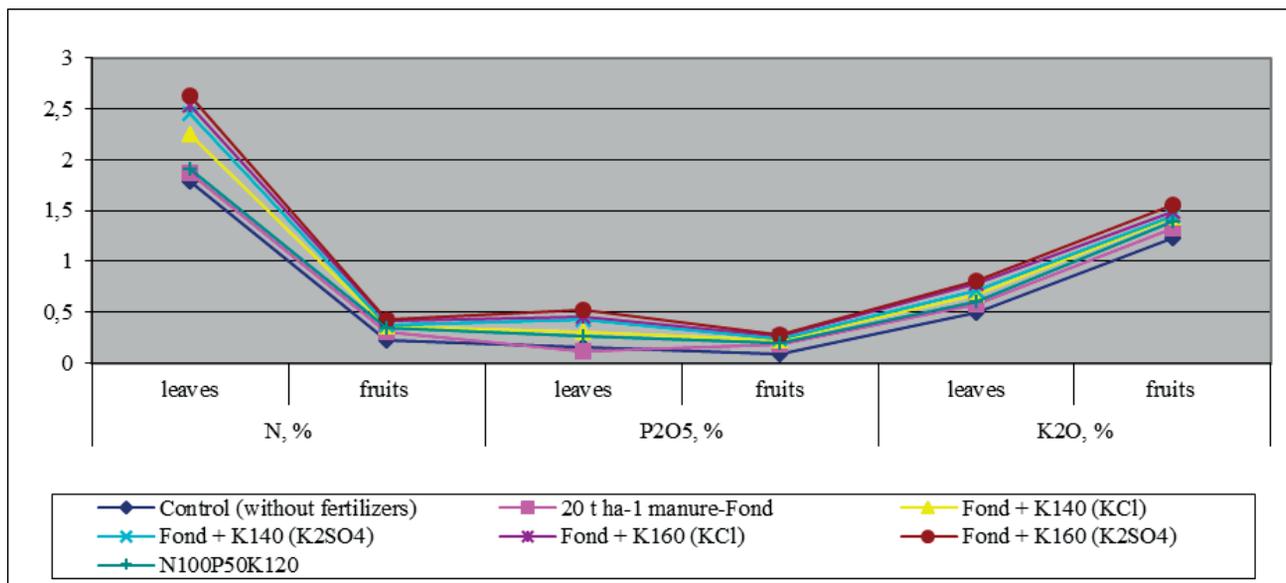


Figure 1. The influence of different forms of potash fertilizers on the accumulation of nutrient elements (NPK) in individual organs of the apple tree ('Golden Delicious')

Thus, in the control (without fertilizers) variant, the accumulation of total nitrogen in apple leaves is 1.79%, and in fruits 0.22%, and in the application of the organic fertilizer system (20 t ha⁻¹ of manure). These data were 1.87 and 0.31%, respectively, and in the mineral fertilizer system (N₁₀₀P₅₀K₁₂₀) - 1.91 and 0.34%, while the organic fertilizer system combined the use of different types of potash fertilizers with organic fertilizers resulted in a much greater accumulation of total nitrogen in apple organs. It was greatest when potash fertilizers were used as potassium sulphate in the dose of 20 t ha⁻¹ K₁₆₀ manure variant, where these data reached 2.63 and 0.43% respectively, which exceeded the 20 t ha⁻¹ K₁₆₀ manure variant (potassium chloride) by 0.09% and 0.01%.

The accumulation of total nitrogen in apple leaves and fruits increased by 0.08% and 0.09%, respectively, compared to the control in the organic fertilizer system, and the total nitrogen increased by 0.12% in the leaves and fruits when an equivalent amount of mineral fertilizers was used in dose of N₁₀₀P₅₀K₁₂₀.

The use of potassium fertilizers in the form of potassium sulphate in the organo-mineral system, in dose of 20 t ha⁻¹ of manure + K₁₆₀ increased the amount of nitrogen, phosphorus and potassium in the leaves and fruits, respectively, by 0.084% and 0.21% nitrogen; 0.37% and 0.19% of phosphorus; and 0.32% and 0.32% of potassium.

The effectiveness of the use of potash fertilizers in conjunction with organic fertilizer (organic-mineral fertilizer system), mainly depended on the size of their doses, as well as on different types of potash fertilizers. At low (K₁₄₀) and high (K₁₆₀) doses of potash fertilizers against organic ones, the potassium sulphate efficiency slightly exceeded the potassium chloride efficiency. In the case of using increased doses of potassium fertilizers (K₁₆₀), potassium sulphate was clearly preferable for the accumulation of essential nutrients (NPK) in the leaves and fruits of the apple tree.

Perhaps this is due to the physiological role of sulphur in the plant. Sulphur is an important element of plant nutrition; its excess is more harmful to plants than a deficiency.

Our studies also revealed the influence of different types of potash fertilizers on the accumulation of nutrients in individual organs of the apple tree in young orchards with 'Fuzhi' variety (Table 1).

Similar results were also obtained during the experiment in intensive orchards (variety 'Fuzhi'). So, in the fruits of intensive orchards, using different types of potash fertilizers against organic (20 t ha⁻¹ of manure), the most effective was the use of potassium sulphate in the dose of K₁₆₀.

The best experience was found to be the joint use of an organic fertilizer system (20 t ha⁻¹ of manure - background) with an increased dose (K₁₆₀) of potassium sulphate: here, compared

with the control variant without fertilizers, the yield was higher by 9.9 t ha⁻¹ or 7.87%, and the removal of nitrogen, phosphorus and potassium from the soil - respectively, 69.02 kg ha⁻¹, 46.3 kg ha⁻¹ and 120.41 kg ha⁻¹; and compared

with the Background + K₁₆₀ potassium chloride variant, these indicators were higher by 0.95 t ha⁻¹ or 4.2%, respectively; 6.2 kg ha⁻¹, 7.06 kg ha⁻¹ and 14.15 kg ha⁻¹.

Table 1. The influence of different forms of potash fertilizers on the accumulation of nutrient (NPK) elements in individual organs of the apple tree (cultivar ‘Fuzhi’)

No	Experimental Variants	The dry matter NPK content					
		N, %		P ₂ O ₅ , %		K ₂ O, %	
		Leaves	fruits	leaves	fruits	leaves	fruits
1	Control (without fertilizers)	1.85	0.26	0.13	0.17	1.28	0.53
2	20 t ha ⁻¹ cattle manure - background (fond)	1.94	0.33	0.18	0.22	1.37	0.64
3	Background + K ₁₄₀ (KCl)	2.48	0.38	0.39	0.24	1.48	0.70
4	Background + K ₁₄₀ (K ₂ SO ₄)	2.59	0.41	0.51	0.25	1.52	0.73
5	Background + K ₁₆₀ (KCl)	2.67	0.44	0.59	0.29	1.58	0.82
6	Background + K ₁₆₀ (K ₂ SO ₄)	2.75	0.46	0.63	0.30	1.61	0.85
7	N ₁₀₀ P ₅₀ K ₁₂₀	2.16	0.36	0.56	0.23	1.42	0.67

This option was also effective against the accumulation of nitrogen, phosphorus and potassium in the leaves and fruits of the tree. NPK carry-out rates by individual plant organs are a mirror reflection of the ratios in the fertilizer system. The study of total nutrient withdrawal in order to establish a link between soil fertility and crop production is a priority for agrochemical research. The removal of nutrients from the soil depends, as you know, on the level of their content in the main

products, as well as productivity (Rubin & Moiseenko, 1970; Semchenko & Sinitsin, 1977; Vitovskaya, 2015; Zelenskaya, 1969). With the use of different types of potash fertilizers in the mineral, organic, and organo - mineral systems, the removal has increased in all variants, that is, the alienation of the main nutrients from the soil with the crop by the apple tree plant ‘Golden Delicious’ variety (Figure 2).

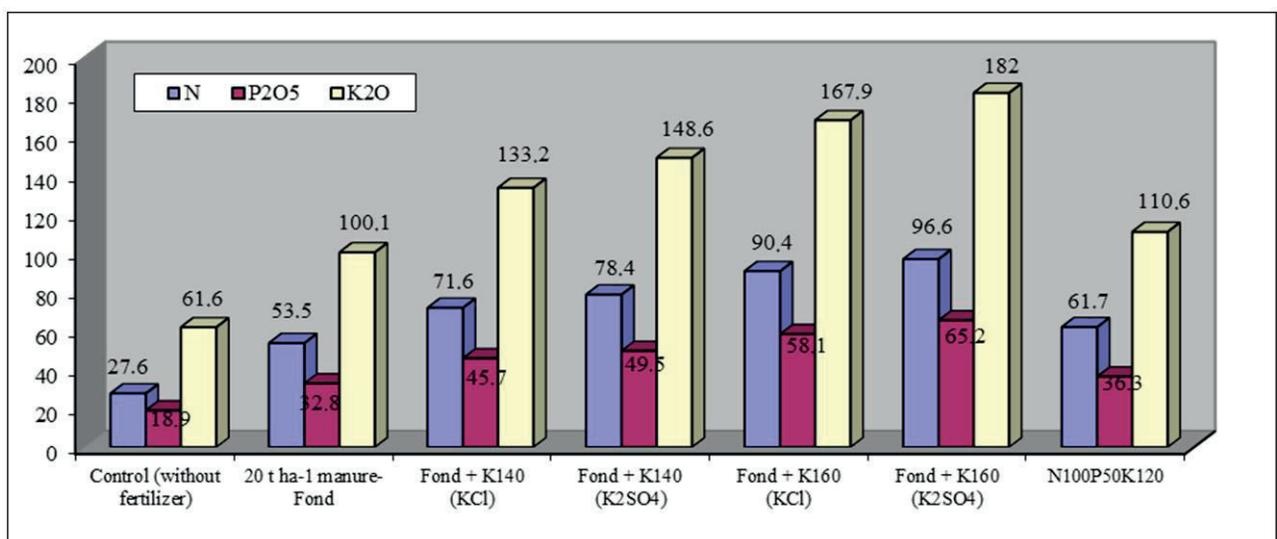


Figure 2. The influence of different forms of potash fertilizers on takeaway of NPK by apple fruits (variety ‘Golden Delicious’)

So, in the control, non-fertilized variants, the removal of nitrogen, phosphorus and potassium with the apple crop was, respectively: 27.6; 18.85; 61.59 kg ha⁻¹.

These indicators increased with the use of an organic fertilizer system in the background variant at a rate of 20 t ha⁻¹ of manure and were 25.8 kg ha⁻¹ more nitrogen compared to the

control variant; 13.9 kg ha⁻¹ for phosphorus and 38.4 kg ha⁻¹ of potassium.

When applying the equivalent amount of mineral fertilizer to 20 t ha⁻¹ of manure in the dose of N₁₀₀P₅₀K₁₂₀, these indicators were higher compared to the control variant by 34.07 kg ha⁻¹ for nitrogen, 17.43 kg ha⁻¹ for phosphorus and 49.06 kg ha⁻¹ for potassium. The use of two types of potash fertilizers - potassium sulphate and potassium chloride against the background of organic fertilizers (organo-mineral fertilizer system) had a different effect on the removal of nutrients from the apple crop in classical orchards. At low (K₁₄₀) and increased (K₁₆₀) doses of potash fertilizers, potassium sulphate exceeded potassium chloride in the removal of nitrogen, phosphorus and potassium. So, in the variant Background (20 t ha⁻¹ of manure) + K₁₄₀(KCl) the nitrogen removal with the apple crop is 71.56 kg ha⁻¹, phosphorus - 45.72 kg ha⁻¹, potassium - 133.19 kg ha⁻¹.

When replacing potassium chloride (KCl) with the same amount of potassium sulphate (K₂SO₄), the nutrient removal (NPK) significantly increased the nitrogen to 78.43 kg ha⁻¹; for phosphorus up to 49.53 kg ha⁻¹ and for potassium up to 148.60 kg ha⁻¹, that is, amounted to 6.24 kg ha⁻¹, 7.0 kg ha⁻¹ and 14.15 kg ha⁻¹, respectively.

At high doses (160) of various forms of potash fertilizers (KCl and K₂SO₄) against the background of organic (20 t ha⁻¹ of manure) in the organo-mineral fertilizer system, these indicators significantly increased.

So, in the variant Background + K₁₆₀ (K₂SO₄), the nutrient removal increased in comparison with the control variant - nitrogen by 62.02, phosphorus by 45.31, potassium by 120.41 kg ha⁻¹; and in comparison with the Background + K₁₆₀ (KCl) option, 6.24, 7.06 and 14.15 kg ha⁻¹, respectively. Similar results were obtained from the experience carried out in an intensive orchards of 'Fuzhi' apple variety (Table 2).

Table 2. Influence of different forms of potash fertilizers on the yield and NPK removal by fruits of apple trees 'Fuzhi'

No.	Experience Variants	Productivity, t ha ⁻¹	Increase		Removal, kg ha ⁻¹		
			t ha ⁻¹	%	N	P ₂ O ₅	K ₂ O
1	Control (without fertilizers)	7.64	-	-	19.87	12.98	40.49
2	20 t ha ⁻¹ cattle manure - background (fond)	12.76	5.12	67.0	42.10	28.07	81.66
3	Background + K ₁₄₀ (KCl)	14.87	7.23	94.6	56.50	35.68	104.10
4	Background + K ₁₄₀ (K ₂ SO ₄)	15.24	7.60	99,4	62.48	38.1	111.25
5	Background + K ₁₆₀ (KCl)	16.57	8.93	116.8	72.90	46.39	135.87
6	Background + K ₁₆₀ (K ₂ SO ₄)	17.15	9.51	124,4	78.89	51.45	145.77
7	N ₁₀₀ P ₅₀ K ₁₂₀	13.23	5.59	73.16	47.62	30.43	88.64

Here, on the variant with the use of potassium sulphate against the background of organic fertilizers was also established as an effective effect: the removal of nitrogen, phosphorus, and potassium increased by 59.02 kg ha⁻¹, 38.47 kg ha⁻¹ and 105.28 kg ha⁻¹, respectively; compared with the control and, respectively, 5.9 kg ha⁻¹, 5.06 kg ha⁻¹ and 9.9 kg ha⁻¹ compared to the Fond + K₁₆₀ (KCl) option.

Thus, the effectiveness of the organo-mineral fertilizer system has been identified. It was found that the use of potassium sulphate at a rate of 160 kg ha⁻¹ against a background of organic (20 t ha⁻¹ of manure) fertilizers is more effective. The effect of different types of potash fertilizers on the 'Golden Delicious' apple yield in irrigated meadow-brown soil was also studied (Figure 3).

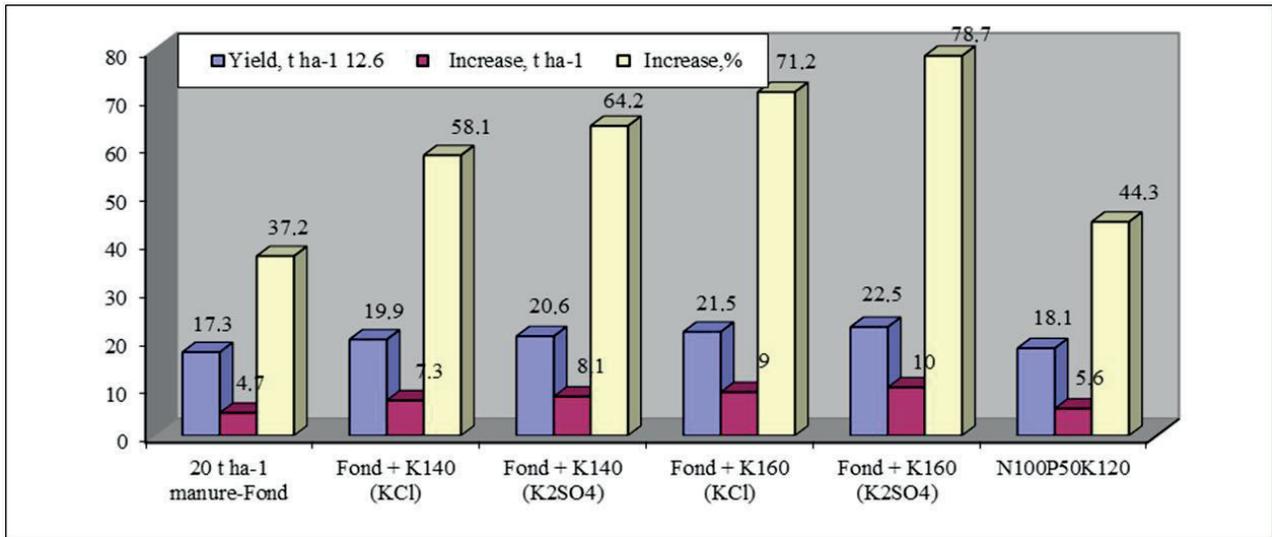


Figure 3. Influence of different forms of potash fertilizers on the yield and fruits of the apple tree 'Golden Delicious'

From the presented data it is seen that the use of various types of potash fertilizers on the background of organic fertilizers (20 t ha⁻¹ of manure) affects the yield of apple trees in different ways. If in the non-fertilized (control) variant, the apple tree yield reaches up to 12.57 t ha⁻¹, then with the use of various fertilizer systems these indicators reach from 17.25 t ha⁻¹ to 22.47 t ha⁻¹ according to the experimental options. At the same time, the increase in yield by fertilized options varies from 4.68 t ha⁻¹ or 37.2% to 9.90 t ha⁻¹ or 78.7%.

When applying the organic systems fertilizer (20 t ha⁻¹ manure), in the conducted experiment in classical orchards 'Golden Delicious' compared with the control, harvest of apple was 5.12 t ha⁻¹ or 67.0%; when using a mineral fertilizer system equivalent to 20 t ha⁻¹ of manure (N₁₀₀P₅₀K₁₂₀), the increase was 5.59 t ha⁻¹ or 73.16%.

The use of different types of potash fertilizers in the norm of K₁₄₀ and K₁₆₀ against the background of the organic system (20 t ha⁻¹ of manure) fertilizers also affects the yield of apple trees in different ways. At lower rates (K₁₄₀), the use of potassium chloride and potassium sulphate together with organic fertilizer (20 t ha⁻¹ of manure) yield apple trees reached 19.88 and 20.64 t ha⁻¹, respectively. The increase was 7.31 and 8.07 t ha⁻¹, or 58.1% and 64.2% compared with the control (not fertilized) option. In these options, potassium sulphate is installed more efficiently from

potash fertilizers, which exceeds potassium chloride by 0.37 t ha⁻¹ or 2.4%.

And at elevated rates (K₁₆₀), the use of various types of potash fertilizers together with organic fertilizers (20 t ha⁻¹ manure), that is, with the organo-mineral fertilizer system, the apple tree yield increased to 22.47 t ha⁻¹. This is the highest result of the field experience. At the same time, the increase in yield compared to the control was 9.90 t ha⁻¹ or 78.7%, and the increase compared to the Fond + K₁₆₀ (KCl) option was 0.95 t ha⁻¹ or 4.2%. Similar results were obtained from the field study carried out in an intensive apple orchards 'Fuzhi' variety.

So, in experiments conducted in intensive orchards using different forms of potash fertilizers, a more effective option was established with the use of sulphate (K₁₆₀) against the background of organic fertilizer (20 t ha⁻¹ manure). In this embodiment, the yield of apple increased by 0.58 t ha⁻¹ or 3.4% compared with the Fond + K₁₆₀ (KCl).

Thus, it has been found that the most effective use of potassium sulphate in conjunction with organic fertilizers, i.e. the organic-mineral fertilizer system.

CONCLUSIONS

As shown by the experiments, the percentage of the staple elements in different organs of apple has a specific value, characteristic of the body, it depends of the fertilizer.

The effect of fertilizers on increasing the percentage of nitrogen was noted significantly

more in the leaves compared with the fruits of the apple tree. When applying various fertilizer systems, the increase in nitrogen and phosphorus compared to the non-fertilized version in the classic orchards 'Golden Delicious' varies between 0.3-0.4% and 0.08 - 0.84%, respectively, and in intensive orchards 'Fuzhi' - 0.09-0.9% and 0.05-0.5%.

The influence of various fertilizer systems of increasing the percentage of potassium was revealed in the leaves and fruits of the apple tree: in comparison with the control version, in the organic fertilizer system in classical orchards site was 0.09%, in intensive - 0.14%, and in the variant 20 t ha⁻¹ of manure + K₁₆₀(K₂SO₄), respectively, 0.38 and 0.32%.

The results of the experiments showed that the removal of nutrients depends not only on the size of the crop, but also on their balance in the nutrient medium. The use of fertilizer systems, depending on the different types of potash fertilizers, affects the removal of the main nutrients with the apple crop in different ways. The largest takeaway in the experiment per unit area was noted when applying the organo-mineral fertilizer system (20 t ha⁻¹ of manure + K₁₆₀) in classical orchards. Moreover, in the composition of the organic-mineral fertilizer system from mineral fertilizers, potassium sulphate was more effective than potassium chloride. In this embodiment, NPK was established with a yield of 96.62 kg ha⁻¹ for nitrogen, 65.16 kg ha⁻¹ for phosphorus and 182.00 kg ha⁻¹ for potassium. At the same time, the increase in NPK removal was in this variant compared to the control by 69.02, 46.30 and 120.41 kg ha⁻¹, respectively. The removal in classical orchards was higher compared to the control variant for nitrogen, phosphorus and potassium, respectively, by 34.07 kg ha⁻¹, 17.43 kg ha⁻¹ and 49.06 kg ha⁻¹ with the mineral fertilizer system; 25.87 kg ha⁻¹, 13.92 kg ha⁻¹ and 38.46 kg ha⁻¹ with an organic fertilizer system (20 t ha⁻¹ of manure). Harvesting in intensive orchards 'Fuji' had similar results, i.e. was higher when making K₁₆₀ in the form of potassium sulphate against the background of organic fertilizers. Here, potassium sulphate was also more effective than potassium chloride. And compared with the use of the same doses of mineral and organic fertilizers (in 20 t ha⁻¹ of manure + K₁₆₀ (KCl), the

nitrogen increased by 69.0 kg ha⁻¹, phosphorus by 46.3 kg ha⁻¹ and potassium -120.4 kg ha⁻¹. Separate, as well as joint application of mineral and organic fertilizers on irrigated meadow-brown soils significantly affects the productivity of apple trees. The best results were obtained in both experiments (orchards) with utilization of potassium fertilizers in high doses of K₁₆₀ in the form of potassium sulphate against organic (organic-mineral fertilizer system). In the variant - 20 t ha⁻¹ of manure + K₁₆₀ (K₂SO₄), the apple yield ('Golden Delicious' variety) increased by 99.0 kg ha⁻¹ or 78.7% compared with the control variant. The use of sulphuric acid potassium (K₁₆₀) together with 20 t ha⁻¹ of manure was more effective than the use of potassium chloride (K₁₆₀). In these options, the difference in apple yield was 0.95 t ha or 4.2%. In intensive apple orchards, high yields on apple were also found in the 20 t ha⁻¹ of manure + K₁₆₀ (potassium sulphate). In this case, the increase amounted to 95.1 kg ha⁻¹ or 124.4% compared with the control version, and compared to the same dose of potassium chloride against the background of 20 t ha⁻¹ of manure by 5.8 t ha⁻¹ or 3.38%.

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