# CROP PRODUCTION

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## AN EFFECTIVE ASSISTANT IN MANUAL HARVESTING OF CURRANT' BERRIES: HISTORY AND PROSPECTS

Research article

**Abstract**

The purpose of the study was to substantiate promising directions for the creation of manual vibrators capable to improve the productivity of berries' harvesting in shrub plantations of various types based on the history of the creation in Russia of technical means for berry harvesting from bushes. The subject of the research was the technological process of interaction of the oscillating fork with the fruit-bearing branch. Everywhere the berries' picking of currant, gooseberry and honeysuckle, dog rose for a long time traditionally was carried out manually. However, since the middle of the last century, people began to use various devices not only to facilitate this process, but also to significantly increase the labor productivity. In the first models of commercial machines for the berries' picking, we used individual manual vibrators for each berry picker and lightweight mobile catchers. With the advent of high-capacity berry harvesters, we gradually ceased to use the technique with manual vibrators. New technologies and materials allow today to create more advanced manual vibrators for use not only in the homestead land, but also at group work on small commercial currants and other small fruit crops plantations, successfully competing with combines. Modernization of machines of this type, working without tractor, will have a positive impact on the environmental situation in perennial plantations.

**Keywords:** berry, currant, machine, vibrator, catcher, fork, oscillations, amplitude, frequency, removal, picking, impurities, cleaning.

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## ЭФФЕКТИВНЫЙ ПОМОЩНИК ПРИ РУЧНОЙ УБОРКЕ ЯГОД СМОРОДИНЫ: ИСТОРИЯ И ПЕРСПЕКТИВЫ

Научная статья

**Аннотация**

Цель исследования – на основе истории создания в России технических средств для сбора ягод с кустов обосновать перспективные направления создания ручных вибраторов, способных повысить производительность уборки ягод в кустарниковых насаждениях различного типа. Предмет исследования – технологический процесс взаимодействия колеблющейся вилки с плодоносящей ветвью. Сбор ягод смородины, крыжовника, жимолости съедобной, шиповника долгое время традиционно проводился вручную повсеместно. Однако с середины прошлого века люди стали использовать различные приспособления не только для облегчения этого процесса, но и с целью существенного повышения производительности труда. В первых моделях коммерческих машин для сбора ягод с кустов использовались индивидуальные ручные вибраторы для каждого сборщика и лёгкие передвижные улавливатели. С появлением ягодоуборочных комбайнов высокой производительности машины с ручными вибраторами постепенно перестали использоваться. Однако новые технологии и материалы позволяют сегодня создать более совершенные ручные вибраторы для использования не только на приусадебных участках, но и при групповой работе на небольших промышленных плантациях смородины и других ягодных культур, успешно конкурирующие с комбайнами. Модернизация машин этого типа, работающих без трактора, положительно скажется на экологической ситуации в многолетних насаждениях.

**Ключевые слова:** ягода, смородина, машина, вибратор, улавливатель, вилка, колебания, амплитуда, частота, сбор плодов, примеси, очистка.

The first commercial models of currant harvesters appeared in Russia (then still in the USSR) in the late 60-ies of the last century. As result of joint work of specialists of the Research zonal Institute of horticulture of the non-Chernozem strip (Moscow) and the Head specialized design Bureau for machines for gardens and vineyards (Chisinau), an electric berry harvesting machine (EBHM 200-8) was created. The scientific director of studies of working bodies of this machine was Lev M. Pilyugin, and the leading designer was Albina D. Krivonosova (Petrenko).

In total, 750 serial samples of EBHM 200-8 were produced in the country in a short period, by the efforts of various organizations and enterprises. These machines were distributed in almost each of the 600 farms with developed berry growing in Russia. Simple in design and reliable in operation, berry harvesters with manual vibrators solved the problem of harvesting of currant berries on commercial plantations. The production of one vibrator was not less than 22 kg/h of berries with a yield of 1.5 t/ha and more [1], and with the simultaneous operation of 8-and manual vibrators (the mass of each vibrator without cable was 1.55 kg), the output per shift of the machine reached 1200 kg or more. From this time forth in Russia a planned annual increase of the area under the bushes of black currant, gooseberry and other berries grown by industrial methods started.

In 1974 in the USSR for the first time a high-performance berry harvester MPYA-1 was presented on the state tests [2], and then after long-term comparative tests with the best foreign analogs (Pattenden, Smallford, Jonas, etc.) and improvements of the design since 1981 its serial production began. Since 1985, new model of berry harvester MPYA-1A and other modifications became serially be produced.

The chief of studies of the working bodies of berry harvesters at all stages in the Research zonal Institute of horticulture in the Non-chernozem strip was Yury A. Utkov, and the elaboration of the design of the MPYA harvesters family in the Head specialized design office of machine for orchards and vineyards was headed by Valery V. Bychkov.

The era of harvesting of currant berries in the world by combines has suspended for a long time the production and the use of berry harvesters with manual vibrators in Russia. On industrial plantations of berry bushes now in the country, mainly Finnish self-propelled and Polish trailed harvesters are working, as the mass production of domestic harvesters has been unreasonably stopped by the early 90-ies of the last century.

Today in Russia there is a situation in which on numerous homestead and suburban areas, as well as in small-area farm plantations of black, red, white currants, gooseberries, honeysuckle and other crops manual vibrators of positional action can be widely used. The same applies to perennial plantings with uncomfortable terrain for combines. It is only necessary to analyze and realize the advantages of manual vibrators in comparison with machines of continuous action.

First, the quality of harvesting berries by manual vibrators, controlled by the berry pickers themselves, is higher than when working combines: the completeness of the removal of berries is 97-100 %, the breakage of plant growth is 5-8 % and leaf fall is 6-8 %. At the same time, there are no special requirements for varieties and agrotechnical background.

Secondly, as result of successful studies [3], there are substantiated the directions of further improvement of the design of manual vibrators with immobile ends of the oscillating fork, which were ahead of their time and therefore they have not been implemented in serial samples. The quality of these vibrators was higher than the serial. For example, breakdown of plant elements was absent at all.

Thirdly, modern materials and innovative technologies, used now in agricultural engineering, allow us to realize the already accumulated scientific potential for the solution of engineering problems in horticulture in full volume.

Fourth, the creation of manual vibrator of a new generation will cause commercial interest primarily in Russia, as it will enhance the prestige of the gardener's profession and replenish a number of existing effective tools with electric driven by a portable battery, used everywhere in everyday life, including in rural areas.

In view of the above, it is possible to formulate fundamentally new regulations concerning the design of manual vibrators for harvesting berries from bushes, and to justify their advantages when used in various berry production technologies.

It is necessary to abandon the positional harvesting unit of type EBHM 200-8. The presence of a tractor with a constantly running engine and a generator to generate electricity, supplying eight manual vibrators, not only significantly reduces the economic efficiency of machine harvesting berries, but also worsens the ecological situation on the plantation (exhaust gases, increased noise of diesel engine). In addition, it is necessary to select berry pickers with approximately the same abilities to operate with manual vibrators and portable heap catchers, which were not always compensated by the length of electro-cables of vibrators (10 m each). These arguments are significant and allow us to make the first conclusion: the individual vibrator must have wireless powered from a portable battery with a total weight of not more than 1.7 kg, and the weight of the empty individual catcher should be reduced to 2 kg (the weight of EBHM 200-8 was 3 kg) by replacing the metal tubular frame with plastic and using lighter, but durable non-woven material, instead of tarpaulin

To improve the quality of the vibrator, its design should fundamentally change, so that the optimal amplitude of oscillations of the base of the fork, contacting with the fruitful branch, at the same time was the maximum.

We will conduct kinematic analysis of the working process of the oscillating fork of the vibrator without the use of mathematical apparatus to facilitate its comprehension by readers without specific training.

The necessary constant oscillation frequency of the two-finger fork is determined by the uniform rotation of the shaft of the eccentric mechanism of the vibrator, which, using a multi-shoulder lever that has its centre of rotation, converts the rotation movement of the eccentric axis in an oscillating movement of the lever in a concrete plane. Moreover, the amplitude of oscillations is provided by the radius of the eccentric and the ratio of the shoulders of oscillating lever, on the opposite (from the eccentric) end of which a two-finger fork was fixed. Thus, the law of motion of the multi-shoulder lever is determined, taking into account that it is in contact with the eccentric at a point moving along an arc of radius equal to the distance from the eccentric to the center of rotation of the multi-shoulder lever. If it is considered, that at a small value of the angle of deviation of the lever from the axis of the vibrator, its sine is approximately equal to the angle itself, then the projection of the remote point located on the radius of the eccentric on the abscissa axis can be considered as amplitude of the deviation of the end of the multi-shoulder lever, on which the two-finger fork is fixed. In view of this, the speed and acceleration of any point on the fork determined by known formulas from the theory of the rotation motion of a rigid body around a fixed axis.

An analysis of the resulting formula of speed of any point of the fork's finger (and to a greater extent and acceleration!) showed that it increases with distance from the base of the fork and reaches a maximum to the ends of the fingers, significantly exceeding the permissible values. The oscillation amplitude of the fork ends also significantly exceeds the optimal value (0.01 m) at the base of the fork by twice or more depending on its type. It is these factors that explain the occasional occurring damage to the fruit-bearing branches in the places of their contact with the oscillating fork. To this, it is necessary to add that at the optimal oscillation frequency of the fork (36.6 Hz), its ends become invisible, and in most cases, the berry picker is not able to "capture" the fruit-bearing branch of the fork base. As result, when the fork is unilaterally exposed to the branch, the ripe berries are not completely separated, and due to the large amplitude, a significant part of them does not fall into the catcher zone, scatters and makes irrecoverable losses. This leads to the second conclusion: the design of the manual vibrator in the process of interacting with the branch must constantly ensure the immobility of the ends of the fork, making them visible to the berry picker. In this case, the "capture" of the branch by the base of the fork is guaranteed in a short period of time, the productivity of picking berries increases, and the quality of the technological process is improved.

During the working shift, the berry picker switches off the vibrator with a toggle switch in order to empty the catcher from the heap (collected berries together with fallen leaves and other impurities) into a pneumatic cleaning system located nearby on the tractor hitch with an electric generator. This occurs 6-8 times during the shift, depending on the yield of plantations. The rest of the time, the vibrator is turned on and is in the hand of the worker picking berries. Therefore, reducing the negative impact of vibration on the hand and the entire human body is an important engineering problem.

A general analysis of possible ways to reduce the vibration level of harvesting apparatus body can be presented as follows. The deviation of the fork from the vibrator axis during operation causes a body deviation in the opposite direction. If to accept that the sum of all external forces acting on the center of masses of the investigated system is equal to zero (vibrator in hands motionless) it is possible to compose a system of two equations of interaction between the centers of mass of the body and the oscillating vibrator lever. To determine the angle between the abscissa axis of the adopted coordinate system and the axis of symmetry of the vibrator level, we apply the law of conservation of the kinetic moment, theorems about the angular momentum of a rigid body around a fixed axis and about the moment of inertia of systems with parallel axes, provided that there is a direct connection between the angles of the axes of symmetry of the lever and the vibrator body with the abscissa axis. After a series of mathematical transformations and the adoption of correct assumptions, we obtain the equation of motion of the center of mass of the vibrator body, which represents the equation of motion of a point along a circle in rectangular coordinates. The radius of this circle is equal to the ratio of the mass of the lever with the fork to the total mass of the lever with the fork and the vibrator body, multiplied by the distance between the centers of mass of the body and the lever with the fork. The analysis of the obtained theoretical dependences shows that to reduce the unwanted vibration amplitude of the vibrator body, it is necessary to bring the mass centers of the lever and the body as close as possible and, if possible, increase the body mass, and reduce the mass of the lever with the fork. In practice, these recommendations allow us to make a third conclusion: joining the mass of the battery to the body of the vibrator will reduce the overall vibration of the harvesting tool, and the manufacture of a lever and fork from modern lightweight but durable materials will also contribute to this. To reduce the angular vibrations of the body, should possible to increase the lever arm from the center of rotation to the eccentric and reduce the radius of the eccentric.

The above scientifically based proposals can be implemented in any country with a developed horticulture. In Russia, there is currently no one to solve this problem, as for various reasons, previously actively working engineering departments and laboratories have been abolished in most of the leading horticultural institutes. However, the most highly profitable branch of agricultural production in Russia – the commercial horticulture has already found engineering support of the Federal Scientific Agroengineering Center (Moscow, Director is the academician Andrey Yu. Izmailov). Here, for the first time in the history of this world-famous scientific institution, recently a work started on the study of working bodies and the creation of specialized horticultural machines. We must assume that the scientists of this center will also soon begin to deal with manual vibrators for picking berries.

Directions for perfection the design of manual vibrators for the harvesting of currant berries may differ from those described above. For example, it can become much easier if you replace the intermediate motor with an electromagnet that directly provides the necessary amplitude and oscillation frequency of the fork with immobile ends. However, the formulated scientifically based proposals are presented in such general form for the first time in order to draw attention to possible technical solutions to one of the urgent problems that interests berry producers in many countries of the world.

Harvesting of currants, gooseberries and other crops grown in areas with difficult terrain, on relatively small (up to 3-5 hectares) farm plots with a set of varieties with different ripening period of berries can occur during group work of berry pickers of any qualification – up to 10 people with individual manual vibrators and catchers. They begin to work independently after receiving instructions for picking berries from a concrete row or group of bushes.

Each collector comes to "his" bush and substitutes to him on any side the light catcher so that by one hand in this area, he was able to slightly tilt alternately 4-6 fruit-bearing branches. In one hand, he holds the vibrator turned on, and by the other he grabs the top of one or two branches, directs in the catcher zone, slightly "pulls" them (but does not tear off the top!) and simultaneously processes by "pricks" of fork vibrator two or three times in the locations of the berries on the branches. He then flips the catcher to another location next of the former, and the process repeats until the berry picker will not notice a significant mass heap in the catcher.

The presence of a compact crown in the rows, as a rule, does not create complex problems for picking berries and rearrangements of the catcher. However, under intensive plantings for the convenience of berry pickers, you can recommend them to pick berries from half a row and periodically, go into the next aisle between rows to pick berries from the other half of the row.

Each berry picker, as soon as its catcher is filled with heap, turns off the vibrator, carries the catcher to a mobile pneumatic berry cleaning located nearby and empties it into the receiving hopper, previously turning on its electric-powered fan. Purified by the air flow from fallen leaves and other impurities, berries fall into the container, which each berry picker marks himself, as depending on the type and size it can be filled in two or three steps. For cleaning berries from impurities you can used any small-

sized agricultural cleaning machine, equipped with a blower-type fan with an electric drive. To generate electricity, you can use any portable generator with an internal combustion engine, if there is no stationary power supply on the field. If necessary, the electric drive of such a cleaning machine can be powered by a battery.

When picking berries with a manual vibrator on the household plot, the cleaning of berries from impurities is carried out manually, disassembling the heap. However, in the presence of a household fan, this can be done with the help of the air flow during the overload of the harvested berries into the container.

## Conclusion

Manual vibrators for picking berries from bushes are indispensable on small plantations with short rows, as well as unfavorable terrain. Their production for commercial purposes can be organized in a short time in small enterprises with a minimum set of equipment in almost any country. They will find a wide demand among the population engaged in the production of currant berries, gooseberries, honeysuckle, blueberries and berries of other crops.

The main advantages of manual vibrators for picking berries are:

1. The productivity of manual labor in the berry harvesting increases by 6 times or more, and which significantly increases with the growth of yield.
2. The high quality of berry picking is guaranteed with minor damage to plant elements that practically do not affect their further growth and development.
3. The relatively low cost of the vibrator and the catcher, which pays off for one harvest season.
4. The attractiveness and prestige of the gardener's work is increasing, and manual mechanisms contribute to the growth of employment of the rural population.
5. The improving of the environmental situation when working in perennial plantations.
6. A number of standardized household hand tools, created by modern technologies and used in rural areas, are being replenished.

## Conflict of Interest

None declared.

## Конфликт интересов

Не указан.

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