Development of a combined unit for chemical and electric radiation treatment of cotton plants

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Abstract. The study is devoted to a combined unit that has been developed for cotton harvesting tractors. This unit combines technologies of chemical and electric radiation treatment of cotton plants. Thus, the authors solve the task of reduction of the negative impact of pesticides on the environment during chemical treatment of plants, including defoliation of cotton, by reducing consumption rates of chemicals. The paper discusses the basic sprayer to form a combined unit selected on the basis of preliminary field tests of boom and fan sprayers with movable and fixed working bodies. The work has established that a fan sprayer with two fixed nozzles has the main positive characteristics of boom and fan sprayers in chemical treatment of cotton, taken as the basis for formation of a combined unit. The authors concluded that field trials of a combined unit have shown that chemical treatment (defoliation) with simultaneous electrical irradiation accelerates the opening of cotton bolls 1.2-1.25 times. This makes it possible to start early harvesting of cotton in risky agriculture to reduce consumption rates of pesticides.

1. Introduction

Use of chemicals to protect cotton from pests and diseases, as well as defoliation and desiccation, leads to contamination of the environment with pesticides [1]. Currently, boom and fan sprayers are mainly used [2]. Each type of the sprayer has its own positive and negative properties. The advantage of a boom sprayer is economical consumption of liquid chemicals [3]. Its sprayers are in operation in the immediate vicinity of the surface of treated plants. Therefore, drift (by wind) of drops of chemical preparations and their loss for evaporation is reduced here. However, when using a boom sprayer, it is necessary to increase the headland or fold the booms; it is less maneuverable and is not able to evenly apply liquid along the height of the bush [4]. The bottom of the leaves is especially poorly processed, where plant pests accumulate.

Fan sprayers are more maneuverable, they do not require an increased headland, and are capable of uniformly treating plants in height by tedding the bushes with air pressure. The disadvantages of fan
sprayers are as follows: drift of part of droplets by wind, high evaporation of droplets and uneven processing of the field across the working width [5].

The works of V.V. Gritsenko, Y.M. Stroykov, N.N. Tretyakov [6], I.F. Pavlov [7], S.I. Kalyuzhnii [8], S.P. Kashin [9], E.I. Khotko, T.P. Pankovich, R.V. Molchanov, S.I. Yarchakovskaya [10], T. Rutskoy are devoted to chemical treatment of plants [11]. The works of M.A. Lozatovskaya [12], S.N. Alimukhamedov [13], F.A. Gapparov [14], A.A. Akhmetov, A.I. Yuldashev [15] deal with chemical treatment of cotton plants. The methods of electric irradiation are used in fight against pests and diseases of agricultural crops. The works of A.M. Mukhamadiyev et al. [16,17], as well as the works of N.F. Kozhevnikova [18], are devoted to this problem.

Based on the experience of creating and operating different designs of sprayers, the problem is still to increase the efficiency and quality of chemical treatment of crops, including defoliation of cotton, along with the decrease in negative impact of chemicals on the environment.

The aim of this work is to increase efficiency of defoliation of cotton before machine harvesting of cotton by means of combined chemical and radiation exposure to plants.

2. Research Method

Technological and technical solutions have been proposed for development of a combined unit that combines chemical and radiation treatment of cotton plants. Efficiency of a combined unit was tested at one of the key technological operations - defoliation of cotton.

To determine a basic sprayer, field tests were carried out on boom and fan sprayers with movable and fixed nozzles. The tests were carried out under equal conditions. All three sprayers were mounted on a 100 h.p. wheeled tractor.

Fan sprayer VP-1 is shown in Figure 1. It consists of a fan, a frame, a slide unit, a hydraulic system and other assembly units. An airborne jet is formed at the exit from a slide unit, which makes periodic oscillatory movements in the horizontal plane.

![Figure 1. Fan universal sprayer VP-1](image)

Boom sprayer MS 600.12 is an additional option of the fan sprayer VP-1 shown in Figure 2.
Figure 2. Fan sprayer VP-1 with jib-stick

The fan sprayer with fixed jets [19] is shown in Figure 3. It consists of a box with two lateral, two lower inclined and rear blowing jets, which together with the nozzles form the air-droplet streams.

Figure 3. Universal Sprayer with double jet VP-1IB

The tests were carried out on defoliation of cotton at the test site of the Center for Testing Technologies and Techniques (CTTT), located in Tashkent region.

The soil of the test site is typical serozem (gray earth) with flat relief. The row spacing of cotton was 90 cm with an average furrow depth of 17.0 cm. The moisture content of the upper soil layer at a 0-10 cm horizon was 12.19% with the hardness of 0.43 MPa. Spraying was carried out at the air temperature of +33°C at the height of 2.0 m. At the time of treatment the average plant height was 93 cm with the width of 53 cm. The number of fruit branches per one plant was 17 pcs. The plants had the dense leaf cover of 46 pcs. per one plant.

3. Results and Discussions
It has been found that all three sprayers have indicators within the framework of Agrotechnical Requirements (ATT) [20].

Taking into account the advantage in maneuverability, quality of pesticide application to plants, exclusion of drift of droplets and their low volatility, the design of the VP-1IB sprayer with fixed nozzles was chosen to form a combined unit for chemical and electric radiation treatment of plants.

A combined unit consists of three independent assembly units: a tractor, a sprayer and an electric irradiator. The wiring diagram of the unit is shown in Figure 4.

The standard wheeled tractor is used without modifications.

The sprayer is a mounted machine. It consists of an enlarged assembly unit, in which the sprayer mechanisms are installed on frame 1. The frame is attached to the hinged system of the tractor, two tanks
2 are mounted by means of brackets on the tractor side members. There are three lines to the tanks: suction, delivery and discharge ones. Pump drive 3 of gearbox 4 and fan 5 are driven from the rear PTO shaft of the tractor through articulated shaft 6.

For selective processing of cotton and other crops, the sprayer is equipped with a hose. To prevent damage to cotton bushes during operation, the lower part of the frame is equipped with shields 7 and 8. The construction also includes discharge nozzle 9, container 10, left 11 and right nozzles 12, side outlets 13, 14, vortex chamber 15, rear outlet 16 and electric irradiator 17.

The electric irradiator is mounted on the tractor bolster from the front with four bolts and consists of: a special platform fixed to the tractor; power supply; control panel located in the tractor cab; installation cables; working organs (two gemicidial lights of ultraviolet radiation DB-60 with the wavelength of 254 Nm). The voltage is removed from the 12V generator, converted by a 220V power source, which powers the lamps. The angle of inclination of electric irradiators (lamps) is adjustable within the range from 0 to 45º to the horizon, depending on a cultivated crop.

The unit was tested by defoliation of cotton. Liquid magnesium chlorate with a consumption rate of 10 kg/ha was used as a defoliant. The unit at the working speed of 3.9 km/h processed cotton with a working width of 20 m.

The experiments were carried out on two backgrounds:
1 - without using electric radiation;
2 - using electric radiation.

The technical efficiency of defoliation of cotton on the sixth day of treatment was 84.09% on the first background, and 75.95% - on the second background (with electric irradiation) and on the 12th day - 92.6% and 93.1%, respectively. The percentage of the opening of green boxes on the sixth day on the first background was 40%, and on the 12th day - 50%. Against the second background (with use of electric irradiation), opening of boxes on the 6th day was 57%, and on the 12th day - 71%.

Figure 4. Wiring diagram of a combined tool for chemical and electroradiation treatment of cotton
1 – frame; 2 – tank; 3 – pump; 4 – reducing gear; 5 – fan; 6 – articulated shaft; 7,8 – shields; 9 – discharge nozzle; 10 – container; 11 – left nozzle; 12 – right nozzle; 13,14 – side outlets; 15 – vortex chamber; 16 – rear outlet; 17 – electric irradiator
4. Conclusion
As a result of the economic tests, it was established that the technology of chemical processing of cotton plants with simultaneous exposure to radiation was performed by a combined unit stably and reliably. Chemical treatment (defoliation) with simultaneous electric irradiation made it possible to increase the efficiency of defoliation in terms of leaf fall and the opening of cotton bolls 1.2-1.25 times. This allows one to start early machine harvesting of cotton in risky agriculture, to reduce consumption rates of pesticides and their negative impact on the environment.
To establish the numerical values of combinations of chemical consumption rates and degree of electrical exposure, a special research cycle is required.

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