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Комбинированная обработка сахарной свеклы в период вегетации растений

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Аннотация. Эффективная система защиты сахарной свеклы в период вегетации является одним из резервных путей повышения продуктивности свекловичных полей. Решением этой проблемы является сочетание механических и химических методов борьбы с сорняками. В настоящем исследовании представлена многофункциональная многосекционная машина, позволяющая проводить ленточную обработку гербицидами, микроудобрениями и регуляторами роста совместно с механической междурядной культивацией. Обработка гербицидами помогает избавиться от сорняков. Внекорневые подкормки гарантируют быстрое восполнение запасов макро- и микроэлементов растений. Необходим на определенных этапах роста растений, характеризующихся повышенной потребностью в питательных веществах. В неблагоприятных условиях вегетации корневая система не может получать питательные вещества из почвы; поэтому внекорневая подкормка является единственным источником питания. Механическая культивация позволяет одновременно проводить прополку, химические и внекорневые подкормки, что значительно снижает эксплуатационные расходы.

Ключевые слова: сахарная свекла, механическая и химическая обработка посевов, внекорневая подкормка, комбинированный агрегат, аппликатор, углы распыления факелов и расположение опрыскивателей.

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Combined treatment of sugar beet during the plant vegetation

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Abstract. Effective system of sugar beet protection during its vegetation is one of the back-up ways of increasing the beet fields' productive capacity. Combination of mechanical and chemical methods for weed control is the solution to this problem. Current study introduces multifunctional multiple-unit machine, which allows performing band treatment with herbicides, micro fertilizers and growth-regulating agents together with mechanical inter-row cultivation. Herbicide treatment helps to get rid of weeds. Foliar applications guarantee fast replenishment of plants with macro- and microelements. It is necessary at certain stages of plant growth, characterized by increased need in nutrients. Under adverse vegetation conditions, root system cannot obtain nutrients from soil; therefore, foliar application is the only source of supply. Mechanical cultivation allows simultaneous weeding, chemical and foliar nutrient applications, considerably reducing the operational costs.

Keywords: sugar beet, mechanical and chemical treatment of crops, foliar top dressing, combined unit, applicator, spray torch angles and the location of sprayers.

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Introduction

Weed control is one of the most significant parts of sugar beet cultivation. In order to obtain high yield of beetroots, one should introduce progressive technologies, applying multiple-unit machines for soil cultivation and combining chemical treatment to control weeds and diseases with mechanical soil cultivation [7–9]. Improper tending can result in extensive damage to sugar beet crops caused by weed vegetation. The reasons for this lie in biological properties of sugar beet that prevent the cultivated plants from resisting weeds

on their own until the row closure. In the first half of the vegetation period, sugar beet is incapable of successful competition with weeds; harvest shortfall ranges from 20 to 50% even if there are small amounts of weeds in the protective areas. Weeds compete with beet for water, nutrients and light, having 3–5 times higher consumption rates compared to beet plants [1].

Methods

The choice of the weed control technique primarily depends on the initial levels of weed infestation. In case of low infestation, mechanical soil cultivation may be sufficient, while in case of large amounts of weeds, herbicides and chemical agents for pest and disease control should be implied [2].

The system of mechanical treatment of soil in rows and inter-row spaces as part of sugar beet cultivation technology is based on comprehensive studies of biological properties of this culture, its requirements for water, air and nutrient conditions, and the necessity of regular weed elimination. Mechanical weeding by tiller cultivators is both easy and efficient, but it is virtually impossible to eradicate the weeds mechanically in the protective area [3].

It is desirable to spray sugar beet crops using special applicator devices that allow you to accurately orient the sprayers relative to the cultivated plants and weeds being treated for dosing working solutions and their local supply directly to the leaves or a strip of soil near a row of plants. This prevents the overspending of expensive herbicides and liquid fertilizers. Sprayers with tips for continuous cone spraying can be installed on the applicators.

To select the type of nozzle tip and determine the places of their installation on the applicators, laboratory studies were conducted on specially made stands according to generally accepted and private methods. The design of the stands provided for the possibility of changing the position of the sprayers relative to the treated surface both in height with orientation relative to the axis of the row of plants and the leaf surface, and in the angle of inclination, taking into account the selected tips with different angles of the spray torch and the pressure of the water supply, tinted in different colors. At the same time, sprayers for foliar top dressing of plants were oriented over the edge of the row with the possibility of changing the height of the arrangement and the angle of inclination relative to the stencil with circles of various diameters applied, simulating the area of the leaf surface of a free-standing plant at various stages of development. Sprayers for ribbon application of herbicides were oriented from two sides relative to the axis of the row with the possibility of changing the height of the location and the angle of inclination relative to the stencil with markings imitating the width of the protective zone.

During the studies, the shape was fixed and the area of the spray spot was determined at different positions of the sprayers relative to the treated surfaces.

Results

The results obtained by numerous researchers studying combinations of various techniques prove that balanced system of crop treatment is more effective than chemical methods alone, whereas the maximum effect can be achieved in case of simultaneous use of these. Therefore, an efficient system of sugar beet protection during its vegetation, which includes proper combination of mechanical and chemical weed control techniques, is one of the most reasonable ways to solve this problem. Current task can be successfully solved through the development of a new multifunctional machine or the modernization of basic models, allowing to perform band treatment with herbicides, microfertilizers and growth-regulating agents together with mechanical inter-row cultivation [4].

The technique for local foliar application of solutions of growth-regulating agents and herbicide application to spaces between plants within the protective areas of the rows is introduced to achieve the objective. Experimental device for this technique is shown in Fig. 1.

The device has been assembled using the tiller cultivator base. It consists of a frame carrying top

Figure 1. Experimental device for application of growth regulators and herbicides.
Notes: 1 — cultivator; 2 — top disperser; 3 — side dispersers

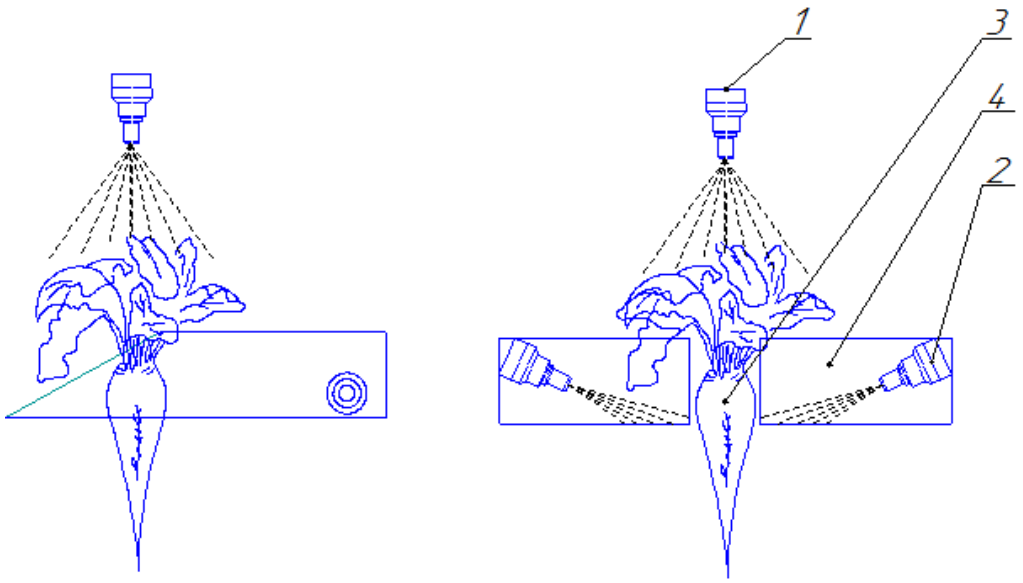

Figure 2. Outline of the device for growth regulators and herbicide application:
a) general view; b) side view. Notes: 1 — disperser for growth regulators application; 2 — disperser for herbicide application; 3 — sugar beet plant; 4 — protective shields

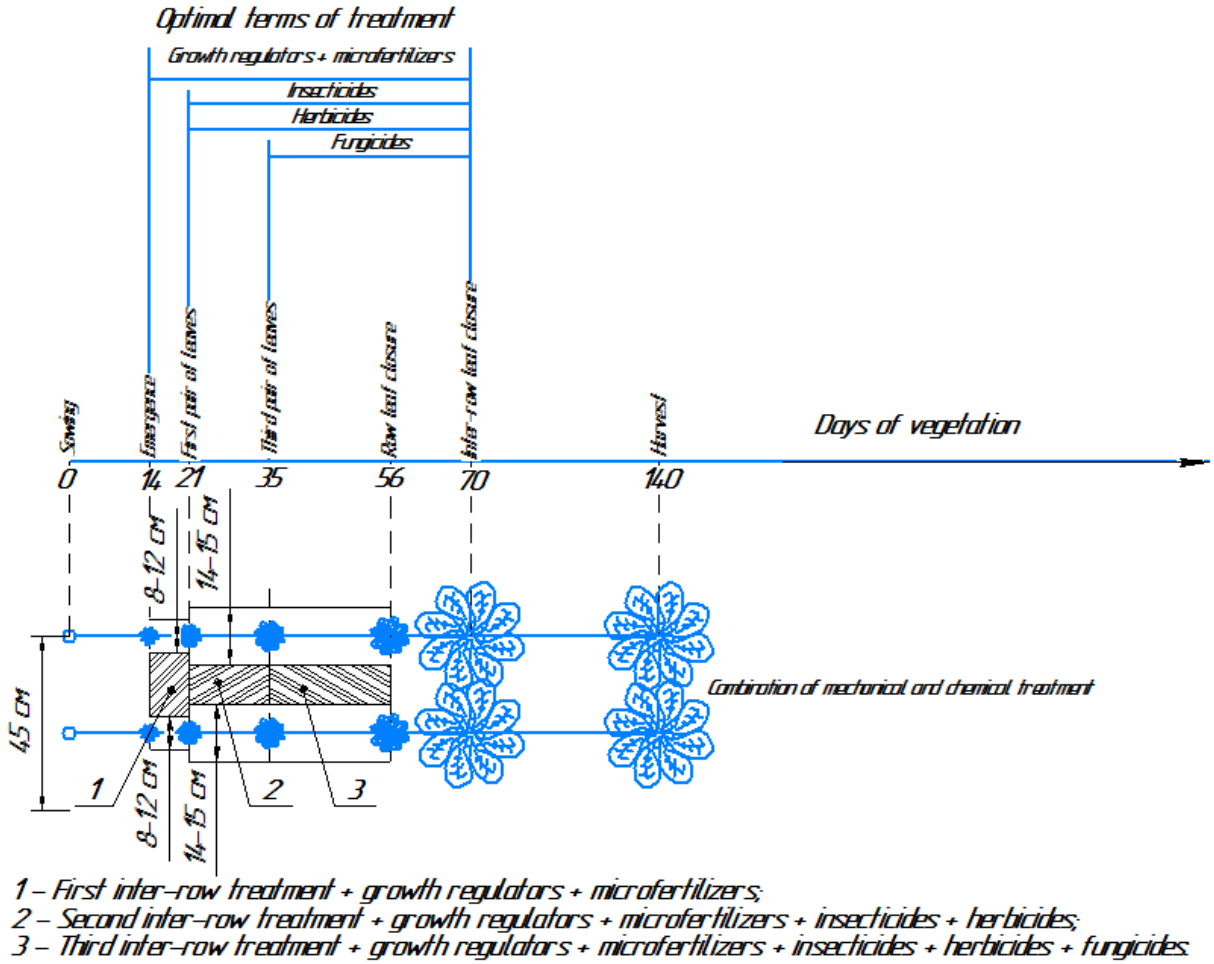

Figure 3. Scheme for the sugar beet crops treatment

disperser for application of sugar beet growth regulators and two side dispersers for herbicide application. Initial portion of complex fertilizers is applied by the tiller cultivator fitted with top disperser for fertilizer application according to the plant vegetation stage. Herbicides are applied to the stalk area on both sides of the row, conveying the toxified soil by the cultivator tooth from the half-band width towards the plant row, forming the dam of soil and herbicide mixture in the protective area of the row. This design is covered by the patent of the Russian Federation (Fig. 2) [5].

A scheme for the sugar beet crops treatment

has been designed basing on the analysis of modern technology (Fig. 3).

The initial stage of growth is crucial in terms of the sugar beet mineral nutrition [6]. The use of complex fertilizers as starter fertilizers provides balanced mineral nutrition of the plants at the beginning of vegetation and intense early growth. At the stages of the first and the second pair of leaves the first inter-row tiller cultivator treatment to the depth of 5 cm with the protective area of 5–6 cm is performed, complex fertilizers are applied to the leaf surface of the sugar beet plants. The first foliar application of nutrients is performed between the row leaf closure and the inter-row leaf closure, while the second one — in the end of July — the beginning of August. In case of drought, the third foliar application is necessary. The second inter-row tiller cultivator treatment is performed to the depth of 6–8 cm with the protective area of 10–12 cm, if necessary. Herbicides, insecticides, fungicides can be applied together with the inter-row treatments. The terms and number of treatments depend on the levels of weed infestation: 3 to 5 chemical treatments and the same amount of inter-row treatments. The first treatment is performed 10–15 days after sowing. The next ones — 10–15 days after the previous treatment. The width of protective areas should be:

- 5–6 cm in case of the first inter-row treatment;
- 10–12 cm in case of the second inter-row treatment;
- 10–12 cm in case of the third inter-row treatment.
- The leaves are of the following size:
- 5.2 cm long, 2.7 cm wide in case of the first inter-row treatment;
- 12.3 cm long, 6.8 cm wide in case of the second inter-row treatment;
- 26.6 cm long, 10.3 cm wide in case of the third inter-row treatment.

During the crop spraying, 200–250 l/ha of complex fertilizer should be applied. In case of band application, the dosage is decreased down to 40%.

Discussion

Herbicides, insecticides, fungicides can be applied simultaneously with row-to-row treatments. To achieve maximum effect with minimal exposure to herbicides on cultivated plants, it is desirable to exclude the ingress of their solutions on the leaf surface. At the same time, in the aisles to save chemicals, it is advisable to carry out processing with cultivator paws (see Fig. 1).

$$S_1 = \frac{\pi \cdot R^2}{2} \cdot \frac{\sin^2 \frac{\alpha}{2}}{\cos\frac{\alpha}{2} \cdot \sin\left(\beta + \frac{\alpha}{2}\right)}; \quad (1)$$

$$S_2 = \frac{\pi \cdot R^2}{2} \cdot \frac{\sin^2 \frac{\alpha}{2}}{\cos\frac{\alpha}{2} \cdot \sin\left(\beta - \frac{\alpha}{2}\right)}. \quad (2)$$

In general, the total area of spraying when treated with a spray gun with a round spray shape is determined by the expression:

$$S = \frac{\pi \cdot R^2}{2} \cdot \frac{\sin^2 \frac{\alpha}{2}}{\cos\frac{\alpha}{2}} \cdot \left[\frac{1}{\sin\left(\beta + \frac{\alpha}{2}\right)} + \frac{1}{\sin\left(\beta - \frac{\alpha}{2}\right)} \right], \quad (3)$$

where S - is the total area of soil surface treatment with one sprayer, cm^2;

H - is the height of the sprayer installation relative to the soil surface, cm;

α - is the angle of the spray torch, degrees;

β - is the angle of inclination of the axis of the spray torch relative to the horizontal surface of the soil, degrees.

Based on the analysis of the dependence of the length of the larger axis of the spraying spot ellipse at fixed angles of inclination of the spray torch axis relative to the horizontal soil surface, the following can be concluded. The length of the larger axis of the ellipse of the spraying spot increases in direct proportion with an increase in the angle of the spray torch and the height of the sprayers with a decrease in the angle of inclination relative to the horizontal surface of the soil.

At the same time, it varies from 1200 mm in the case of using a sprayer with a 600 spray torch installed at a height.

In the process of plant development, depending on the phenophase, the sizes of individual leaves and the height of their location above the soil surface, the area and diameter of the leaf surface of a free-standing plant change. Depending on the type and timing of treatment, the installation and location of the sprayers on the applicator should change.

Conclusion

Band treatment of sugar beet with chemical agents is an effective method of weed control. This technique has several advantages over the overall spraying. First, the costs of chemical treatment decrease, as the agents are applied together with the inter-row mechanical treatment, rather than separately, therefore, two working operations are performed in one pass. The width of the herbicide-treated band in case of band herbicide application to the sugar beet crops with inter-row spaces 45 cm wide was calculated to be 10–12 cm. The area of the agent application in this case is only 30–35% of total inter-row area; therefore, the amount of the spray material spent is 2–2.5 times lower, compared to the overall spraying. Operational costs are improved due to decreased expenditure of the agent, water transportation, spray material preparation, and time required for filing the machines with the spray material. Considerable increase in sugar beet production at the farms of the Central Region of Russia has been accomplished by virtue of well-timed inter-row tiller cultivator treatment of soil, complex fertilizers application, effective weed and pest control [6].

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