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Development of a Mobile Electrical Installation for Destroying Weeds

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Annotation.

The article provides scientific and technical information about the types, distribution and harmful effects of weeds on crop yields, information analysis of scientific, technical and research works on the effectiveness of existing technologies used in clearing contaminated crop areas from weeds.

As a solution to the problem, an environmentally friendly, highly efficient electrical technology is proposed, based on the destruction of weeds with discharges of electric pulse current.

The design of the electrotechnological device, the processing procedure, processing parameters and the results of production tests are presented.

According to research results, rhizomes after treatment with voltage U = 5.0...9.0 kV and τ = 0.4 s. on the 30th day of recording, new shoots are produced from which new stems sprout with a height of 13 to 24 cm; samples after treatment U = 5.0...9.0 kV and τ = 0.6 s. on the 30th day of recording, new shoots with stems up to 9 cm are produced; in treated samples U = 5.0...9.0 kV and τ = 1.0 s. on the 30th day of registration they lose full viability.

A characteristic feature of the study is that after electrical treatment, weeds tend to survive and remain viable. Therefore, plants produce new shoots from the buds of the rhizomes until they are completely exhausted, which indicates the onset of the final stage of the life cycle.

Key words: cultivated plants, productivity, weeds, rhizomes of perennial plants, tractor, potato digger, mobile electrical installation, transformer. electrode, cable, spark gap, capacitor, voltage, current pulse.

1. Introduction. In the cultivated areas of the world, there are more than 30,000 species of weeds, 1,800 species of which annually cause great harm and high economic losses to agricultural crops [1].

The peculiarity of the problem is that the number and type of weeds increases from year to year. For example, in the CIS in 1990, the total species of weeds was about 2000; currently, in Uzbekistan alone, 841 species of weeds belonging to 72 families have been identified, of which 519 are annual weeds, and 322 are perennial [2].

Nevertheless, great damage is caused by single-flying and multi-flying rhizomatous weeds. According to statistics, of the total number of summer taproot weeds is 21%, rhizomatous weeds - 7% and weeds of all other biological groups - 2%. [3, 4].

In addition, weeds are reserves for various harmful microorganisms and soil diseases. In the world, crop losses due to the harmful effects of various harmful insects, pathogens and viruses in grain crops are 500-510, sugar beets 65-75, potatoes 125-135, vegetables 78-79 million tons, these figures are from the entire harvest make up 30-40% or in monetary equivalent is 75 billion USA dollars [5].

While major crop species compete with more than 200 species of weeds, about 60 species infest food, feed, various grasses, and agricultural products. This, in turn, leads to a decrease in soil fertility, a deterioration in quality, a decrease in the microelement composition of the soil, the withdrawal of sown areas from agriculture, and a deterioration in the ecological state of the environment [1, 6].

Analysis of scientific and technical information and study of existing technology for the destruction of weeds shows their insignificant effectiveness in the destruction of perennial rhizomatous weeds. Therefore, to solve the problem of destroying perennial rhizomatous weeds, an analysis of theoretical and experimental studies using electrical methods of influence was carried out.

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2. Experiment and methods for solving them

Currently, the use of various electrical methods based on the use of various factors of electrical energy has been proposed.

The use of direct and alternating current, low and high voltage, ultra-high frequency, electromagnetic field, exposure to electric spark discharges, heating plant tissue and soil with current (creating a thermal effect), etc. However, the methods described above do not give the desired result when destroying perennial rhizomatous weeds. Therefore, a study was conducted using electrical pulsed current discharges with high voltage - electric pulse treatment of rhizomes of perennial weeds (MSW). Based on our proposed technology, we have formulated the requirements for the design of a mobile unit and processing electrodes for weeds located in crop areas [8, 9]:

- the design of the mobile unit and processing electrodes must have high mechanical strength and reliable insulation from electrical energy leakage to the body of the mobile unit [8,9];

- during operation, the electrode system of the installation and the high voltage source must ensure: reliable contact, uniform processing and continuous supply of high-voltage electrical pulses of the required parameter [8, 9].

To implement the proposed technology for the destruction of KMC on the basis of the existing potato digger KTN-2V, taking into account the above requirements and on the basis of the obtained copyright certificates, a pilot plant was manufactured (Fig. 1). The technological diagram of the KTN-2V operation is shown in Fig. 2. [7].

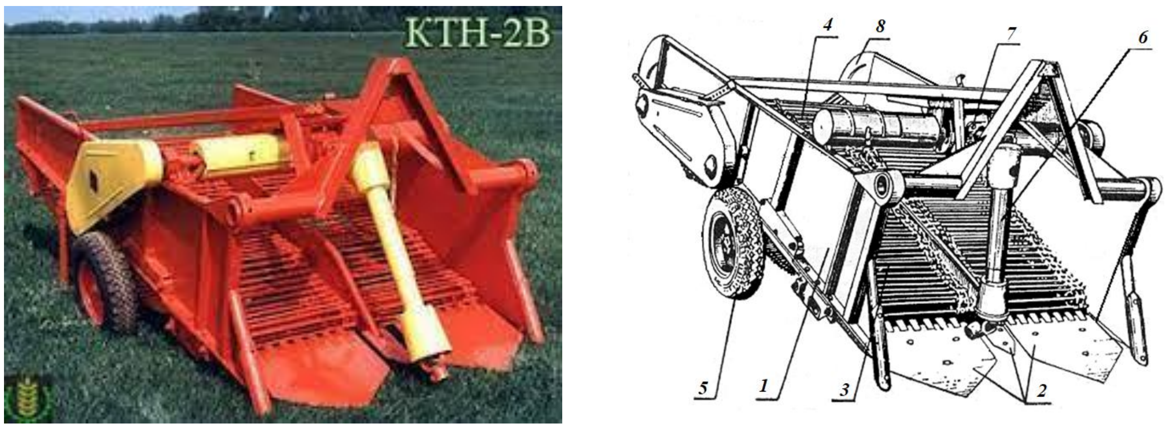

Fig.1. Potato digger KTN-2V
1-frame; 2-shares; 3-main elevator; 4-cascade elevator; 5-wheel support; 6-gear cardan; 7-reducer; 8-reflector.

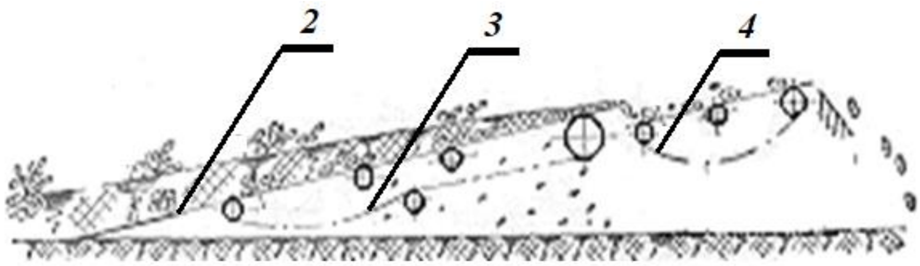

Fig. 2. Technological diagram. 2-share; 3-main elevator; 4-cascade elevator.

The main mechanical characteristics and technical data of the existing potato digger KTN-2V are given in Table -1 [7].

Table 1.
Basic technical data and characteristics

№	Name, unit of measurement	Meaning
1.	Brand	KTN-2V

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2.	Type	mounted
3.	Productivity per hour of net work, ha/h	0,25...0,47
4.	Operating speed of the unit, km/h	1,8...3,4
5.	Working width, m	1,4
6.	Digging depth, cm	22
7.	Transport speed, km/h	16
8.	Machine weight:	
	with spare parts and tools, kg	835+3%
	without spare parts and tools, kg	730+3%
9.	Overall dimensions, mm	
	Width	1725
	Length	3220
	Height	1250
	Ground clearance, mm	250
	Turning radius of the unit at the outermost point, m	6,2
10.	Characteristics of working bodies	
	a) plowshares	passive
	b) main elevator	
11.	Type	rod, two-section.
	rod diameter, mm	11
12.	Pitch, mm	41,3
13.	Linear speed of the web, m/s	2,02
	c) cascade elevator	
14.	Type	bar
15.	Rod diameter, mm	11
16.	Step	41,3
17.	Linear speed of the web, m/s	2,02
	d) support wheels	
18.	Type	pneumatic
19.	Quantity, pcs.	2
20.	Tire size, mm	140x510
21.	Can be mounted with tractors	МТЗ-80 (82),
22.	Drive unit	from tractor power take-off (PTO) shaft
23.	Power taken from the tractor PTO, W (hp)	до 1410 (20)
24.	Number of service personnel	1 tractor driver

It uses frame-1, plowshares-2, main elevator-3, cascade elevator-4, support wheel-5; cardan transmission-6, gearbox-7 without design and technical changes [1, 9, 11, 12, 13, 14].

An articulated movable electrode 15 is additionally mounted to the potato digger frame, which is suspended from the insulator and is located a short distance above the conveyor. In this case, adjustment of the distance between the movable electrode 16 and the rod conveyor (main elevator) 13 is provided. To crush soil lumps and weed tubers, taking into account their better separation, a lump crusher 14 is provided, made in the form of a welded metal drum assembled from rod rods.

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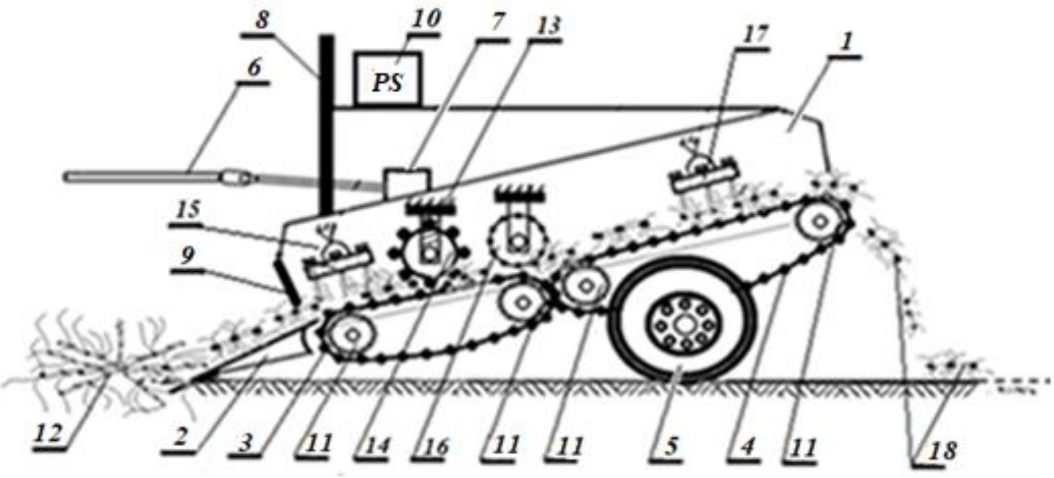
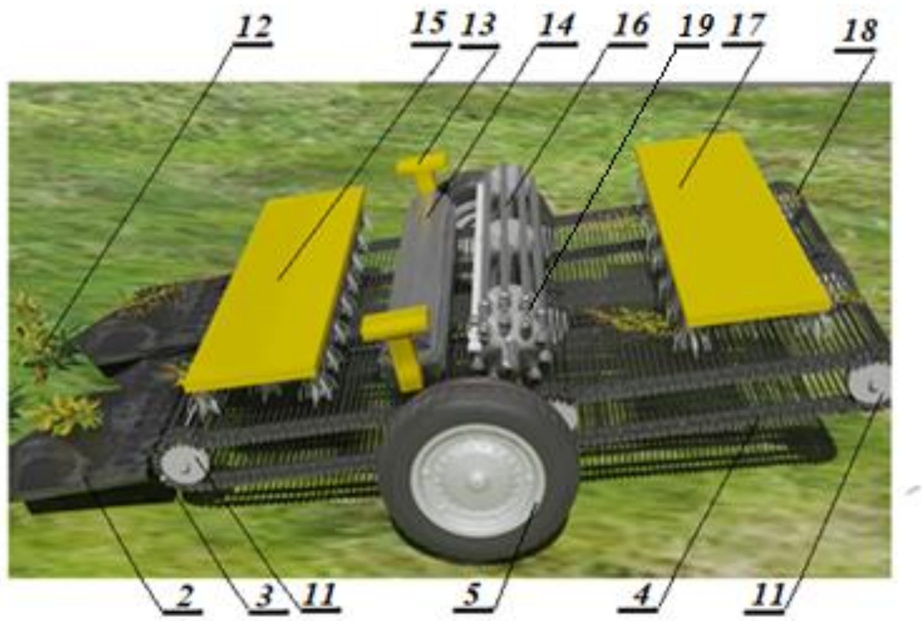
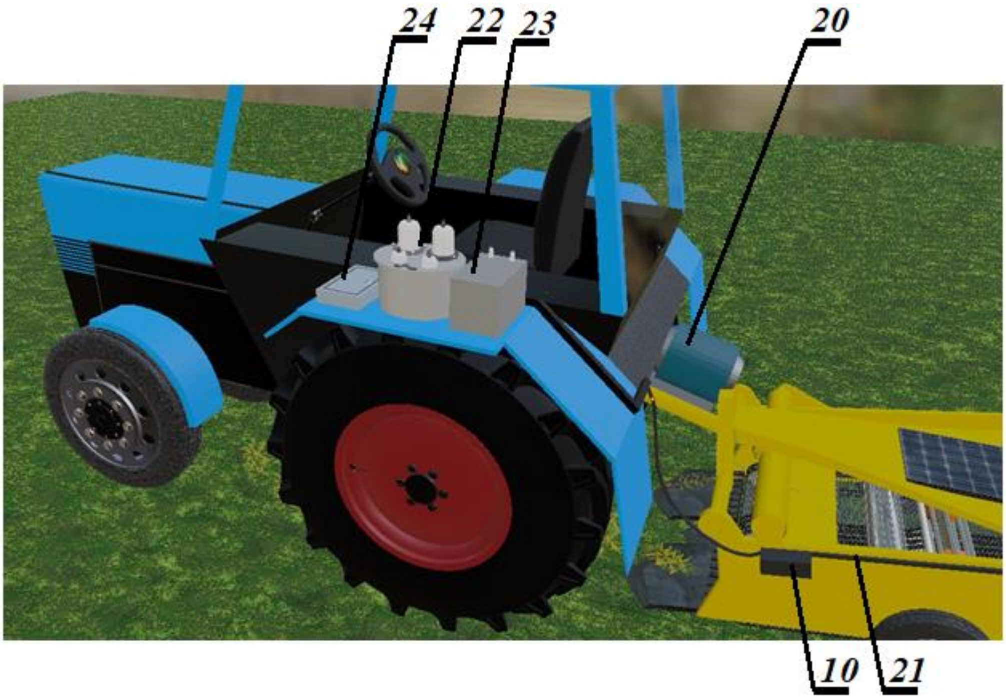


Fig. 3. Layout of electromechanical elements in a mobile device (side view): 1-frame, 2-shares, 3-main elevator, 4-cascade elevator, 5-support wheel; 6-cardan gear, 7-reducer, 8-device for attaching the combine to the tractor, 9-side flat cutter, 10-power source for electrical discharges; 11-drive gears of the rod conveyor, 12-weed rhizomes, 13-spring articulated movable mount for the clod crusher, 14-clump crusher; 15-first electrode (passive); 16-actively rotating electrode (drum-type dielectric disk); 17-third passive electrode (brush type), 18-processed rhizomes.



Rice. 4 – Placing work items in a mobile device (side view): 2 shares, 3 main elevator, 4 cascade elevator, 5 support wheel; 11-drive gears of the rod conveyor, 12-weed rhizomes, 13-spring articulated movable mount for the clod crusher, 14-clump crusher; 15-first electrode (passive); 16-actively rotating electrode (drum-type dielectric disk); 17-third passive electrode (brush type), 18-processed rhizomes, 19-spark intermediate.

An active electron with a dielectric drum 16 is installed behind the lump crusher, made in the form of a squirrel wheel, consisting of metallic rod electrodes fixed along the entire perimeter of the cylindrical drum (Fig. 4). The lump crusher 14 and the dielectric drum 16 are connected to the drive mechanism via a chain transmission. To supply current pulses to the electrodes 16, a spark gap is provided – an intermediate spark gap 19, which is mounted on an insulator and mounted on the frame of a mobile device [9, 15, 16]. The electrical Installation is mounted –ehind the MTZ-80 tractor, which is coupled with a source of high-voltage pulses (Fig. 5).



Rice. 5. General view of the tractor and mobile electrical installation
10 – terminal box, 20 – generator, 21 – cable, 22 – high-voltage transformer TV1, 23 – step-up transformer TV2, 24 – metal box for electrical equipment.

3. Results and discussions

The operation of the electrical installation is carried out as follows: after the tractor with the electrical installation enters the cultivated field, the installation is lowered to the working position by means of a hydraulic pump, then the PTO tractor is driven by a synchronous generator 20, a drive mechanism and an articulated rod conveyor - the main elevator, lump crusher 14 and a dielectric drum with rod (electrodes) 16.

After this, the tractor is set in motion, and at the same time the source of electrical pulse discharges is turned on. Soil-cutting plowshares 2 cut the soil 25 cm thick. The cut soil, and with it the weed rhizomes, are supplied to a rod conveyor - a sieve, where the rhizomes are separated from the soil and are subjected to 2-stage exposure to pulsed discharge currents [9, 14].

The first stage of electrical treatment of rhizomes occurs at the moment of contact of rhizomes with a hinged movable electrode, and the second stage occurs during the period of contact of weed rhizomes with a rotating electrode with dielectric disks 16. After which the treated rhizomes enter the second - cascade elevator above which a third - passive electrode is installed. At the moment the twice-treated rhizomes pass through the interelectrode space, the passive positive electrode 17 and the grounded metal rods of the cascade elevator, the next, third treatment is performed.

Plant objects processed three times to convert organic matter and enrich the soil are thrown out or plowed onto the ground for intensive decomposition.

Electrical equipment, in addition to processing electrodes, spark gaps 19 and flexible connecting high-voltage cables 21, is installed on the MTZ-80 tractor. A general view of the tractor and mobile electrical installation is shown in Fig. 4 and 5 [9, 14].

A synchronous generator, which serves as a source of electric current and is driven from the power take-off hall of the tractor using a chain drive, is installed on a special platform at the rear of the tractor [9, 14].

High-voltage transformer TV1 21, step-up transformer TV2 23, capacitor banks, high-voltage rectifier diodes are installed on the tractor frame in an additionally manufactured platform and in a metal box 24. Control, protection and power units are installed in the cabin of the MTZ-80 tractor above the tractor sensor panel in a special metal box; connections between power sources, control units and working parts of the electrical installation are made using high-voltage cables [9, 14].

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To prevent various mechanical damage to the insulation and for electrical safety purposes, all electrical cables are laid in special flexible metal sleeves.

The methodology for conducting production tests of a mobile device in order to study the dynamics of decomposition of weeds in the soil treated with pulsed discharge currents was as follows: in three sections of the cotton field of the Maksadbek-Mukhtorbek farm, soil with weed rhizomes of 10 m2 was dug up square, 25 cm deep.

Then the weed rhizomes were separated from the soil, and their number and weight were determined. After that, the arithmetic average of weeds per 10 m2 area was determined, equal to 23.5 kg.

Next, rhizomes of gumaya weeds were dug out from the soil and forming 23.5 kg each, and several batches of experimental roots were prepared. In order to determine the most effective shape and number of processing electrodes during electric pulse processing of a mobile device, the experimental roots were alternately subjected to electric pulse treatment with different electrodes: passive brush-shaped (electrode with steel tentacles); actively rotating electrode with dielectric disks made of metal rods; passive electrode with steel tentacles.

After electric pulse treatment $\tau = 0.5...1$ s and the capacity of storage capacitors from C = 0.470×109 F to C = 1×109 F.

All treated (experimental) and untreated (control) weed rhizomes were separately buried in the soil for further observations. The results of the work performed were recorded in a journal of chronological observations [9, 14, 16].

After 30 days, the experimental and control sections of rhizomes were dug up, cleaned of dirt and, after sorting, the quantitative and weight indicators were determined. The data obtained were recorded in a journal of chronological observations, on the basis of which Table 1 was compiled [14].

Analysis of the results table. 1 indicates that the experimental root segments after electrical treatment on a passive electrode on day 30 lost their viability in terms of quantity and weight by 37%; on actively rotating - by 49% on passive and active rotating with steel tentacles - by 75%, with three times (passive + active + passive) 100%, when the control ones during this period increased in number and weight from 100 to 114% [16].

According to the results of Table 1, rhizome samples after treatment with voltage U = 5.0...9.0 kV and $\tau = 0.4$ s. on the 30th day of recording, new shoots are produced from which new stems sprout with a height of 13 to 24 cm; samples after treatment U = 5.0...9.0 kV and $\tau = 0.6$ s. on the 30th day of recording, new shoots with stems up to 9 cm are produced; in treated samples U = 5.0...9.0 kV and $\tau = 1.0$ s. on the 30th day of registration they lose full viability.

A characteristic aspect of the study is that after electrical treatment, weeds tend to survive and remain viable. Therefore, new shoots are given from the buds into the raft until they are completely depleted, which can be observed in new yellowed shoots.

From the above it follows that to achieve the intended goal, three-time treatment of weed rhizomes with two passive and actively rotating electrodes made of metal rods is sufficient.

Conclusions

1. A mobile mobile device for the destruction of perennial rhizomatous weeds meets the requirements, i.e. during electrical treatment with U = 7 kV, $\tau = 1.0$ s and C = 1•10-9 F, plant destruction is ensured up to 100% within 30 days, which is confirmed by the results of laboratory studies.
2. Electrical treatment of rhizomes at a voltage of U = 9 kV, $\tau = 1.0$ s, C = 1•10-9 F can provide high processing efficiency, but the increase in energy intensity and cost of the process should be taken into account.
3. The research results show the complete suitability of the mobile electrical installation for the destruction of many summer rhizomatous weeds and is environmentally safe and cost-effective.

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