**OPTIMIZATION OF THE OF SUNFLOWER CROPS STRUCTURE IN TECHNOLOGIES WITH RETARDANTS APPLICATION**


**Summary.** The results of experimental studies to determine the actual changes in stem height, plant productivity and sunflower yield depending on the plant density and different variants of retardant application are presented in the article. The research was carried out in a model field experiment with a density gradient from 19.84 to 160.0 thousand plant / ha. The aim of the research was to determine the optimal parameters of the crop structure of new sunflower Choral hybrid in the technology with retardant application. It has been established that the optimal variant for ensuring the technological parameters of the plant height of the Choral hybrid in the northeastern Forest-Steppe of Ukraine was the complex application of Moddus retardant according to the scheme “seed treatment + plant treatment in the phase of 8-10 leaves”. To maintain the basic level of yield, it is proposed to increase the calculated indicators of the final (pre-harvest) crop density from 56.5 to 73.1 thousand plants / ha.

**Annotation.** In the article, the results of experimental studies of the effect of retardants on plant height and sunflower productivity are presented. The studies were conducted in a model field experiment with a density gradient from 19.84 to 160.0 thousand plant / ha. The aim of the research was to determine the optimal parameters of the crop structure of the new sunflower Choral hybrid in the technology with retardant application. It has been established that the optimal variant for ensuring the technological parameters of the plant height of the Choral hybrid in the northeastern Forest-Steppe of Ukraine was the complex application of Moddus retardant according to the scheme “seed treatment + plant treatment in the phase of 8-10 leaves”. To maintain the basic level of yield, it is proposed to increase the calculated indicators of the final (pre-harvest) crop density from 56.5 to 73.1 thousand plants / ha.

**Key words:** sunflower, retardants, crop yield, yield structure, optimal crop density.

Sunflower is the main oil crop in Ukraine. The wide range of parameter variability of vegetative development of sunflower plants needs to optimize the basic technological parameters of crop when changing the hybrids assortment, growing conditions and the ways of cultivation technology. Recently, the use of retardants has become widespread in sunflower growing technologies in Ukraine. The precondition for this process was the increase of crop area in the northern Forest-Steppe and Polissya, where the level of moisture supply is not the main limiting factor. This process is complemented as well by the focus of farmers on high-yielding, tall hybrids with a growing season of more than 110 days. Under these conditions, the use of retardants makes it possible to preserve the technological parameters of plants, which in turn reduces the probability of lodging crops and provides the possibility of their pre-harvest desiccation by sprayers with a clearance of 1700-1800 mm (without using aircraft).

The study results of retardants application on different crops indicate that with a unified mechanism of action, which is provided by inhibition of gibberellins, there is a difference in species and even varietal reactions of plants. The difference in reaction is determined by the complex of anatomical and physiological features of plants. First of all, it is the difference in the number of vascular-fibrous bundles, the ratio of xylem and phloem elements, the dynamics of stem growth in different phases of the growing season, etc. An important point in the retardants application is the level of their influence on plant productivity, since in many cases the change in habitus is complex process, covering the entire plant, including reproductive organs. The problem of retardant control of sunflower crop height was studied, mainly in the direction of yield index optimization, content and chemical composition of oil, features of dry matter formation and biological yield. [1,2,3]. However, in detailed article, presented the results of chlormequat chloride application in oil sunflower, researchers inform that none of the retardants is ideal for controlling the stem height in this crop nowadays. [4]. This conclusion of the is based on the results indicated the technologically significant reduction in plant height (45 cm or more) is possible only with two treatments of vegetative plants. The second treatment can cause the decrease in yield level by 17-20%. Thus, the task of...
The retardant application on sunflower remains relevant and poorly studied. The issues of expediency of adjusting the main technological parameters, in particular the optimization of the estimated density of crop plants due to changes in the vertical layers structure, remains insufficiently covered in the scientific literature.

**The aim** of the research was to determine the actual level of plant stem reduction and to establish the advantages of parameters optimizing of crop density of the Choral hybrid in technologies with different schemes of retardant application.

**Materials and methods.** The research was carried out within the program of developing the model of sunflower variety for the conditions of the north-eastern Forest-Steppe and Polissya of Ukraine, (state registration number 0116U001506), which was done in 2016-2020 at the Institute of Agriculture of Northeast of Ukraine and Sumy National Agrarian University. The study was carried out in a field experiment with a wedge-shaped arrangement of rows (Fig. 1).

![Figure 1. Field experiment with a wedge-shaped arrangement of sunflower rows, hybrid Choral, (photo in budding phase, June 2020)](image)

The nutrition area of plants in the experiment was close to usual (rectangular), was provided by a stepwise increase in the distance between rows and plants in a row. The minimum distance between rows (and plants in a row) was 0.25 m, the maximum - 0.71 m. The total length of the row was 22.6 m. This scheme provided the formation of gradient: from 0.06 to 0.50 m² by plant nutrition area and from 19.84 to 160.0 thousand plants / ha by estimated crop density. As a factor of variability on the density gradient, variants with different treatment regimens with the Moddus growth regulator (trinexapac-ethyl, 250 g / l) were studied, namely:

- 0 - without treatment (control);
- 1 - seed treatment (Moddus 5ml / 1 kg of seeds);
- 2 - treatment of vegetative plants in the phase of 8-10 leaves (Moddus 1.0 l / ha);
- 3 - complex treatment (seed treatment + treatment of vegetative plants in the phase of 8-10 leaves).

Estimated parameters of the working mixture consumption: for seed treatment - 75 ml / 1 kg, for the treatment of vegetative plants - 250 l / ha.

Choral is a sunflower hybrid created at the Institute of Agriculture of Northeast of Ukraine and send for State variety testing in 2021. Basic characteristics of the hybrid according to the results of the competitive variety testing: yield - 4.25 t / ha; weight of 1000 seeds - 62.5 g; husk - 21.8%; the oil seed content - 49.3%.

The results were processed using the Statistica 6.0 package [5]. Commentary and generalization of the material are presented taking into account the specifics of biological objects [6].

**Results and discussion.** In general, the obtained data largely explain the current contradictions in the results of studies on the influence of retardants on the growth dynamics and yield of both sunflower and other crops with a low level of self-regulation of the crop structure [7, 8, 9]. In general, in the field experiment with a wedge-shaped arrangement of rows, specific dynamics of plant height change depending on the retardant application was observed. (Fig. 2).
The plant height on the gradient (in the direction of density increasing) changed from 171.8 to 209.3 (+21.8%) in the control, from 154.3 to 207.8 (+34.7%) in the variant with seed treatment, from 147.8 to 166.5 (+12.7%) in the treatment of vegetative plants and from 142.6 to 159.8 cm (+12.1%) with the complex treatment. The effect of different treatment options varied depending on the plant density. The greatest effect of stem reduction was observed in areas with maximum density (160 thousand units / ha). Statistically significant reduction of the stem compared to the control (209.3 cm) was observed in the 8-10 leaves phase - 42.8 cm and -49.5 cm with complex treatment (20.45 and 23.65%, respectively). The difference in plant height in the control and the seed treatment variant (207.8 cm) was statistically insignificant.

Another dependence was observed in areas with a minimum density of 19.84 thousand / ha. Statistically significant reduction in plant height -17.5 cm or 9.8% was fixed in areas with seed treatment, with the treatment of vegetative plants -24.0 cm or 13.6%, and in the variant with complex treatment -29.2 cm or 16.6%. In general, with increasing plant density and competition level, there was a tendency for reduction of retardant effect in the variant with seed treatment, and the increase of influence in variant with the treatment of vegetative plants in the phase of 8-10 leaves as well as complex treatment.

Under the experiment conditions, statistically significant reduction in plant height in the variant with seed treatment was observed only in areas with minimal competition (estimated density was less than 27 thousand plants / ha), i.e. in the absence of the effect of "pulling for light". In other cases, when conditions were close to the density of commercial crops and more, the difference in the length of the lower internodes, which took place in the juvenile phases of ontogenesis was leveled due to the development of the middle and upper internodes. The intensity of this process was determined by the level of intraspecific competition.

Thus, the actual level of reduction in plant height was determined by the ways of retardant application and the estimated crop density.

Regarding the aim of the research, namely the optimization of the technology of hybrid Choral growing, variants with plant treatment in the phase of 8-10 leaves or complex treatment can be considered.

The next step of the study was to assess the dynamics of the structure of plant productivity depending on the retardant application. Parameters of seed weight per plant (g / plant), the number of seeds in the head (pcs / plant), the weight of 1000 seeds (g), were determined and their average values on the density gradient were calculated. (Table 1).

Table 1

<table>
<thead>
<tr>
<th>Variants</th>
<th>Estimated crop density, th/ha</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>No treatment (control)</td>
<td>164.0</td>
<td>24.0</td>
</tr>
<tr>
<td></td>
<td>101.6</td>
<td>16.1</td>
</tr>
<tr>
<td>Seed treatment</td>
<td>101.6</td>
<td>16.1</td>
</tr>
</tbody>
</table>

The figure shows the change in dynamics of sunflower height depending on retardant application and estimated crop density (2018-2020).
Under normal conditions (control), the difference in plant productivity between the extreme plants varied from 164.0 g in the absence of competition to 24.2 g / plant in areas with a density of 160 thousand / ha. The average productivity of one plant within the gradient was 101.8 g. In the variants with retardant application, there was a decrease in the average plant productivity to 95.72 g, 83.3 and 70.6 g for the variants "seed treatment", "treatment of vegetative plants" and "complex treatment", respectively. Changes in the gradient occurred due to decrease in the number of seeds in the head. Thus, plants with a minimum crop density formed an average of 1739.5 pcs / plant, and the range of values on the gradient varied from 2421.2 to 571.4 pcs / plant. In order of decreasing the average number of seeds, variants with the retardant application were ranked: treatment of vegetative plants - 1313.3; seed treatment - 1133.1 and complex treatment - 1063.3 pcs / plant.

At the same time, the order of variant ranking was retained both under conditions of minimum and maximum planting density. The dynamics of changes in the mass of 1000 seeds was more complex. Only one of the variant (the complex treatment) had value of the average (56.2 g) close to control. In the variants with seed treatment and treatment of vegetative plants, the average values were higher and were 79.2 and 60.4 g, respectively.

The final stage of the study was to determine the optimal parameters of plant density, which ensure the formation of maximum crop yields. (Table 2). The highest yield of 4.93 t / ha was formed in control with a density of 56.7 thousand plants / ha. The average productivity of plants in this segment of the gradient was 87.1 g, (or 53.1% of the maximum level) under conditions of minimum density. For parameters of seed number and weight of 1000 seeds, their values were 67.8 and 58.8%, respectively. The same density range (56.7 thousand hectares) provided the maximum level of yield on the variant with the treatment of vegetative plants. The lower, compared to the control, plant productivity parameters, namely 74.7 versus 87.1 g of the controls, resulted in a statistically lower yield level of 4.23 t / ha or - 0.7 t / ha. The estimated level of yield in the variants with seed treatment and complex treatment was close to the control variants 5.08 and 4.83 t / ha, respectively.

Table 2

<table>
<thead>
<tr>
<th>Parameters</th>
<th>No treatment (control)</th>
<th>Seed treatment</th>
<th>Phase of 8-10 leaves</th>
<th>Complex treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum yield, t / ha</td>
<td>4.93</td>
<td>5.08</td>
<td>4.23</td>
<td>4.83</td>
</tr>
<tr>
<td>Optimal density, thousand plants / ha. *</td>
<td>56.69</td>
<td>62.51</td>
<td>56.69</td>
<td>73.05</td>
</tr>
<tr>
<td>Productivity, g / plant</td>
<td>87.10</td>
<td>81.3</td>
<td>74.7</td>
<td>66.1</td>
</tr>
<tr>
<td>Number of seeds, pcs / plant</td>
<td>1641.5</td>
<td>1001.9</td>
<td>1427.4</td>
<td>1391.9</td>
</tr>
<tr>
<td>Weight of 1000 seeds, g</td>
<td>53.0</td>
<td>81.08</td>
<td>52.35</td>
<td>47.5</td>
</tr>
</tbody>
</table>

* - density, provided maximum yield
However, the implementation of these parameters took place in areas with higher density, namely 62.51 and 73.05 thousand / ha.

Analysis of the dynamics of plant productivity and the yield of the Choral hybrid indicates the advisability of adjusting the technological parameters of crop, namely, the parameters of the final density, depending on the variants for retardant application. Achieving the stability of the hybrid yield in variants with seed treatment and complex treatment should be ensured by an increase in the estimated density of crop up to 62.1% and 73.1 thousand plants / ha.

Conclusions. According to the results of experimental researches it was established that the optimal variant of providing technological parameters of plant height of sunflower Choral hybrid in the conditions of north-eastern Forest-steppe of Ukraine was complex application of Moddus retardant according to the scheme "seed treatment + plant treatment in phase 8-10 leaves". Maintaining the basic level of yield implies the change in the calculated indicators of the final (pre-harvest) sowing density from 56.5 to 73.1 thousand plants / ha.

References
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