Analysis of Machines Providing Liquid Fertilizer to the Root System of Orchard and Vine Seedlings

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Abstract: In the world, scientific-research works are being conducted aimed at the development of new scientific and technical bases of resource-saving technologies of pouring fertilizer juice between garden rows and the technical means that implement them. In this direction, the development of the structural scheme of the working part that locally pours fertilizer juice between the rows of the garden and the justification of the technological work process, the purposeful scientific research on ensuring resource efficiency in the processes of its interaction with the soil and tree roots conducting research is one of the urgent issues. In this regard, it is necessary to develop multifunctional working parts.

Keywords: garden, fertilizer, juice, organic, mineral, local, pouring, tree, soil.

The average yield of fruit in our republic is 99 s/ha, and that of grapes is 60 s/ha. However, this indicator is 1.5-2.0 times less than our fruit and grape production capacity. There are many reasons for low productivity, including failure to carry out the technological processes between garden rows on time and in good quality, sometimes soil cultivation is not compatible with agrotechnics, timely and moderate application of organic and mineral fertilizers. not to increase, especially not to inject them locally.

The most effective way to increase the productivity of gardens is to pour fertilizer juice locally into the soil of the zone where the tree root system branches.

Local feeding of fruit trees was first carried out at the end of the 19th century in Germany by P. Wagner and at the same time in Ukraine at the experimental site of K. Derebchinskiy. As a result, the yield of fruit trees increased by 6 s/ha. In Russia, since 1935, the local method of feeding fruit trees has become widespread. N.D. Spivakovsky, G.K. Vaskan, V.D. Korneychuk, V.K. Plakidi, V.N. Kichigin, G.V. Nastaslar, MsKes E.Soil, and Uzbek scientists M.M. Mirzayev, I. Ashirbekov, U. Komilov apply organic fertilizers to gardens and vineyards in the form of juice. it was noted that feeding by burying the root system increases productivity by 15-30%.

Currently, this method is widely implemented in foreign countries, including in the USA, 50% of all fertilizers intended for garden soil are poured in the form of juice.

According to the technology of pouring organic fertilizers between garden rows, first organic fertilizers are buried in special pits and turned into humus or compost, and then 60-100 t per hectare using special machines sprinkled on the surface of the field.

Mineral fertilizers are first crushed in grinders, brought to the required size, transported to the garden in a vehicle, and then sprinkled between the rows of the garden in special aggregates. Fertilizer juice is divided into mineral and organic types. The moisture content of organic

fertilizer juice is up to 98%. There are many types of aggregates for transporting mineral fertilizer juice and pouring it locally into the soil. Due to the large size of the fertilizer spreader, it is not widely used due to the fact that it is aggregated with a tractor of a high traction class, and it is inconvenient to move between garden rows, and it damages and breaks tree branches. According to the method proposed by YE.A. Vadimovich, fertilizer juice is poured into the root system of the tree with high pressure (Fig. 1). The unit consists of hydroimpulse chamber 1, pipe 2, pump 3, pipe 4 to the tree root system, insulator 5.
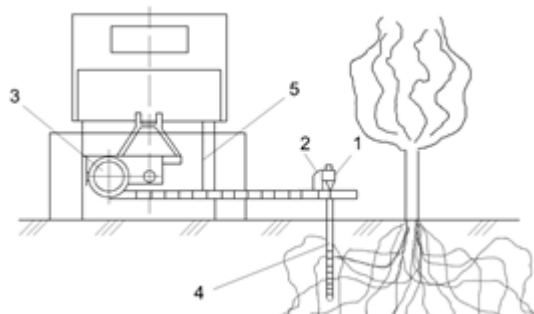
1-hydraulic chamber; 2nd pipe; 3rd pump; 4-pipe to the root system of the tree; 5th insulator

Figure 1. Aggregate for pouring fertilizer juice into the soil

The construction and technological work process of the unit is complex, low productivity and requires tractors with high traction power. Scheme of the working part for local injection of fertilizer juice into the soil It is presented in Fig. 2.
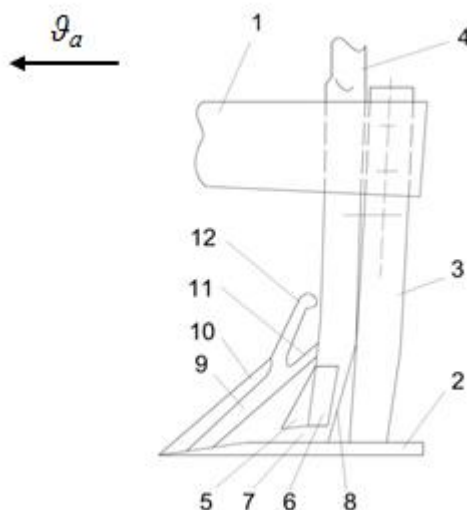

Frame 1; 2nd axial arcuate tooth; 3rd column; 4-fertilizer juice discharge pipe; 5, 6 levers, 7 slot; the back wall of the 8th pipe; 9-tree roots slip slope; 10th blade; 11,12-lower and upper branches.

Figure 2. Scheme of the working part for local injection of fertilizer juice into the soil

It is frame 1, arrow-shaped tooth 2, rack 3, fertilizer juice discharge pipe 4, levers 5, 6, slot 7, back wall of the pipe 8, plant roots sliding slope 9, knife 10 , consisting of 11 lower branches and 12 upper branches. A small amount of fertilizer juice can be poured locally with the working part. The placement of the fertilizer drain pipe in front of the column leads to an increase in drag resistance.

The work tool that simultaneously softens the soil and pours fertilizer juice under it (Fig. 2) consists of a pipe 1, a column 2, nozzles 3, the lower part of the column 4, and an auger 5.
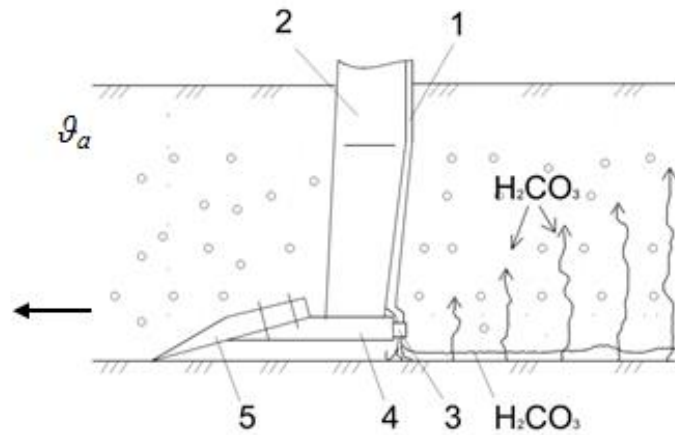
1-conductor; 2nd column; 3-pieces; the bottom of the 4th column; Pier 5.

Figure 3. Scheme of the working tool for local injection of fertilizer juice into the soil

The working part is designed for local pouring of fertilizer juice in the form of a narrow band. This is a disadvantage for the area where the root system of the fruit tree is branched. As a result, the efficiency of fertilizer use is low.

In addition to tillage, the machine that pours fertilizer juice under the plowed field (Fig. 4) consists of a reservoir and working parts of tillage.
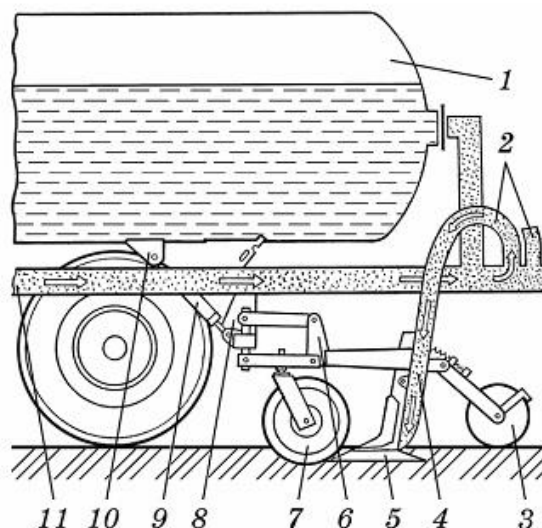

1st reservoir; 2nd distribution device; 3rd reel; 4.11 pipe; 5th tooth; 6-parallelogram mechanism; 7-disc blade; frame 8; 9-hydraulic cylinder; 10th bracket; 11th central pipeline.

Figure 4. Scheme of the technological process of the machine for local injection of fertilizer juice

The machine is designed for continuous local injection of fertilizer juice. This leads to the local injection of fertilizer juice in unnecessary places and its excessive consumption. The large number of working parts made the design of the machine complex. In intensive gardens, a special unit for local injection of fertilizer juice has been developed (Fig. 5).

It consists of tractor 1, leading and driven stars 2, driving wheel 3, chain 4, cover 5, container for collecting fertilizer juice 6, bucket 7, egate receiver 8, egate cover 9, reservoir 10 found Aggregation was carried out using a garden tractor.
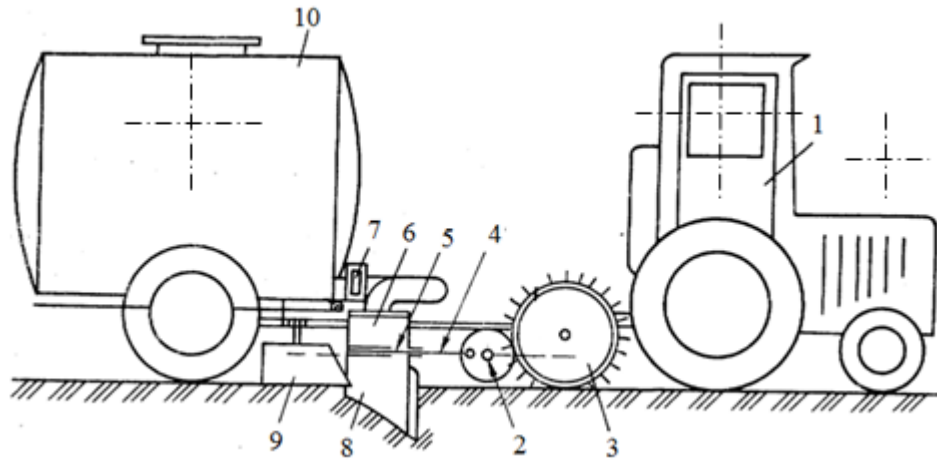
1-tractor; 2nd asterisk; 3-driving wheel; 4th chain; 5th cover; 6- container for collecting fertilizer juice; 7th collection; 8-egat opener; 9-egat cover; 10th reservoir

Figure 5. Unit for local injection of fertilizer juice into gardens

The cover 5 of the container 6, where the fertilizer juice is collected in the unit, is opened and closed on the principle of the forward and reverse movement. During this period, the hole through which fertilizer juice is poured into container 6 is opened and closed. Drive to cover 5 is transmitted from wheel 3.

The disadvantage of the unit is that due to the uneven surface between the garden rows, the cover may not be opened at the specified time and place, because the movement is transmitted from wheel 3, as a result, the technological process is not always performed stably.

Another disadvantage of the unit is that each of the working parts that open and close the gate for local injection of fertilizer juice is separate, which leads to an increase in energy and metal volume.

The analysis of the construction and technological work processes of the working parts for the local injection of fertilizer juice showed that they are based on first pushing the soil on both sides to open the agate and pour the fertilizer juice to the bottom, and then to close the agate.

With the traditional method, the amount of local injection of fertilizer juice using one working part is determined by the following expression,

$$G = QV \quad (1)$$

where Q-unit amount of fertilizer juice poured into the soil, l; V – volume of soil moistened with fertilizer juice, m^3.

Taking into account the expression (1), the consumption of fertilizer juice during the same time with one working part is also determined,

$$q = \frac{G}{t} = \frac{QV}{t} \quad , (2)$$

Depending on the density of the fertilizer juice, the shape and geometric dimensions of the hole through which it is poured, the consumption of one working part during one time,

$$q = \lambda \psi \sqrt{2P\rho} \quad , (3)$$

where l is the consumption coefficient of fertilizer juice depending on the shape and geometric dimensions of the hole; ps – cross-sectional area of the hole, m2; R is the pressure of the fertilizer juice exiting the hole, Pa; r – density of fertilizer juice, kg/m3.

The above expressions show that the amount of fertilizer juice depends on the parameters of the hole through which it is poured from the working part. This is a factor that should be taken into account in further research.

In the research, the amount of moistened soil was determined when fertilizer juice was poured locally. According to it, the volume of moistened soil

(Fig. 6),

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(Fig. 6),

$$V = hab, \quad (4)$$

where a, b are the width and height of soil moistened with fertilizer juice, m; h-aggregate distance covered at one time, m;
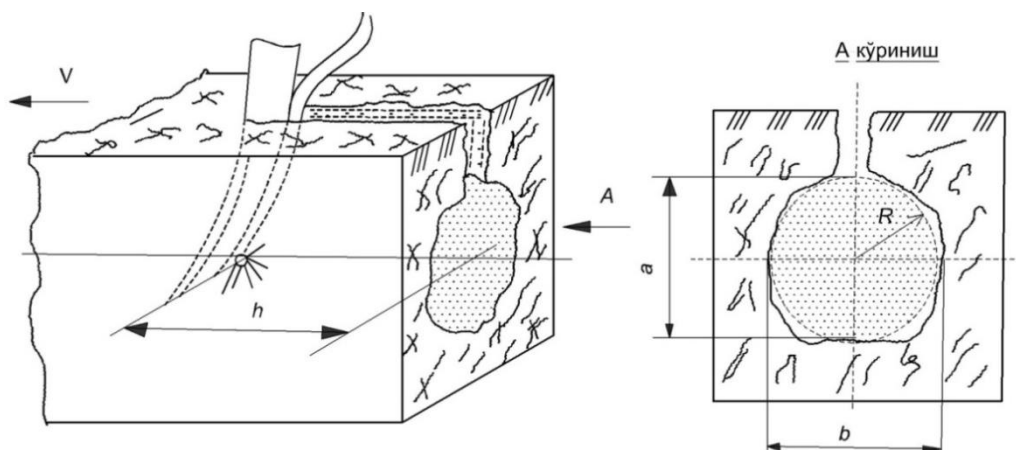

Figure 6. Scheme for determining the volume of the part of the soil moistened with fertilizer juice

According to the results of the research conducted by many researchers, when fertilizer juice is poured locally, the cross-section of the moistened soil is close to the shape of a circle. Correspondingly, cross-section of moistened soil,

$$V = \pi r^2 h \quad (5)$$

where r is the radius of the soil moistened circle, m.

D.A. Yegorov determined the drag resistance of the working part that cuts tree roots,

$R=R_1+R_2+R_3, \quad (6)$

where R1 is the force used to deform the soil, N; The force used to raise the R_2-blade on the surface of the working part, N; R_3-power spent on cutting the root of the tree, N. The force spent on deformation of R_1-soil is determined as follows,

$$P_1 = \left(\gamma_\kappa ghN_\gamma + CN_C + C_a N_{Ca}\right)hb_u + \frac{\gamma_\kappa h^2 l_{yc} \sin\varphi_{yc} tg\varphi}{2} \, , (7)$$

where gk is the density of the root soil layer, kg/m³; g-fall acceleration, m/s²; h-processing depth, m; Ng is the coefficient to take into account the angle of inclination of the soil; S-soil cohesion; N_S-soil cohesion accounting coefficient; S_a-soil adhesion; $N_{S\,a}$-soil adhesion coefficient; the width of this pier, m; lus-column length, m; angle of installation of phus-pillar, degrees; φ-soil to metal friction angle, degrees. The force used to raise the R_2-blade on the surface of the working part is determined by the following expression, where the length of the L-push-puller, m; h-processing depth, m;

$$P_2 = 0.5\gamma_\kappa gLh\cos\alpha\left(B\sin\alpha + tg\varphi t_i n_i \cos\alpha\right), (8)$$

Coverage width of the V-car, m; width of ti-push-extractor, m; the number of ni-push-extractors, pcs.; a-push-puller installation angle, degrees.

The force required to prune the root of the R3-tree is defined by the following expression,

$$P_3 = 0.3975 \cdot [\sigma]\sqrt[4]{\frac{8k_i}{E}} \cdot h\left(\frac{b_0 h}{\cos\varphi_{yc}}\right)^{\frac{D-2}{2}} \sum\left(\omega_i d_i^{1.25}\right), (9)$$

where [s] is the limiting strength of static bending of the root, N/mm2;

Elastic modulus of YE-tree root, Pa; coefficient depending on the solid part of the root, Pa/m; b0-working part width, m; Fractal size of D-root system; number of roots in ωi-i diameter, units; root diameter, m.

The status and development perspective of the construction of the working part that locally pours fertilizer juice between the garden rows and the researches on improving their work processes. made it possible to improve.

By developing and justifying the parameters of the working part for the local injection of fertilizer juice, it is possible to achieve simultaneous execution of the processes of fertilizer injection and closing. Increasing the quality indicators of the method of local injection of fertilizer juice, reducing metal and energy consumption, developing the working part, theoretical and experimental justification of its parameters is an urgent scientific and technical issue.

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