Application of a Growth Regulator Based on 24-Epibrassinolide in Sugar Beet Cultivation Technology

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Abstract. To suppress weeds in the crops of sugar beets, 2 to 5 treatments with herbicides are carried out, which worsens the quality of the resulting plant products and increases the risk of the formation of populations of weeds resistant to herbicides. To reduce the application rate of the herbicide in sugar beet crops, growth regulators based on the active ingredient – 24-epibrassinolide were used, which increases the culture's resistance to unfavorable environmental factors. It has been experimentally shown that the use of a growth regulator in a tank mixture with a 23% lower rate of herbicide application in the growth phase of a BBCH H 12–14 crop increased the herbicidal effect and promoted active growth of the crop. This technique had a positive effect on the quantity and quality of the sugar beet root crop. A statistically significant effect is shown from the use of 24-epibrassinolide in a tank mixture with a fungicide, as a result of which an increase in the adaptive potential of a cultivated plant against fungal diseases (the causative agent of micromycetes Cercospora beticola, Phoma betae) was observed.

1. Introduction

Growth in sugar beet production (Beta vulgaris L., v. saccharifera) and meeting the needs of the population in raw materials for the production of sugar and plant products (pulp, molasses, defecate, etc.), are associated with the improvement of agricultural technology for the cultivation of this crop. At present, the yield of sugar beet in the country averages 42–45 t/ha, in the beet regions of Europe (Switzerland, the Netherlands, Germany, etc.) it is 10–15 t/ha. Sugar beets have high demands on moisture during the initial phases of growth and on light during the entire growing season. To obtain a guaranteed yield of this crop, it is important to control competing weeds. In modern agriculture, agricultural technology and chemical means of protection are actively used, which makes it possible to reduce the number of inter-row cultivation and reduce crop losses by 20–50% [1–4]. But there is a problem associated with the active growth of weeds (white goosefoot, knot-grass, black bindweed, cleavers and etc.), which develop phase resistance to herbicides, which will require the use of higher application rates. The use of multicomponent tank mixtures (three or more active substances), in order to reduce the herbicide load, does not solve this problem [5]. A method of using tank mixtures of herbicides with growth regulators is proposed. As a result, the effectiveness of herbicides in tank mixtures increases due to their greater intake into the weed plant and inhibition of the transformation
(decomposition) of active substances. In cultivated plants, the rate of destruction of herbicides increases, which helps to reduce herbicidal stress [6, 7]. Among the growth regulators, 24-epibrassinolide (EPB) is distinguished, a polyhydroxylated steroid compound that is necessary in the regulation of physiological processes in a plant. Its use increases the effectiveness of the herbicides against weeds and quality indicators of productivity – fruits and root crops [1, 2, 8–10]. Sugar beet is an economically significant crop for agriculture, but there is not enough data on large-scale field studies on the use of tank mixtures of herbicides and growth regulators.

Therefore, the aim of the study is to evaluate the effectiveness of the use of a growth regulator based on 24-epibrassinolide in a tank mixture with chemical plant protection agents (herbicide) in the technology of sugar beet cultivation.

2. Materials and methods
The effectiveness of the action of the plant growth regulator based on 24-epibrassinolide was studied in the period 2017–2018, in the conditions of the Lipetsk region. The experiments were carried out on fields equal to 10 hectares. Sowing rate of Freya sugar beet – 1.35 sowing units per 1 ha or 135 thousand pieces / ha. The area of the record plot is 2.5 ha. Repetition – fourfold.

Soil – black soil, leached, medium-thick, medium-loamy (humus content 3.5-4.0 %. pH – 5.5–6.0, availability of nutrients is normal).

The climate is moderately continental with warm summers and cold stable winters: the average annual air temperature is 4.7–5.6 °C. The duration of the period with a positive average daily temperature is 222–231 days. The sum of the average daily temperatures above + 10 °C ranges from 2325 to 2535 °C, the average annual amount of atmospheric precipitation is from 531 to 587 mm (on average 450 mm). The hydrothermal coefficient is 0.9–1.0 (with an average long-term HTC = 1.1–1.2). Humidification is sufficient, the moisture regime is ustic. Compared with the average annual data, the weather conditions in 2017–2018 were characterized by heavy rains in June and high temperatures in August.

The sugar beet crop protection system included:
– against a wide range of weeds multicomponent herbicide based on three active ingredients etofumezate + phenmedipham + desmedipham (112 + 91 + 71 g / l) at a dose of 1.1–1.3 l / ha;
– against infectious diseases - fungicidal preparations in a tank mixture based on copper oxychloride at a dose of 2 kg / ha, flutriafol - at a dose of 0.15 l / ha, boric acid - at a dose of 0.2 kg / ha);
– growth regulator based on the active ingredient 24-epibrassinolide (EBL) at a dose of 0.05 and 0.1 l / ha.

In the experiment, the first treatment with pesticides (herbicide) was carried out in the first decade of May 2017–2018, the second treatment with pesticides (fungicide) after 18–20 days. The growth regulator was used in a tank mix with a 23% lower rate of herbicide consumption in phase 2 of true leaves of the culture (BBCH 12–14) and in a tank mix with a recommended rate of fungicide consumption in the early phase of weed growth (2–4 leaves). The test scheme included the following options (taking into account the accepted abbreviations): MG1 - herbicide at a dose of 1.01 / ha; MG2 - herbicide at a recommended dose of 1.3 l / ha; MG 1+GR 1 – herbicide + growth regulator at a dose (1.0 + 0.05 l / ha); MG 1+GR 2 – herbicide + growth regulator at a dose (1.0 + 0.1 l / ha).

The harvesting of sugar beet root crops was carried out at the onset of biological ripeness in the first decade of September 2017–2018. The methods adopted in agrochemistry were used to determine the quality of the crop – sugar content and sugar yield.

Mathematical processing of the data based on the research results was carried out by the method of analysis of variance at a 95% probability level (Pα) using the software capabilities of MS Excel.

3. Research results
In the crops of sugar beet, the tested multicomponent herbicide in the recommended dose was characterized by a high efficiency equal to 58 ± 14%. against annual dicotyledonous weeds (including pigweed - *Amaranthus L.*) – 69±15% and some cereal weeds (barnyard-grass – *Echinochloa crus-galli,* 1999).
green foxtail – *Setaria* Beauv., common windgrass – *Apera spica-venti* (L.) Pal. Beauv.). Consideration of weediness in the experiment, carried out 30 days after treatment, showed that the tank mixture of the herbicide with EBL actively affected the perennial weeds, especially at the rate of growth regulator consumption of 0.1 l / ha. (figure 1). On variants MG 1 + GR 1 and MG 1 + GR 2, the number of perennial weeds was 4 times lower in comparison with variants MG1, MG2. The number of annual weeds was also 25% lower. The efficiency of the MG 1 + GR 1 tank mixture was lower than that of the MG 1 + GR 2 variant, due to the rapid regrowth (and insufficient death) of the rough knotweed (*Polygonum scarbrum* Moench.). EBL, included in the tank mix of a multicomponent herbicide, had a stimulating effect on the development of beets. When the herbicide and growth regulator were applied, the formation of a second pair of leaves was observed, while the plants of the herbicidal variant (without EBL) had only one pair of true leaves. In the future, the growth of leaf apparatus when using the mixture was faster than that of plants treated with herbicide alone. As a result, it can be said that the inclusion of a growth regulator in the working solution of the herbicide with a 23% lower rate of herbicide consumption increased the herbicidal effect and reduced weed infestation by 38–40%, compared to spraying with herbicide at the recommended rate (1.3 l / ha). Additionally, the application of the growth regulator alone was evaluated 4 days after herbicidal treatment. This technique did not give a practical result, the level of weed infestation did not change.

**Figure 1.** The effect of introducing the growth regulator EBL in a tank mixture with a multicomponent herbicide on sugar beet crops (legend in the text).

The direct result of reducing the infestation of sugar beet crops is the competitiveness of the crop compared to weeds. Another effect was noted - an increase in the resistance of the culture to infectious diseases. For example, in the variant with the use of EBL in a tank mixture with a fungicide, the prevalence of the disease (P) cercospora in beet (the causative agent *Cercospora beticola*) decreased from 42 ± 6% to 22 ± 2%, and its development (R) from 3.7 ± 0.6% to 1.5 ± 0.5% (figure 2).
Figure 2. Sugar beet sensitivity to pathogens: Cercospora leaf spot Cercospora beticola, phytopathogenic fungus Phoma betae, virus Sombane mosaic virus: R – disease progression, P – spread of disease.

There was a positive result of reducing the incidence of phomosis (the causative agent Phoma betae): on variant MG 2, the number of diseased plants was on average 15 ± 0.7% and the degree of development was 1.4 ± 0.3%, compared to options MG 1+GR 1 and MG 1+GR 2, where the spread of the disease did not exceed 10% and the progress of the disease up to 0.7%. In the case of a viral mosaic of plants (the causative agent is the Sombane mosaic virus), the differences are not significant, since in all variants of the experiment, the presence of a mosaic was noted in single plants. The obtained result coincides with the data of other authors, which indicate the ability of phytohormones to increase the adaptive potential of plants to fungal diseases – root rot, etc. [8, 9].

We emphasize that the greatest inhibition of fungal diseases was observed with a two-fold application of the growth regulator, i.e. mixed with herbicide, and mixed with fungicide. We believe that the use of EBL in the early stages of sugar beet development in a tank mixture with a multicomponent herbicide can be considered as a preventive treatment to reduce the incidence of a crop as a result of increasing its adaptive potential.

Improvement of the phytosanitary situation in the agrocenosis of sugar beet when using EBL in a mixture with pesticides had a positive effect on the crop yield (table 1). The saved yield on variants MG 1 + GR 1 and MG 1 + GR 2 was 7–21% (or 3.7–14.7 t / ha). The improvement of the quality of root crops was also determined. The use of EBL in the crops of sugar beet influenced the increase in sugar content equal to 5.9-25.0% (with the sugar content on the variant MG 2 = 14–16%).

Table 1. Sugar beet yield and the quality of the root crop.

| Experiment option | Yield, t / ha | Saved yield, % | Sugar content, % | Sugar yield, t / ha |
|-------------------|--------------|----------------|-----------------|-------------------|
| MG 2              | 51.0–71.4    | –              | 14.8–15.7       | 8.0–10.5          |
| MG 1+GR 1         | 58.1–74.0    | 7.2–19.5       | 15.1–16.5       | 9.5–11.2          |
| MG 1+GR 2         | 58.5–74.5    | 8.4–20.6       | 15.2–17.1       | 10.1–11.3         |
The sugar yield index increased on variants MG 1 + GR 1 and MG 1 + GR 2 and was equal to 6-12% (or 9.5–11.3 t / ha). An increase in the content of sugars in root crops is associated with an increase in the growth processes of beets and the intensity of the process of photosynthesis. The cost of an increase in yield, taking into account the sugar content of root crops, exceeded the cost of using EBL and makes it possible to increase the profitability of sugar beet production.

4. Conclusion
In our studies, it was found that the infection of plants with fungal diseases was statistically significantly lower in the variants with the use of the growth regulator, in comparison with the treatment with the herbicide alone. The growth regulator of EBL, when combined with plant protection products, increased the herbicidal activity of the preparations, activated the growth processes of sugar beet and increased the adaptive potential to infectious (fungal) diseases. The cumulative effect of the use of EPB in the tank mixture, with a 23% lower rate of herbicide consumption in the BBCH 12-14 culture phase and in the tank mix with the recommended rate of fungicide consumption in the early phase of weed growth (2–4 leaves), provided a stable level of preserved sugar beet yield up to 20% in different years of use.

The use of a tank mixture of a multicomponent herbicide with a 23% lower consumption rate (1.0 l / ha) with EBL (0.1 l / ha) controlled the number of dicotyledonous and cereal weeds. The death of perennial species was higher when treated with the herbicide at the recommended dose of 1.3 l / ha (without the use of EBL).

The combined use of the herbicide with the growth regulator EBL is undoubtedly effective. Firstly, the economic factor is a reduction in processing costs and the cost of a hectare rate of herbicide; secondly, the biological factor is the control of harmful weeds (white goosefoot – Chenopodium album L., cleavers – Galium aparine L., cereal species – Gramineae (Poaceae) Juss.) in critical periods of cultural growth; thirdly, the economic factor is the growth rate of culture and an increase in its adaptive potential.

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