The resistance to pulling the working part where the manure juice is poured locally

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Abstract. The object of the research consists of the architecture of the root system of intensive garden soil and trees, the process of interaction of the aggregate and its working part with the soil and roots, which pour the fertilizer juice locally. The only way to grow ecologically clean products from the garden is to feed the fruit trees locally with manure juice. In intensive gardens, it is advisable to pour the manure juice into the zone of branching tree roots 0.8–0.1 m long, 20–30 sm deep, and an average width of 15 sm. In the process of cutting the soil and roots of the working part of the fertilizer juice pouring unit, the force of gravity is formed. A dynamometer was used to determine the force required to cut the roots. To do this, it was dag a hole of 80 sm long, 30 sm deep and 15 sm wide along the row, without damaging the roots, leaving a distance of 20 sm directly from the trunk of the tree in the garden. The soil-cleaned roots were pulled into a dynamometer loop, pulled until they broke, and the breaking force was determined. For gardens, pouring sap on average 1 m long, 25-30 sm deep and 12-15 sm wide, leaving a protection zone of 20-25 sm from the trunk, increases the efficiency of fertilizer use. In the local method, the gravitational resistance of the working part, which pours the juice to depth, is on average 3.5 kN.

1. Introduction
The object of research includes the architecture of the root system of intensive garden soil and trees, the aggregate for local application of fertilizer juice, and its technological work processes.

In recent years, the volume of cotton fields in the country has been reduced and areas for fruit and vegetable production are expanding [1, 2, 3, 4]. At the same time, special attention is paid to measures to increase the productivity of orchards and in return to fully meet the needs of our people in ecologically clean, world-class fruit. Therefore, the issue of reducing the use of mineral fertilizers and instead of it maximizing the use of organic fertilizers, especially manure juice, is being replaced.

To solve this problem, it is necessary to increase the use of manure juice and give it locally directly to the zone where the fruit tree root system is branched [5, 6, 7].

In the conditions of our republic, manure and mineral fertilizers are usually spread on the field surface and buried by tillage. However, phosphorus and potassium fertilizers are slowly absorbed by the soil and they hardly move in the soil [8, 9]. Therefore, in recent years, gardens are recommended to apply fertilizers around its roots, that is, in the zone where the roots are branched in a horizontal plane, in intensive gardens this distance is 0.8-0.1 m and a depth of 20-30 sm [10, 11].

Based on the planting scheme of intensive orchards, the absence of aggregates that provide 8.0-12 l of manure juice locally assigned to the root system of each tree represents the relevance and necessity of the research.
The analysis of the literature shows that when the manure is spread on the field in a simple way, the development of roots is reduced by 1.2-1.4 times, and branching by 1.3-1.7 times are emphasized. Studies on the calculation of the gravitational resistance of the working part during the processing of garden row spacing did not take into account the morphology of the roots and the characteristics of the manure juice [12, 22].

Because they do not have a 15 sm wide strip of manure juice poured in the form of a tape and do not have a working part design that provides it. Tractors with a traction capacity of 44 kW with the ability to move between garden rows are produced locally. The power of this tractor is small, and the mass of the local manure juice burner is large, about 3 t.

In one pass of the unit, each of the two working parts, at the same time, opens the ridge to a depth of 25-30 sm, pours the juice to a width of 12-15 sm, and closes the ridge. Therefore, the purpose of the study was to ensure the minimum amount of resistance of the working part of the unit to the local injection of manure juice.

To achieve this goal, the following tasks must be performed:
- study of the morphology of the root system of intensive garden trees;
- determine the force required to break the roots;
- comparison of theoretical and experimental results;
- formation of recommendations for reducing the force of gravity

2. Methods
To determine the relevance of the results of theoretical research to the experimental one, experiments were conducted directly in the intensive garden itself. The experiments were performed on a 6-year-old apple tree. To determine its resistance to cutting roots experimentally, a shovel, a simple ruler, an electronic caliper, and a dynamometer CRANE SCALE (Cap. 100 kg) were used. After studying the soil moisture and hardness, an average distance of 20 sm was left from the trunk, and 80 sm in length, 30 sm in depth, and 15 sm in width were dug along the row. During the uranium mining process, care was taken to keep the roots intact. All roots with a thickness greater than 3 mm were numbered and the diameter of each was measured. This was used to determine the number of roots, their location across the soil layer, and the average diameter of the roots. It was then attached to each of them to the dynamometer loop and pulled it apart by hand. The process was videotaped and the amount of power at the time of the interruption was recorded in a special field notebook. This experiment was conducted on the root system of three trees in the garden and the data obtained were processed by mathematical-statistical methods. One of the reasons why the experiments were not carried out in a laboratory setting is the characteristics of the root of intensive garden trees.

Firstly, the bonding force between the root shell and the core is not strong, and secondly, there is no possibility of firmly attaching the root in the test to the base on both sides. As a result, the reliability of the experimental data decreases. It is therefore convenient to conduct experiments under conditions in which the roots are in a natural state to obtain the expected results.

3. Results and discussion
Technological parameters of the technology of localization of soil and aggregate manure juice are defined as follows (Figure 1): b - protective zone, m; Bi - width of manure juice filling, m; a - depth of filling of manure juice, m; l - The length of pouring manure juice, m. Based on the analysis of the results of the research, the following was adopted: b=0.25 m; Bi=0.3 m; a=0.25 m; l=0.8-0.1 m. Manure juice is given in the first year along one side of the tree and the next year on the other side.
Since there is no local fertilizer aggregation system in the republic, the scheme of the fruit tree is developed as follows. Picture 2 A tractors for cultivation between the aggregate gardens is consisted of from a device for localization of manure juice and a hydrothermal device. It consists of a tractor (40 horsepower), blade pump, reservoir, breaker, working part, and frame. A distinctive feature of the design of the aggregate is the possibility of separate operation of hydraulic and soil treatment facilities.

On the determination of resistance to drag the working part of the tree, which provides low energy consumption and at the same time localization of manure juice, theoretical research has been carried out to develop a mathematical model of the process of interaction of the working part with soil and root [1-22].

In general, the force exerted by fruit trees to root is determined by the following expression [2, 3, 4, 5, 6, 7, 8]

$$P_l = k_1 k_2 b \sqrt{\frac{m}{s}} d^2 \left[ k_3 \sigma_s \sqrt{\frac{p}{\pi E}} \sqrt{1 + f^2 \sin(\varphi + \phi) + k_4 \sigma_p} \right]$$

(1)
where \( k_1 \) is cutting root system \( S_1 \) the sum of the surfaces \( S_n \) according to the surface; \( k_2 \) is the number of roots to be cut simultaneously with a single side blade of the working part, piece; \( b \) is the width of working part, m; \( m \) is the number of roots in the soil layer equal to the dimensions of the side blade of the working part on the longitudinal vertical plane, piece; \( s \) is the surface where roots placed, \( m^2 \); \( d \) is average diameters of roots, m; \( k_f \) the number of roots cut by the working part from the number of roots cut from the number of working parts; \( p_k \) is the hardness of the soil, Pa; \( f \) is coefficient of friction of the root; \( \varphi \) is friction angle, degree; \( \psi \) is cutting angle, degree; \( E \) is the modulus of elasticity of the root, Pa; \( \sigma \) is specific resistance of the root, Pa; \( \sigma_r \) is boundary strength in root elongation, Pa.

**Figure 3.** The graph of the variation of the force expended on cutting the root with the working part depending on its diameter

Parameters of the working part, working conditions, taking into account the physical and mechanical properties of the soil, aggregate \( \leq 1.5 \) m/s from the resistance force generated when moving at low speeds is determined by the following gain \([4, 5, 6, 7, 8, 9]\):

\[
P = Kab + abl_1 \gamma \frac{\sin \xi}{\cos \xi - f_1 \sin \psi \sin \xi} + P_d
\]  

(2)

where \( K \) is specific resistance of soil, Pa; \( a \) is processing depth, m; \( l_i \) is scan length, m; \( \xi \) is side blade mounting angle, degrees; \( \gamma \) is volumetric mass of soil, N/m\(^3\); \( f_1 \) is coefficient of friction of the soil; \( P_d \) is average power expended to cut the roots, N; \( k_j=0.13 \), \( k_l=4 \) piece, \( b=0.22 \) m, \( m=71 \) piece, \( s=0.08 \) m\(^2\), \( d=0.0072 \) m, \( k_1=0.39 \), \( k_2=0.61 \), \( p_k=1.3 \) mPa, \( f=0.57 \), \( \varphi=30^\circ \), \( \psi=35^\circ \), \( E=5.2 \cdot 10^9 \) Pa, \( \sigma=20000 \) Pa, \( \sigma_r=155255 \) Pa, \( K=40000 \) Pa, \( a=0.2 \) m, \( l_i=0.05 \) m, \( \xi=30^\circ \), \( j=13000 \) N/m\(^3\) and \( f_j=0.3 \) accepted \([11-18]\), the calculations carried out on expression (2) showed that the drag resistance of a working part is 3.45 kN when the unit is moving at a speed of 1.1 m/s.
As can be seen from the graph in Figure 4, an increase in machining depth leads to an increase in the resistance force to drag the workpiece. The connection looks close to a straight line.

The graph of the force expended on cutting the root of an apple tree based on its diameter according to field experiments is given in Figure 5.

The analysis of Fig. 5 shows that the average force applied to cut roots with a diameter of 10 mm is 230 N. This value was 533 N in fruitless trees [13–19], it shows with a difference of 43% of the results. From this it can be seen that the force expended to cut the roots of fruit trees is considerably smaller than that of fruitless ones.

In determining the differences between the results of the study, it was necessary to compare the rates of theoretical cutting of roots and their experimental breaking. Therefore, it was accepted that the forces expended in cutting and cutting roots of the same diameter are mutually equal. When comparing the results of theoretical and experimental studies conducted to determine the strength of resistance to cutting roots, the difference in performance did not exceed 20%.
4. Conclusion
1. Application of all types of fertilizers that nourish the gardens in the form of juice and local methods will allow increasing the yield and soil fertility.
2. For intensive gardens, pouring sap on average 1 m long, 25-30 sm deep and 12-15 sm wide, leaving a protective zone of 20-25 sm from the trunk, increases the efficiency of fertilizer use.
3. The nature of the deformation of garden soil and tree roots is different, so it is expedient to consider the soil and root system as a single object when substantiating the parameters of the locally watered part.
4. The average drag resistance of the working part, which pours the juice locally at a speed of 1.1 m/s, depth of 30 sm, and a width of 15 sm, is 3.5 kN.
5. It is recommended to apply fertilizer juice to the gardens locally when the soil moisture is not less than 16%.

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