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GROWTH STIMULATING ACTIVITY OF NEW PLANT GROWTH REGULATORS

This study was conducted to evaluate growth stimulating activity of new biologically active compounds on shoot germination and seedlings length of wheat and spruce seeds. The best results were obtained by the treatment of spruce seeds with the preparations 3 and 5, where spruce seeds germination was 87.7 − 88%, whereas for the control it was 84%, for the standard − 86 %, and seedlings length in these experiment options was from 8.5 cm to 8.8 cm, for the control – 4.0 cm, for the standard – 7.2 cm. Germination energy and formed shoots germination on wheat seeds were for the control 64.5% and 83.5%, respectively, for KN-2 preparation at 0.01% concentration were 71.0% and 85.5%, for the compound 6 at the concentration 0.1% – 98.0% and 98.5%, at 0.01% concentration – 82.5% and 84.4 %. Using of the growth stimulant 6 completely suppresses the development of saprophytic and pathogenic microflora.

The stimulant 7 showed at 0.01% concentration a high shoot forming activity by Spirea propagation, where averaged shoot length was 3.91 cm compared to the control, Cornevin, KN-2 (1.63; 2.58; 3.59 cm, respectively) and the average percentage of rooted propagules was 44%, similar to the standards (Cornevin and KN-2). The growth stimulant 10 was the most effective and showed a high root forming activity at 0.01% concentration by propagation processing, where the averaged root length was 3.4 cm as compared to the control, Cornevin, KN-2 (1.63, 2.26, 1.67 cm, respectively). A high percentage of rooting at 0.001% concentration was 63%, which exceeds the control and standards Cornevin and KN-2 by 43%, 53%, 52%, respectively. Obtained results of the research demonstrate that the treatment of seedlings with the growth stimulants activates the formation of the root system and shoots.

Key words: Growth stimulants, germination, growth stimulating, shoot and root forming activity.

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Жаңа өсімдік өсуін реттегіштердің өсуді ынталандыру белсенділігі

Бұл зерттеулер жаңа биологиялық белсенді қосылыстардың бидай мен шырша тұқымдарының өсінділері мен көшеттерінің ұзындығына ынталандыру белсенділігін анықтау мақсатында жүргізілді. Шырша тұқымдарын 3 және 5 препараттармен өңдеу кезінде жақсы нәтижелер алынды, онда шырша тұқымдарының өнгіштігі 87,7 – 88% құрады, ал бақылуда – 84%, эталонда – 86%, ал осы нұсқалардағы көшеттердің ұзындығы 8,5-тен 8,8 см-ге дейін, бақылауда – 4,0 см, эталонды пайдалана отырып – 7,2 см құрады. Бидай тұқымдарында өскін энергиясы және бақылауда пайда болған өскіндердің өнгіштігі 64,5 және 83,5% құрады, тиісінше КН-2 препараты үшін концентрациясы 0,01% – 71,0 және 85,5%, 0,1% концентрациясында 6 қосылысты пайдалану – 98,0 және 98,5%, концентрациясы 0,01% – 82,5 және 84,4% құрады. 6 өсуді ынталандырғышын қолдану сапрофиттік және патогендік микрофлораның дамуын толығымен тежейді.

Спиреяны кесу кезінде 0,01% концентрациясында жоғары өскін өсу қабілетін 7 ынталандырғыш көрсетті, мұнда бақылау, Корневин, КН-2 (сәйкесінше 1,63; 2,58; 3,59) салыстырғанда орташа есеппен 3,91 см құрады және стандарттарға ұқсас (Корневин және КН-2) өскіндердің орташа пайызы 44%-ға тең. Өскіндерді өңдеу кезінде 10 өсу ынталандырғышы тиімді екендігі анықталды, ол 0,01% концентрациясында жоғары тамыртүзгіш қабілетін көрсетті, онда тамырдың ұзындығы бақылау, Корневин, КН-2 (1,63; 2,26; 1,67 см) салыстырғанда орташа есеппен 3,4 құрады. 0,001% концентрациясы кезінде тамырланудың жоғары пайызы 63%-ға тең, бұл бақылаудан 43%-ға, Корневин эталоны 53%-ға, КН-2 52%-ға артық. Зерттеулер негізінде алынған нәтижелер көшеттерді өсуді ынталандырғыштармен өңдеу бақылаумен және Корневин, КН-2 эталондарымен салыстырғанда тамыр жүйесі мен өскіндердің пайда болуын жоғары белсендіретіні анықталды.

Түйін сөздер: өсуді ынталандырғыштар, өнгіштік, өсуді үдеткіш, өскін- және тамырландырғыш белсенділіктер.

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Ростстимулирующая активность новых регуляторов роста растений

Данное исследование было проведено с целью оценки ростстимулирующей активности новых биологически активных соединений на всхожесть побегов и длину проростков семян пшеницы и ели. Лучшие результаты получены при обработке семян ели препаратами 3 и 5, где всхожесть семян ели составила 87,7 – 88%, тогда как в контроле – 84%, в эталоне – 86%, длина проростков в данных вариантах эксперимента составила от 8,5 до 8,8 см, в контроле – 4,0 см, с использованием эталона – 7,2 см. На семенах пшеницы энергия прорастания и всхожесть образовавшихся побегов в контроле составили 64,5 и 83,5 %, соответственно, для препарата КН-2 при концентрации 0,01% – 71,0 и 85,5 %; с использованием соединения 6 при концентрации 0,1% – 98,0 и 98,5 %; при концентрации 0,01% – 82,5 и 84,4 %. Применение стимулятора роста 6 полностью подавляет развитие сапрофитной и патогенной микрофлоры.

Высокую побегообразующую активность при черенковании спиреи показал стимулятор 7 в концентрации 0,01%, где длина побегов составила в среднем 3,91 см по сравнению с контролем, Корневином, КН-2 (1,63; 2,58; 3,59, соответственно) и средний процент укорененных черенков равен 44%, схожий с эталонами (Корневин и КН-2). При обработке черенков наиболее эффективным оказался стимулятор роста 10, который при концентрации 0,01% показал высокую корнеобразующую активность, где длина корней составила в среднем 3,4 по сравнению с контролем, Корневином, КН-2 (1,63; 2,26; 1,67 см), соответственно. Высокий процент укоренения при концентрации 0,001% равен 63%, что превосходит контроль на 43%, эталон «Корневин» – на 53%, КН-2 – на 52%. Полученные результаты исследования показывают, что обработка саженцев стимуляторами роста активизирует образование корневой системы и побегов.

Ключевые слова: стимуляторы роста, всхожесть, ростстимулирующая, побего- и корнеобразующая активность.

Introduction

Interest to plant growth regulators (PGRs), which have a wide spectrum of action, is growing every year. A feature of growth regulators is the ability to positively influence the physicochemical processes in plants and provide them with microelements, contributing to the growth of crop productivity. Special value is the ability of growth stimulants to stimulate adaptation processes and increase plant resistance to unfavorable environmental factors. PGRs significantly activate growth and development of plants, have a directed effect on individual organogenesis stages, and accelerate the passage of phenological development phases, increase resistance to adverse environmental factors [1].

Currently, the assortment of growth regulators on the market is quite diverse and is constantly updated with new preparations. The PGRs created in recent years on the basis of synthetic raw materials open up new approaches to the management of plant metabolism processes and allow to solve the problems of practical crop production.

PGRs are using for acceleration of plant growth or its inhibition, rooting in propagation processing, increasing crop yield, removing seeds from dormancy, producing seedless fruits, leaves and fruits dropping, plants drying before harvest and in agricultural biotechnology [2, 3]. Effective growth regulators were studied and identified and their peculiarities of influence on various varieties of rootstocks of fruit and berry crops [4 – 8].

The use of PGRs in agricultural practice in order to germination increasing, crop yield, quality and plant resistance against unfavorable environmental factors is becoming an important link in the technologies of growing and cultivating grain, horticultural and fruit crops [9, 10].

Domestic and foreign scientists are actively searching for new plant growth regulators with a wide spectrum of action. Within many years of research have been developed methods for a preparation of planting material for berry and ornamental shrubs, rootstocks for reproduction using PGRs, which can increase a level of regenerative ability of vegetative offspring, reduce a period of root formation, improve development, increase viability, winter hardiness of rooted material and increase the yield of standard seedlings. The effectiveness of the methods is confirmed on a large number of varieties with different root forming ability and by using of growth stimulants with various directions of action [11 – 13].

For many years A.B. Bekturov Institute of Chemical Sciences together with the institutes of agrarian and biological profile have been carried out research aimed at creating new highly effective environmentally friendly growth stimulants to improve germination quality, plant and agricultural crop productivity and yield. The results of this research were the developing of plant growth stimulators Akpinol, Fospinol, AN-16 and their other analogues [14 – 20].

In recent years, PGRs, that have a wide spectrum of physiological activity, safe for humans and the environment have been developed based on advanced scientific achievements [21, 22]. Among crop protection products the greatest preference is given to growth stimulants with a polyfunctional action, which have a complex effect, for example, have both growth regulating and protective actions [23]. The use of such products is one of the ways to solve environmental problems in agriculture and is a good way for increasing the efficiency of plant protection against phytopathogens, and is a necessary element for modern agriculture.

Thus, are relevant for agriculture the search and testing of new environmentally friendly plant growth regulators, which have not only growth stimulating, but also a protective effect against unfavorable factors and diseases.

The aim of this investigation is to study the effect of new plant growth stimulants on the laboratory germination of wheat and spruce seeds, to determine root forming, root length, growth propagation, and number of roots in grafted Vangutta Spirea seedlings.

Materials and research methods

The study of growth stimulating activity was carried out at S. Zh. Zhiembaev Kazakh Research Institute of Quarantine and Plant Protection and at the Institute of Botany and Phytointroduction of the Committee of Forestry and Wildlife of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan. The objects of laboratory research were wheat (Saratovskaya-29 variety) and spruce seeds. Determination of activity of the growth stimulants was carried out in the laboratory of biotechnology according to the well-known method [24].

The laboratory experiment options on wheat and spruce seeds:

1. Control (water)
2. Akpinol KN-2 (standard), (0.01mg / l)
3. Compound 1 (0.01 mg/l and 0.1 mg/l)
4. Compound 2 (0.01 mg/l and 0.1 mg/l)
5. Compound 3 (0.01 mg/l and 0.1 mg/l)
6. Compound 4 (0.01 mg/l and 0.1 mg/l)
7. Compound 5 (0.01 mg/l and 0.1 mg/l)
8. Compound 6 (0.01 mg/l and 0.1 mg/l)

The effectiveness of preparations using in seedlings propagation of Spirea Vangutta (*Spiraeax x vanhouttei*) was determined in the laboratory for the protection of the gene pool and the introduction of fruit plants named after A.D. Dzhangalieva of the Institute of Botany and Phytointroduction. This experiment, control and observations were carried out according to the generally accepted method [25]. We used semi-lignified cuttings of Spirea Vangutta (*Spiraea x vanhouttei*) in an amount of 65 pieces each 8 – 9 cm long and with three buds in this experiment. The cuttings of Spirea were immersed separately in solutions of compounds in two concentrations (0.001%, 0.01%) for 6 hours. The cuttings were planted in a greenhouse with a prepared substrate (soil:sand). The experiment lasted 4 months. The survival rate of the planted cuttings was determined one month after planting. Quality of the planting material and the parameters of their development – cuttings height, roots number and length were determined at the end of the vegetative period.

Experiment options on cuttings

1. Control (without treatment)
2. Cornevin (standard), (0.01 %, 0.001%)
3. Akpinol KN-2 (standard), (0.01 %, 0.001%)
4. Compound 7 (0.01 %, 0.001%)
5. Compound 8 (0.01 %, 0.001%)
6. Compound 9 (0.01 %, 0.001%)

7. Compound 10 (0.01 %, 0.001%)

The studied compounds 1-10 were synthesized at A.B. Bekturov Institute of chemical sciences in the laboratory of chemistry of physiologically active compounds. The studied compounds are various dithiocarbamine derivatives (heterocyclic dithiocarbamates 1,3-5,9,10, dithioacetylenic heterocyclic alcohols 2,6, thioanhydrides of heterocyclic dithiocarbamic acids 7,8 and aromatic dithiocarbamate 10).

Results and discussion

This study was carried out to investigate influence of the compounds on wheat and spruce seeds germination in laboratory conditions. Seed samples were moistened in the solutions of the compounds 1-6 with 0.01 mg/l and 0.1 mg/l concentrations. In the control seeds were moistened with water. The sowing quality of seeds was determined in humid chambers placed in a thermostat at a temperature of 24 ^{0}C. In each variant were used 50 seeds in 3-fold repetition. Germination energy was estimated on the 3-rd day, laboratory germination on the 7-th day after treatment by the number of germinated seeds. The growth stimulating activity of the studied compounds was determined by two parameters: germination energy and shoot germination.

Table 1 – Effect of the compounds 1 – 6 on germination and microflora of wheat seeds

Variant	Germination energy, %	Laboratory germination, %	Intensity of microflora growth, %	
			mushroom	bacterial
Control (water)	64,5	83,5	+++	+++
Akpinol KN-2 (standard), (0.01mg/l)	71,0	85,5	++	+
Compound 1 (0.01 mg/l)	74,5	76,5	++	-
Compound 1 (0.1 mg/l)	72,5	74,5	++	-
Compound 2 (0.01 mg/l)	74,2	76,2	+++	++
Compound 2 (0.1 mg/l)	78,5	79,0	++	-
Compound 3 (0.01 mg/l)	61,0	75,5	++	+
Compound 3 (0.1 mg/l)	64,5	76,5	++	-
Compound 4 (0.01 mg/l)	51,0	55,2	++	+
Compound 4 (0.1 mg/l)	54,5	56,5	++	-
Compound 5 (0.01 mg/l)	54,2	56,2	+++	++
Compound 5 (0.1 mg/l)	48,5	57,0	++	-
Compound 6 (0.01 mg/l)	82,5	84,4	+	-
Compound 6 (0.1 mg/l)	98,0	98,5	-	-
Note: + – weak growth; ++ – average growth; +++ – intensive growth;				

The results of the laboratory experience showed, that the studied growth regulators have physiological activity. Of the studied compounds, the most effective result was obtained when wheat seeds were treated with the compound 6. So, the germination energy and the shoots germination in the control were 64.5, 83.5%, respectively, for the standard (KH-2) at 0.01% concentration – 71.0 and 85.5%, for the compound 6 – 82.5 and 84.4%, and at 0.1% concentration – 98.0 and 98.5%, respectively (Table 1). It should be noted that the phytoexamination results showed, that in the control wheat seeds were definitely infected with the microflora of saprophytic fungi: *Mucor, Penicillium* and *Alternaria*, while the compound 6 completely suppressed the development of saprophytic and pathogenic microflora.

In continuation of this study, the effect of growth regulators on spruce seed germination was studied in laboratory conditions. The growth stimulating activity of the tested compounds 1 – 6 was determined by two parameters: seedlings length and shoots germination (Table 2).

Table 2 – Effect of the compounds 1-6 on spruce seeds germination

Variant	Seedling length, cm	Germination, %
Control (water)	4.0	84
Akpinol KN-2 (standard), (0.01mg/l)	7,2	86
Compound 1 (0.01 mg/l)	6.9	86
Compound 2 (0.01 mg/l)	4.5	87
Compound 3 (0.01 mg/l)	8,8	88
Compound 4 (0.01 mg/l)	8.1	88
Compound 5 (0.01 mg/l)	8,5	87,7
Compound 6 (0.01 mg/l)	7,4	88

The studied growth regulators showed high activity on spruce seeds. The best results were obtained when treatment was with the compounds 3 and 5, where spruce seeds germination was 87.7 – 88%, for the control – 84%, for the standard – 86%, and seedlings length in these variants was 8.5 − 8.8 cm, for the control – 4.0 cm, and for the standard – 7.2 cm.

We have studied the nature of the effect of plant growth regulators on the growth and development cuttings of Spirea Vangutta in a field. Important indicators of the physiological activity of root and vegetative mass forming stimulants are the number of roots, their length, and growth of the aerial part of cuttings.

The results of the study carried out using the growth stimulants are presented in the Table 3.

The biometric measurements showed that the treatment of cuttings with the studied compounds significantly activated shoots and roots formation in comparison to the control and the standards.

Table 3 – Effect of the compounds 7 – 10 on shoot and root forming of cuttings of Spirea Vangutta

Compound	Number of shoots	Shoot length	Number of roots	Root length
Concentration 0.001%				
Control (water)	0,76±0,13	1,63±0,33	5±0,24	3,06±0,22
Cornevin	1±0,11	2,26±0,33	5,19±0,36	3,26±0,21
KN-2	1±0,10	1,67±0,28	3,96±0,35	3,48±0,31
Compound 7	1,07±0,11	2,49±0,25	4,21±0,36	3,96±0,30
Compound 8	0,91±0,12	2,41±0,37	4,36±0,34	3,27±0,26
Compound 9	1±0,18	2,15±0,36	5,33±0,51	2,58±0,22
Compound 10	0,95±0,09	2,45±0,32	5,15±0,34	3,4±0,24
Concentration 0.01%				
Control (water)	0,76±0,13	1,63±0,33	5±0,24	3,06±0,22
Cornevin	0,96±0,13	2,58±0,42	5±0,42	3,24±0,21
KN-2	1,12±0,11	3,59±0,45	4,36±0,28	3,55±0,20
Compound 7	0,93±0,13	3,91±0,54	4,14±0,30	2,51±0,20
Compound 8	1,14±0,13	2,59±0,39	4,93±0,37	4,11±0,36
Compound 9	0,9±0,12	3,06±0,57	6,35±0,63	3,16±0,27
Compound 10	0,97±0,11	2,33±0,28	5,74±0,42	3,59±0,21

Analysis of the table data showed, that the compound 7 exhibits the greatest shoot forming activity and contributes to a larger number of shoots formation and their length in comparison to the control, the standards Cornevin and KN-2. Therefore, at 0.01% concentration the number of shoots, shoots length were 0.93±0.13 cm, 3.91±0.54 cm, respectively, and at 0.001% concentration were 1.07±0.11, 2.49±0.25 cm, respectively, by using the compound 7.

The compound 8 at 0.001% concentration showed also a high shoot forming ability, where the shoot length was 2.41 cm, compared to the control, Cornevin and KN-2 standards (1.63, 2.26, 1.67 cm, respectively). The rooting rate was 50% compared to the control, Cornevin and KN-2 standards (44, 41, 42 %, respectively) (Figure 1).

The compound 10 showed a high root forming activity. Thus, the number of roots and length of formed roots at 0.01% concentration for the control were 5 ± 0.24, 3.06 ± 0.22 cm, respectively, for Cornevin standard were 5 ± 0.42, 3.24 ± 0.21 cm, for KN-2 were 4.36 ± 0.28, 3.55 ± 0.20 cm, while using the compound 10 were 5.74 ± 0.42, 3.59 ± 0.21 cm, respectively (Table 3).

The number of roots and the length of formed roots were at 0.001% concentration for the control 5 ± 0.24, 3.06 ± 0.22 cm, respectively, for Cornevin standard 5.19 ± 0.36, 3.26 ± 0.21 cm, for KN-2 – 3.96 ± 0.35, 3.48 ± 0.31 cm, and for the compound 10 – 5.15 ± 0.34, 3.4 ± 0.24 cm, respectively.

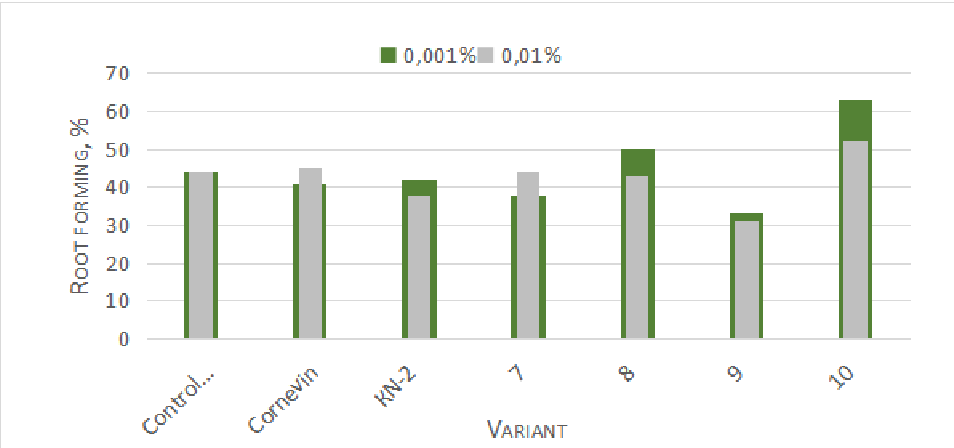

Figure 1 – Root forming activity of the compounds 7-10

In this study, it was found that the treatment of cuttings with the investigated growth stimulants activates the root system and shoots formation compared to the control and the standards Cornevin and KN-2.

Fig. 1 showed that the root forming percentage of lignified cuttings has a large interval between indicators from 31 to 63%, depending on the variant of the experiment.

In the variant of the experiment using the compound 10 (0.01%), the root forming of cuttings was 52%, better by 18% relative to the control variant and by 15% (Cornevin) and 36% (KN-2).

The best result of the root forming of cuttings 63 % was recorded in the variant of the compound 10 at 0.001% concentration, which exceeds the control by 43%, the standards Cornevin by 53% and KN-2 by 52%.

Conclusion

In this study, it was established that the investigated new plant growth regulators (3, 5, 6) have high growth stimulating activity and are effective stimulants of wheat and spruce seeds germination. Furthermore, was identified the growth stimulant, which completely inhibits the development of pathogenic microflora.

It was discovered that the studied plant growth regulators have shoot and root forming activity, among which the preparations 7 and 10 showed high efficiency by propagation of Spirea Vangutta cuttings.

The analysis of growth-stimulating activity revealed a pattern between the structure of the stimulants and their species-specificity of the biological action. It was discovered that heterocyclic dithiocarbamates have high growth stimulating activity in relation to spruce. Whereas the dithioacetylenic alcohols of these dithiocarbamates showed a high action on wheat. Thioanhydrides of heterocyclic dithiocarbamic acids showed high shoot forming activity and aromatic dithiocarbamate root forming activity.

The obtained results indicated that the investigated plant growth stimulants at the same time stimulate the growth, development and physiological processes of plants, increase the ability to adapt to unfavorable environmental factors.

Conflict of interest

All authors declare that they have no conflict of interest.

Founding

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