Using growth regulators in production of peas

D V Vinogradov, M V Evsenina

Technological Department, Ryazan State Agrotechnological University named after P.A. Kostychev, 1, Kostychev Str., Ryazan, 390044, Russia

E-mail: marina.vlady@mail.ru

Abstract. Intensive agriculture poses new challenges for science and practice that go far beyond increasing the gross yield. They include the prevention of lodging of cereals when high agricultural background, the synchronization of fruit ripening, which is necessary for their machine harvesting, an increase in the proportion of early harvesting with its unchanged value. The competent use of plant growth regulators will allow solving such problems. In most cases, they are not used to increase the yield of dry matter per unit area. This task is successfully solved by such traditional means as fertilizers. Physiologically active compounds are widely used in vegetable and berry crops, in crops of grain and legumes. These crops, due to their biological characteristics, require management of growth and development during the period of crop formation, especially in conditions of the Non-Black Earth Zone. All common pea varieties are characterized by uneven ripening, cracking of beans, being close to the soil and significant lodging of stems. All these things force researchers to search for physiologically active compounds that can shorten the stem, activate photosynthetic activity, accelerate maturation, facilitate harvesting and increase productivity. Undoubtedly, as the understanding of the mechanisms of hormonal regulation of plant growth and development is expanded and deepened, more and more possibilities will appear for managing these processes to increase productivity or reduce labor costs.

1. Introduction

One of the most important problems in the global agriculture is to increase the production of vegetable protein. Great importance is attributed to the further development of the production of leguminous crops, being one of the important sources of replenishment of vegetable protein resources [1]. Based on the study of world experience and the experience of the best Russian farms, one can confidently say that an integrated approach is needed to solve the problem of vegetable protein. This is where all the levers to increase protein production should be used. It is practically impossible to solve this problem only by increasing the short-time yield. The decisive factor in further increasing the gross yield of legumes is their intensive cultivation [2–4].

The leading grain legume in the country is peas, which occupy about 80 % of the area under vegetables. It is cultivated almost everywhere in the country. Modern pea varieties have a fairly high potential for seed productivity [5, 6].

The national economic significance of peas as a crop is enormous. The seeds and herbage are rich in protein, containing all the essential amino acids. The protein content in seeds, on an absolutely dry matter, is 24-30 %. Peas provide a high-value food grain. They are used fresh and canned [7]. They are used for the production of green and concentrated fodder, silage, hay and haylage. Pea straw is richer
in protein than grain straw. Its content in 1 kg is 0.3 f. units. and 31 grams of digestible protein. The herbage of peas in the flowering phase contains up to 3-3.5 % protein [8]. Green peas contain 25-30 % sugar, many vitamins (A, B<sub>1</sub>, B<sub>2</sub> and C) and mineral salts. At the same time, the cultivation of peas is not only a factor in increasing grain production, but also a method for increasing soil fertility by enriching it with nitrogen as a result of its biological fixation. This process is of particular importance as it gives the possibility of reducing energy costs for the cultivation of grain and row crops after peas by reducing the application of energy-intensive nitrogen fertilizers [9, 10].

A prerequisite for the cultivation of peas using intensive technology is a high culture of agriculture, timely and high-quality performance of all technological operations, strict adherence to the norms and terms of the use of chemical protection means, rational use of available fertilizers. These determined the purpose and direction of the research.

2. Materials and methods

The purpose of the study was to actualize the capabilities inherent in leguminous plants with the help of growth regulators.

The objective of the research was to identify the effect of two groups of physiologically active compounds: heteroauxin (analogue of auxin) and camposan (ethylene product) used to soak seeds, on the growth and development, productivity of peas when cultivated for seeds.

A field experiment was laid on the topic of research. Soils on the experimental site were gray forest, heavy loamy with an average level of fertility: humus content was 2.4-3.0 %, mobile forms of phosphorus were 18.1 mg/100 g, potassium was 14 mg/100 g of soil and pH was 5.3-5.6.

For sowing, Astronaut pea variety and Rocket pea variety were used. Seed material after checking corresponded to the following quality indicators: the content of seeds of the main crop (purity) - 99 %, weeds - 0 and germination rate 96 %, which corresponded to the index of seeds of the 1st class.

Soaking the seeds in solutions (control was soaked in water) lasted for 24 hours, in five variants. The replication was fourfold, the arrangement of plots was in one tier.

Sowing was carried out manually on May 15. The seeding rate was 1.8 mln. viable seeds per hectare in pure sowing. Agrotechnics was common. Seedlings were harrowed across the sowing. Fertilizers were applied for cultivation in the following norm: N<sub>30</sub>P<sub>40</sub>K<sub>72</sub> kg rate of appl. per 1 ha.

The experimental design by options was as follows:
1. Water (control)
2. Heteroauxin 0.001 %
3. Heteroauxin 0.005 %
4. Camposan 0.001 %
5. Camposan 0.005 %

Mathematical processing of the data was carried out according to B.A. Dospekhov.

3. Results

Analyzing the field experiment carried out, it should be noted that peas to a large extent respond to the treatment of physiologically active compounds: heteroauxin and camposan, used in the experiment for soaking pea seeds. It was noted that soaking pea seeds in heteroauxin promoted more harmonious seed germination. Seeds soaked in a solution of 0.001 % concentration gave the greatest effect. Germination exceeded the control by 35.6 %. At a concentration of 0.005 %, the field was at the control level. An overestimated concentration of heteroauxin 0.005 %, even gave a negative result.

Soaking the seeds in a camposan solution according to the variants of the experiment did not have any significant effect on the field germination of peas. The effect when the seeds were soaked with camposan at a concentration of 0.001 % was smaller and the concentration of a solution of 0.005 % increased germination by 9.1 % (Table 1).

The experiment was supposed to reveal the effect of physiologically active compounds on the growth and development of peas. But in conditions of high humidity, the plants in all the variants of the experiment turned out to be tall in the year of the experiment. Astronaut variety was especially
different, while the action of camposan was clearly traced in both variants, but the concentration of a 0.005 % solution turned out to be the most effective. Camposan at a concentration of 0.005 % reduced the growth of peas by 10.7 % compared to the control.

### Table 1. Field germination of peas Astronaut

| Variant                          | Seeded on S=0.25 m², pcs. | Came up, pcs. | Germination rate, % |
|----------------------------------|---------------------------|---------------|---------------------|
| Water (control)                  | 45                        | 31.0          | 68.8                |
| Heteroauxin 0.001 %              | 45                        | 41.4          | 91.1                |
| Heteroauxin 0.005 %              | 45                        | 32.1          | 71.1                |
| Camposan 0.001 %                 | 45                        | 31.8          | 70.7                |
| Camposan 0.005 %                 | 45                        | 35.3          | 77.8                |

Rocket peas by the ripening period were 1.5 times lower than Astronaut ones, and practically did not respond to the effect of physiologically active compounds.

The data on the effect of physiologically active compounds on the accumulation of herbage and dry matter are of particular interest. The most intense accumulation of herbage begins in the budding phase. Rocket peas during this period accumulate on average 3.7 g of dry matter per plant per day. All variants treated with physiologically active compounds exceed the control variant. The accumulation of herbage in Astronaut variety is mainly at the control level.

According to the accumulation of dry matter, both varieties differ insignificantly according to the variants of the experiment in the budding phase. The accumulation of dry matter increases sharply in the phase of seed filling. It proceeds most intensively in Rocket variety in the variant with heteroauxin at a concentration of 0.001 %. The accumulation of dry matter occurred in Astronaut, somewhat more intensively when treated with 0.001 % heteroauxin. No clear effect on the formation of the leaf surface was noted in the experiments, when processing seed material with growth regulators. Camposan at a 0.001 % concentration had an overwhelming effect in Astronaut variety in the seed filling phase. The effect of heteroauxin was also manifested in Rocket variety. In this variety, in general, the leaf area was formed 1.5 times more intensively than in Astronaut peas. Thus, in the phase of bean formation, the leaf area was formed, depending on the variant, from 826.9 to 1,093.7 cm²/plant (Table 2).

### Table 2. The effect of physiologically active compounds on the formation of leaf area, cm²/plant

| No. | Variant                          | Development phases |
|-----|----------------------------------|--------------------|
|     |                                  | Tillering 09.06    | Budding 27.06      | Pod formation 14.07 | Filling 29.07 |
|     |                                  |                    |                   |                  |                |
| Astronaut | 1 Water (control) | 60.0 | 512.8 | 433.6 | 358.7 |
|           | 2 Heteroauxin 0.001 % | 64.3 | 628.8 | 403.4 | 248.6 |
|           | 3 Heteroauxin 0.005 % | 62.6 | 546.1 | 367.9 | 287.7 |
|           | 4 Camposan 0.001 % | 58.5 | 556.8 | 499.4 | 151.8 |
|           | 5 Camposan 0.005 % | 59.6 | 537.5 | 618.3 | 244.9 |
| Rocket   | 1 Water (control) | 639.3 | 1093.7 | 474.0 |
|           | 2 Heteroauxin 0.001 % | 632.8 | 974.1 | 514.3 |
|           | 3 Heteroauxin 0.005 % | 543.1 | 835.4 | 544.2 |
|           | 4 Camposan 0.001 % | 569.0 | 826.9 | 389.3 |
|           | 5 Camposan 0.005 % | 635.2 | 895.1 | 471.4 |

The formation of the leaf surface had a significant effect on the net productivity of photosynthesis of pea plants and the photosynthetic potential of crops (Table 3).
Table 3. Net productivity of photosynthesis (g/m$^2$ a day), photosynthetic potential of pea crops when using physiologically active compounds

| Variant | Tillering – budding | Budding – pod formation | Pod formation – filling | Photosynthetic potential of crops, mln.m$^2$/g a day |
|---------|---------------------|-------------------------|------------------------|-----------------------------------------------|
|         | 09.06 – 27.06       | 27.06 – 14.07           | 14.07 – 29.07          |                                               |
| Astronaut |                      |                         |                        |                                               |
| Water (control) | 3.1 | 4.7 | 3.7 | 2.2 |
| Heteroauxin 0.001 % | 2.2 | 4.8 | 4.7 | 2.8 |
| Heteroauxin 0.005 % | 2.5 | 4.0 | 4.1 | 2.0 |
| Camposan 0.001 % | 2.4 | 4.0 | 2.4 | 2.0 |
| Camposan 0.005 % | 2.4 | 5.3 | 3.9 | 2.6 |
| Rocket |                      |                         |                        |                                               |
| Water (control) | 2.7 | 3.4 | 4.1 | 5.4 |
| Heteroauxin 0.001 % | 2.7 | 3.4 | 7.2 | 6.9 |
| Heteroauxin 0.005 % | 3.0 | 3.8 | 6.0 | 5.1 |
| Camposan 0.001 % | 3.1 | 3.1 | 6.4 | 4.3 |
| Camposan 0.005 % | 2.2 | 3.3 | 6.7 | 5.3 |

It should be noted that the treatment of seeds with heteroauxin contributes to a longer work of the leaf apparatus, that is, a high leaf area remains in these variants in the next period, when the plants are filled with seeds and the future yield is formed. The best results on the productivity of photosynthesis were obtained on Rocket variety (in the tillering - budding phase) in variants III and IV. Here, 3-3.1 g of dry matter per day is synthesized on 1 m$^2$ of leaves. In the last period (pod formation - filling), the productivity of photosynthesis increased 1.5-2.1 times in all variants, i.e. for each 1 m$^2$ of leaf surface per day, from 6 to 7.2 g of dry matter was created, compared to the control with 4.1 g. Thus, seed treatment with physiologically active compounds has a positive effect on the net productivity of photosynthesis.

Pea crops generally formed a strong average leaf area. The greatest value of the photosynthetic potential was observed in variants II and V (Astronaut variety), where a solution of heteroauxin at a concentration of 0.001 % and a solution of camposan at a concentration of 0.005 % were used. The same variants showed their worth in Rocket variety. In general, the efficiency of the use of physiologically active compounds was not high, which could be explained by weather conditions of the growing season.

Analysis of the yield and its structure showed that physiologically active compounds had different effects on the growth, development and productivity of peas. The effect was exerted not only by preparations of different chemical composition, but also by homogeneous preparations at different concentrations. Astronaut and Rocket varieties responded positively to seed treatment with heteroauxin at a 0.001% solution concentration. Heteroauxin at a higher concentration gave a much less effect. Astronaut variety gave an increase in yield by 13.6 dt/ha, when using physiologically active compound heteroauxin at 0.001 % concentration. Both varieties responded well to seed treatment with camposan 0.005 % concentration. The increase was 8.3-8.4 dt/ha (Table 4).

Rocket variety gave an increase of 0.5 dt/ha in the variant with a 0.001 % camposan solution. Astronaut variety responded negatively to the treatment and had a yield loss of 6.3 dt/ha compared to the control.

Seed formation proceeded at high humidity in heavily lodged crops. These conditions greatly influenced the formation of the structure of the crop (Table 5).

In the first phase, Astronaut did not exhibit the effect of physiologically active compounds. In the last phase (pod formation - filling), variants II and III variants were affected by heteroauxin, but camposan at a concentration of 0.001% had an overwhelming effect, where the accumulation of dry
matter per day was 2.4 g, which was 1.5 g lower than the control.

Table 4. Pea yield when treated with physiologically active compounds

| Variant                  | Astronaut    | Rocket       |
|--------------------------|--------------|--------------|
|                          | Yield, dt/ha | Extra yield  | Yield, dt/ha | Extra yield  |
|                          |              | dt/ha %      |              | dt/ha %      |
| Water (control)          | 26.2         | 28.2         |
| Heteroauxin 0.001 %      | 39.8         | 51.9         | 45.9         | 62.8         |
| Heteroauxin 0.005 %      | 27.6         | 5.3          | 37.4         | 32.6         |
| Camposan 0.001 %         | 19.9         | -2.4         | 28.7         | 1.8          |
| Camposan 0.005 %         | 34.5         | 31.6         | 36.6         | 29.8         |
| LSD 05                   | 7.17         | 10.87        |

Table 5. Pea crop structure, Astronaut variety

| Options                  | Number of beans per 1 plant. | Number of seeds in the bean | Mass of 1000 grains, g |
|--------------------------|------------------------------|----------------------------|----------------------|
|                          | Total, pc. | Developed, % |                     |                      |
| 1. Water (control)       | 4.0         | 86.5         | 124.5                |
| 2. Heteroauxin 0.001 %   | 4.8         | 84.5         | 154.1                |
| 3. Heteroauxin 0.005 %   | 4.4         | 81.0         | 129.9                |
| 4. Camposan 0.001 %      | 4.4         | 89.2         | 122.1                |
| 5. Camposan 0.005 %      | 5.2         | 90.0         | 150.3                |

The analysis showed that the percentage of developed seeds as a whole for the variants was very reduced and amounted to 90 % in the best variant. However, it should be noted that on the variants treated with physiologically active compounds, a greater number of pods was formed from 4.4 to 5.2 versus 4.0 pcs/plant in the control.

4. Conclusion

Based on the studies carried out on the effect of pre-sowing soaking of pea seeds in solutions of physiologically active compounds, the following conclusions can be drawn.

Pre-sowing soaking of seeds in a solution of heteroauxin at a concentration of 0.001% stimulated a more harmonious germination of seeds and an increase in field germination by 22.3 %. Seed treatment with camposan did not affect field germination, but plant height decreased, especially at high concentrations (0.005 %).

There was a clear effect in both varieties. Heteroauxin at a low concentration (0.001%) influenced the formation of leaf area, the accumulation of dry matter and the net productivity of photosynthesis. According to some indicators, camposan appeared at a concentration of 0.005 %.

Treatment of seeds with heteroauxin at a concentration of 0.001% and in a camposan solution at a concentration of 0.005 % turned out to be the most effective for seed productivity of peas. The yield of Astronaut variety was 39.8 and 34.5 dt/ha and that of Rocket variety was 45.9 and 36.6 dt/ha, which, depending on the variety, was 8.6-51.9 % higher than the control. Conditional net income increased 1.3-2 times and production costs decreased.

References

[1] Vinogradov D V, Naumtseva K V and Lupova E I 2019 Use of biological fertilizers in white mustard crops in the non-Chernozem zone of Russia IOP Conf. Series: Earth and Environmental Science 341 012204. doi:10.1088/1755-1315/341/1/012204

[2] Anikin N, Terentyev V, Andreev K, Shemyakin A, Martynushkin A 2020 Qualitative assessment of passenger service Journal of Physics: Conference Series 012094
[3] Kashirina L G, Ivanishchev K A, Romanov K I 2020 The quality of dairy products made from the milk of cows consuming vitamin-containing preparations *BIO Web of Conferences* **17** 00096

[4] Byshov N V, Latyshenok M B, Makarov V A, Latyshenok N M, Ivashkin A V 2021 Prospects and method of seed grain storage in a container with gas-regulating medium *IOP Conf. Series: Earth and Environmental Science* **624** 012118. doi:10.1088/1755-1315/624/1/012118

[5] Ushanev A I, Uspensky I A, Yukhin I A 2020 Pilot installation for applying protective coating on the surface of the agricultural equipment *IOP Conference Series: Earth and Environmental Science* **012049**

[6] Toghyani M, Mohammadsalehi A, Gheisari A, Tabeidian S 2009 The effect of low-glucosinolate rapeseed meal in diets with multi-enzyme supplement on performance and protein digestibility in broiler chicks *J. Anim. Feed Sci.* **18** 313–321

[7] Byshov N V, Simdyankin A A, Uspensky I A, Pukov R V 2019 Accounting for the time of ultrasonic fuel processing in the surface tension coefficient *ARPN Journal of Engineering and Applied Sciences* **14**(21) 3753-3756

[8] Thanaseelaan V, Niswanathan K, Chandrasekaran D, Prabakaran R, Chellapandan M 2007 Chemical composition, amino acids, minerals and antinutritional factors of rapeseed meal *J. of Vet. and Anim. Sci.* **3** 101–105

[9] Ciurescu G 2009 Efficiency of soybean meal replacement by rapeseed meal and/or canola seeds in commercial layer diets *Arch. Zootecn.* **12** 27–33

[10] Lupova E I, Vinogradov D V, Eysenina M V, Nikitov S V 2021 Modern approaches to production of high-quality spring rape *IOP Conf. Series: Earth and Environmental Science* **624** 012076, doi:10.1088/1755-1315/624/1/012076