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Victoria Tsygankova
Department for Chemistry of Bioactive Nitrogen-Containing Heterocyclic Compounds, Institute of Bioorganic Chemistry and Petrochemistry, National Academy of Sciences of Ukraine, Murmanskaya Str, Kyiv, Ukraine

Yaroslav Andrusevich
Department for Chemistry of Bioactive Nitrogen-Containing Heterocyclic Compounds, Institute of Bioorganic Chemistry and Petrochemistry, National Academy of Sciences of Ukraine, Murmanskaya Str, Kyiv, Ukraine

Olexandra Shtompel
Department for Chemistry of Bioactive Nitrogen-Containing Heterocyclic Compounds, Institute of Bioorganic Chemistry and Petrochemistry, National Academy of Sciences of Ukraine, Murmanskaya Str, Kyiv, Ukraine

Stepan Pilyo
Department for Chemistry of Bioactive Nitrogen-Containing Heterocyclic Compounds, Institute of Bioorganic Chemistry and Petrochemistry, National Academy of Sciences of Ukraine, Murmanskaya Str, Kyiv, Ukraine

Volodymyr Prokopenko
Department for Chemistry of Bioactive Nitrogen-Containing Heterocyclic Compounds, Institute of Bioorganic Chemistry and Petrochemistry, National Academy of Sciences of Ukraine, Murmanskaya Str, Kyiv, Ukraine

Andrii Kornienko
Department for Chemistry of Bioactive Nitrogen-Containing Heterocyclic Compounds, Institute of Bioorganic Chemistry and Petrochemistry, National Academy of Sciences of Ukraine, Murmanskaya Str, Kyiv, Ukraine

Volodymyr Brovarets
Department for Chemistry of Bioactive Nitrogen-Containing Heterocyclic Compounds, Institute of Bioorganic Chemistry and Petrochemistry, National Academy of Sciences of Ukraine, Murmanskaya Str, Kyiv, Ukraine

Correspondence
Victoria Tsygankova
Department for Chemistry of Bioactive Nitrogen-Containing Heterocyclic Compounds, Institute of Bioorganic Chemistry and Petrochemistry, National Academy of Sciences of Ukraine, Murmanskaya Str, Kyiv, Ukraine

Study of growth regulating activity derivatives of [1,3]Oxazolo[5,4-*d*]pyrimidine and N-Sulfonyl substituted of 1,3-Oxazole on soybean, wheat, flax and pumpkin plants

Victoria Tsygankova, Yaroslav Andrusevich, Olexandra Shtompel, Stepan Pilyo, Volodymyr Prokopenko, Andrii Kornienko and Volodymyr Brovarets

Abstract
In our work the low molecular weight heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and N-sulfonyl substituted of 1,3-oxazole were synthesized. Comparative analysis of plant growth stimulating activity of these heterocyclic compounds and plant hormones auxins IAA and NAA, and cytokinin Kinetin was conducted. It was found that all tested heterocyclic compounds used in concentration 10^{-9}M/l of distilled water revealed high auxin-like growth stimulating activity on the soybean (*Glycine max* L.) of cultivar Valuta, wheat (*Triticum aestivum* L.) of cultivar Zimoyarka, and flax (*Linum usitatissimum* L.) of cultivar Svitanok. The growth parameters of 20^{th}-day-old seedlings of soybean, wheat, and flax grown on the 10^{-9}M water solutions of heterocyclic compounds were as generally similar or higher than the growth parameters of seedlings grown on the water solution of auxins IAA and NAA used in the same concentration as compared to lower growth parameters of control untreated seedlings grown on the distilled water. Specific bioassay on cytokinin-like activity, conducted on the isolated cotyledons of muscat pumpkin (*Cucurbita moschata* Duch. et Poir.) of cultivar Gilea, showed that all testing heterocyclic compounds used in concentration 10^{-9}M/l of distilled water demonstrated expressive cytokinin-like stimulating effect on the growth of the isolated cotyledons of pumpkin. Obtained data confirm perceptiveness of application derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and N-sulfonyl substituted of 1,3-oxazole in the agricultural practice for intensification of growth and development of soybean, wheat, flax and pumpkin plants.

Keywords: [1,3]oxazolo[5,4-*d*]pyrimidine and N-sulfonyl substituted of 1,3-oxazole, IAA, NAA, Kinetin, *Glycine max* L., *Triticum aestivum* L., *Linum usitatissimum* L., *Cucurbita moschata* Duch. et Poir

1. Introduction

The main task for successful development of high-intensive world agriculture is an improving of crop growth and increase their productivity under unfavorable of abiotic and biotic stress-factors of environment (i.e. drought, cold, salinity, soil pollution and various plant pathogenic organisms) [1-5]. Today the different classes of plant growth regulatory compounds of natural origin such as phytohormones or their synthetic analogs, biostimulants, herbicides, organic fertilizers and micronutrients are widely used in the agricultural practice to accelerate plant growth and increase their productivity, and to protect against environmental stress-factors [6-15]. Together with traditional plant growth regulators the new classes of biologically active compounds created on the base of synthetic or natural low-molecular weight heterocyclic compounds derivatives of pyridine, pyrimidine, pyrazole, triazine, oxazole, and isoflavones are widely applied in the agricultural industry as plant growth regulators, herbicides, fungicides and antibacterial agents [16-25]. Advantage of application of these heterocyclic compounds in the agricultural practice is their high effectiveness at very small concentrations and environmental safety due to lack of toxic effect on the human, animal and plant cells; moreover they are widely used in the medical practice as therapeutic agents for treatment of nervous, allergic, gastroesophageal, cancer, bacterial, viral, fungal, infectious, and inflammatory diseases [26-32].

Soybean, wheat, flax and pumpkin are the most economically valuable crops cultivated over the world [33-36]. Soybean (*Glycine max* L.) belongs to important grain legumes and oilseed crop, which is source of more than 40% of proteins and 50% of oil used in the world food industry [37, 38]. Rhizobium-legume symbiosis enhances fixation of atmospheric nitrogen and increases soil fertility [39, 40]. Biodegradable soy protein isolate is an important basic material for food industry, agriculture and biotechnology [41]. Soybean contains biologically active compounds used in medical practice such as isoflavones, lectins, saponins, peptid lunazin and protease inhibitors such as Bowman-Birk protease inhibitor (BBI) and Kunitz trypsin inhibitor (KTI) that revealed cytotoxic activity against cancer [42-45].

Wheat (*Triticum aestivum* L.) is the major strategic cereal crop which is cultivated over the world [46-50]. Wheat provides by 30% of the food calories consumed by world population (4.5 billion people) [48, 49]. Wheat is also used as a raw material for the production of malt and beer [50]. Wheat contains various bioactive compounds such as alkaloids, saponins, glycosides, terpenoids, steroids, flavonoids and tannins that may be used for purposes of pharmaceutical industry [51]. However, despite the rapidly increasing of wheat sowing, there are significant problems with the increasing of the productivity of this crop because world population is expected to reach 9.7 billion people by 2050 [52].

Flax (*Linum usitatissimum* L.) is the oldest crop which is cultivated in more than 20 world countries [53-55]. Flax is widely used to produce cellulosic fiber for textile and paper industry and seed oil for food, cosmetic and pharmaceutical industry [55-57]. Flax seed lignan secoisolariciresinol diglucoside (SDG) and seed oil which contains more than 50% of omega-3 fatty acid - a-linolenic acid (ALA), sterols and tocopherols are used as supplements to dietary food and as pharmaceutical drugs for treatment of different diseases: weight gain, heart disease, hypertension, atherosclerosis, diabetes, arthritis, memory problems, depression, cancer, inflammatory diseases, kidney disorders etc. [56-58]. Moreover flax oil has polymer-forming properties due to high content of linolenic acid; therefore it is an ideal raw material for manufacture of paints, varnishes and ink [36, 56, 59].

Pumpkin (*Cucurbita pepo* L.) is the wide cultivated crop which is used as an important source for human dietary food, pharmaceutical products and animal forage [60-62]. Pumpkin seed oil contains biologically active compounds such as sterols, omega-3 and omega-6 essential fatty acids, tocopherols and carotenoids that have antidiabetic, antifungal, antibacterial, antioxidant and antiinflammatory properties due to which it is used in medical practice for protection and therapy of many diseases, such as hypertension, diabetes, cancer etc. [63-67].

Unfortunately the adverse environmental factors negatively impact on growing and productivity of these crops [68-70]. Today the various phytohormones, plant growth regulators, biostimulants, herbicides as well as fertilizers, micronutrients and vitamins are widely used for improvement of growth and development of soybean [71-74], wheat [75-81], flax [82-86] and pumpkin plants [87, 88].

The elaboration of new effective ecologically safe plant growth regulators created on the base of low molecular weight heterocyclic compounds for improving of growth and increase of productivity of these crops is alternative strategic approach. At the Institute of Bioorganic Chemistry and Petrochemistry of National Academy of Sciences of Ukraine the new effective plant growth substances elaborated on the base of low molecular weight five and six-membered heterocyclic compounds are synthesized. Our previous researches showed that some low molecular weight heterocyclic compounds created on the base of derivatives of pyridine, pyrimidine, pyrazole and isoflavones revealed high stimulating shoot organogenesis activity in the isolated tissue cultures of *Linum usitatissimum* L. cultivar heavenly *in vitro* conditions and high stimulating effect on germination of seeds and vegetative growth of maize (*Zea mays* L.) cultivar Odesskaya 10 [58, 89]. Therefore the great theoretical and practical interest is possibility of application of new classes of low molecular weight heterocyclic compounds for intensification of growth and development of the important for agriculture crops such as soybean, wheat, flax and pumpkin.

The objective of this work was study of growth stimulating activity of low molecular weight heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and N-sulfonyl substituted of 1,3-oxazole according to their impact on the acceleration of growth and development of the soybean, wheat and flax plants and on the growth of biomass of the isolated cotyledons of pumpkin.

2. Materials and Methods

2.1 Synthesis of heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and N-sulfonyl substituted of 1,3-oxazole

Low molecular weight heterocyclic compounds were synthesized at the Department for Chemistry of Bioactive Nitrogen-Containing Heterocyclic Compounds of Institute of Bioorganic Chemistry and Petrochemistry of NAS of Ukraine.

2.1.1 General

IR spectra (KBr) were recorded with the Vertex 70 instrument. ^{1}H NMR spectra were obtained with the Varian Mercury spectrometer (400 MHz) in DMSO-d_6, with TMS as internal standard. GC-MS spectra were registered with the Agilent 1100 Series HPLC device equipped with a mass selective UV diode array detector. Conditions of the GC–MS analysis were as follows: Zorbax SB-C18 column (1.18 µm, 4.6 × 15 mm, PN 821975-932); acetonitrile–water (95 : 5), 0.1% aqueous trifluoroacetic acid; eluent flow rate 3 mL/min; injection volume 1 µL; UV detector (215, 254, 285 nm); chemical ionization at atmospheric pressure (APCI), scanning range m/z 80–1000. Elemental analysis was performed at the analytical laboratory of the Institute of Bioorganic Chemistry and Petrochemistry, National Academy of Sciences of Ukraine. Melting points were measured using the Fisher-Johns apparatus. The reaction progress was monitored by TLC on Silufol UV-254 plates eluting with the 9:1 chloroform–methanol mixture and developing with UV irradiation.

2.1.2 General procedure for synthesis of 7-amino-5-aryl-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidines (compounds №1 and №4, Table 1)

Mixture of 4-cyano-1,3-oxazole-5-sulfonyl chloride (0.01 mol), appropriate amidine hydrochloride (0.01 mol) and triethylamine (0.02 mol) in 50 ml of anhydrous tetrahydrofuran was stirred at 20–25 °C for 48 h. The precipitate was filtered off; the solvent was removed in a vacuum. The residue was treated with water, filtered off, dried, and purified by recrystallization from acetonitrile [90].

2.1.3 General procedure for synthesis of 5-aryl-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine-7(6H)-ones (compounds №2 and №3, Table 1)

Mixture of methyl 5-chlorosulfonyl-2-phenil-1,3-oxazole-4-carboxylate (0.001 mol), corresponding amidine hydrochloride (0.001 mol), and triethylamine (0.002 mol) in 10 mL of anhydrous tetrahydrofuran was stirred at 20–25°C during 24 h and then at 65°C during 1 h. After cooling, 20 mL of water was added. The precipitate was filtered off, dried, and purified by recrystallized from solvent system (MeCN-DMF, 3:1) [91].

2.1.4 General procedure for synthesis of 2-aryl-5-(piperidine-1-ylsulfonyl)-1,3-oxazole-4-carbonitriles (compounds №5 and №6, Table 1)

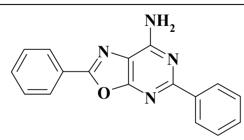
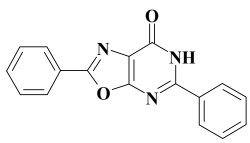
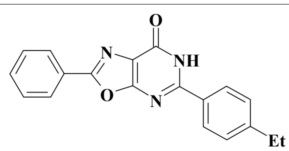
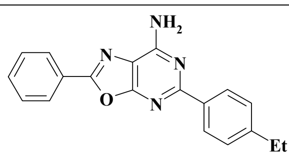
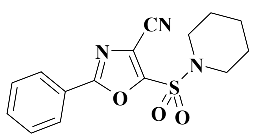
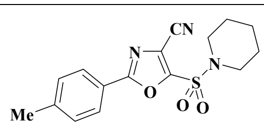
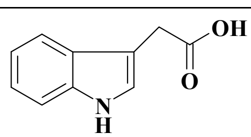
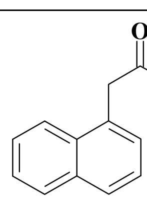
To a solution of 2-aryl-4-cyano-1,3-oxazole-5-sulfonyl chloride (0.001 mol) was added piperidine (0.0008 mol) and triethylamine (0.0008 mol). The mixture was heated for 2 h and kept at 20–25°C for 12 h. The precipitate was filtered off; the solvent was removed in a vacuum. The residue was treated with water, filtered off, dried and purified by recrystallized from ethanol [92].

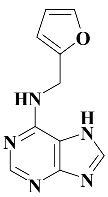
2.2 Chemical structures of heterocyclic compounds and phytohormones used for bioassays

In our experiments we conducted comparative analysis of plant growth regulating activity of low molecular weight five and six-membered heterocyclic compounds: derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine (compounds № 1-4) and N-sulfonyl substituted of 1,3-oxazole (compounds № 5 and № 6), as well as phytohormones auxins IAA (compounds № 7) and NAA (compound № 8) and cytokinin Kinetin (compound № 9).

Chemical structures of phytohormones and heterocyclic compounds used for bioassays are shown on the Table 1.

Table 1: Chemical structures of synthetic compounds used for bioassays

Compound No	Structural formula	Name	Molar mass
1		7-Amino-2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidine	288.31
2		2,5-Diphenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one	289.30
3		5-(4-Ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one	317.35
4		7-Amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine	316.37
5		2-Phenyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile	317.37
6		2-Tolyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile	331.40
7		IAA (1*H*-Indol-3-ylacetic acid)	175.19
8		NAA (1-Naphthylacetic acid)	186.21

9		Kinetin (*N*-(2-Furylmethyl)-7*H*-purin-6-amine)	215.22

2.3 Impact of synthetic heterocyclic compounds on growth and development of soybean, wheat and flax plants

In the laboratory conditions we studied impact of synthetic heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and N-sulfonyl substituted of 1,3-oxazole on germination of seeds and growth of seedlings of crops: the soybean (*Glycine max* L.) of cultivar Valuta, wheat (*Triticum aestivum* L.) of cultivar Zimoyarka and flax (*Linum usitatissimum* L.) of cultivar Svitanok. With this aim seeds of soybean, wheat and flax plants were surface sterilized successively in 1% $KMnO_4$ solution for 3 min and 96% ethanol solution for 1 min and then washed three times in the sterilized distilled water. After this procedure seeds were placed in the cuvettes (each containing 50 seeds) on the perlite moistened with distilled water (control) or with water solution of each heterocyclic compound used in concentration 10^{-9}M/1 of distilled water or water solution of auxins IAA or NAA used in the same concentration (experiment). Control and experimental seeds were placed in the thermostat for their germination in darkness at the temperature 25 ^{0}C during the 48 hours. Sprouted seedlings were placed in the plant growth chamber in which seedlings were grown for 20 days at the 16/8 h light/dark conditions, at the temperature 24 ^{0}C, light intensity 3000 lux and air humidity 60-80%. Comparative analysis of biometric indexes of seedlings (i.e. number of germinated seeds (%), seedlings height (cm), roots number (pcs), roots length (mm)) was carried out at the 20th day after their sprouting according to the guideline [93].

2.4 Impact of synthetic heterocyclic compounds on the growth of biomass of the isolated cotyledons of pumpkin

To determine stimulating activity of tested heterocyclic compounds on the growth of muscat pumpkin (*Cucurbita moschata* Duch. et Poir.) of cultivar Gilea, we used specific bioassay on cytokinin-like activity, which was conducted on the isolated cotyledons of this plant [94]. With this aim seeds were surface sterilized in 1% $KMnO_4$ solution for 3 min and 96% ethanol solution for 1 min and then washed with distilled water. After this procedure seeds were placed in the cuvettes (each containing 20-25 seeds) on the filter paper moistened with distilled water. After this procedure seeds were placed in the thermostat for their germination in darkness at the temperature 25 ^{0}C during the 96 hours. The 4th-day-old pumpkin seedlings were separated from cotyledons using sterile scalpel. The isolated cotyledons were weighted and placed in the cuvettes (each containing 20 seeds) on the filter paper moistened with distilled water (control) or with water solution of each heterocyclic compound used in concentration 10^{-9}M/1 of distilled water or with water solution of phytohormone cytokinin - Kinetin used in the same concentration (experiment). Control and experimental isolated cotyledons were placed in the plant growth chamber in which they were grown during 16 days at the above mentioned conditions. To determine the index of growth of biomass (g) of the isolated cotyledons of pumpkin, they were washed with sterilized distilled water and weighted with the interval of each 4 day.

2.5 Statistical Analysis

All experiments were performed in three replicates. Statistical analysis of the data was performed using dispersive Student's-t test with the level of significance at $P \leq 0.05$, the values are mean ± SD [95].

3. Results

3.1 Stimulating effect of chemical heterocyclic compounds and auxin NAA on the growth and development of soybean seedlings

In the laboratory conditions we studied impact of chemical heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and N-sulfonyl substituted of 1,3-oxazole as well as phytohormone auxin NAA on the germination of seeds and growth of soybean (*Glycine max* L.) of cultivar Valuta. It was shown that all tested heterocyclic compounds and phytohormone auxin NAA used in concentration 10^{-9}M/l of distilled water revealed high stimulating effect on the growth of the 20th-day-old soybean seedlings and considerably improved growth and development of their root system (Fig. 1).

Fig 1: Impact of chemical heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine (№1 - 7-amino-2,5-diphenyl[1,3] oxazolo[5,4-*d*]pyrimidine, №2 - 2,5-diphenyl[1,3]oxazolo[5,4-*d*] pyrimidin-7(6*H*)-one, №3 - 5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo [5,4-*d*]pyrimidin-7(6*H*)-one, №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine), compounds derivatives of N-sulfonyl substituted of 1,3-oxazole (№5 - 2-phenyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile and №6 - 2-tolyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile), and phytohormone auxin NAA on the root formation of the 20th-day-old soybean seedlings as compared to control (C) soybean seedlings

The comparative analysis of biometric indexes of 20th-day-old soybean seedlings (i.e. number of germinated seeds (%), length of seedlings (cm), total number of roots (pcs), total length of roots (mm)) showed that the biometric indexes of seedlings grown on the 10^{-9}M water solution of chemical heterocyclic compounds were similar or higher than the biometric indexes seedlings grown on the 10^{-9}M water solution of phytohormone auxin NAA used at the same concentration as compared to lower biometric indexes seedlings grown on the distilled water (control). The results of stimulating effect of the heterocyclic compounds on the biometric indexes of 20th-day-old soybean seedlings are shown on the Fig 2.

Particularly it was found that the biometric indexes of soybean seedlings grown on the 10^{-9}M water solution of compound №1 - 7-amino-2,5-diphenyl[1,3]oxazolo[5,4-

d]pyrimidine were as generally higher than the biometric indexes of soybean seedlings grown either on the distilled water (control) or on the 10^{-9}M water solution of auxin NAA as follows: according with length of seedlings – at the 17% as compared with control; according with total length of roots – at the 4.85 times as compared with control and at the 62% as compared with NAA; according with total number of roots – at the 3.72 times as compared with control, and at the 28% as compared with NAA, respectively (Fig. 2).

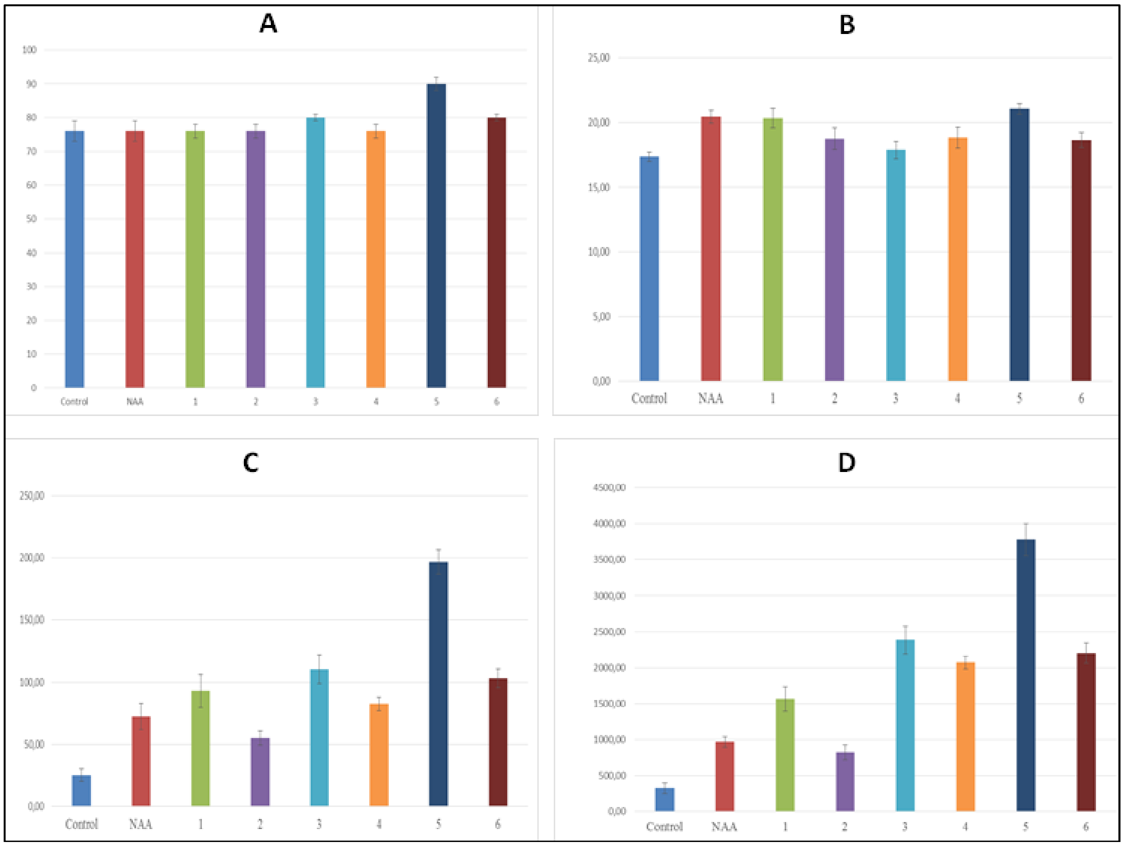


Fig 2: Impact of chemical heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine (№1 - 7-amino-2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidine, №2 - 2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, №3 - 5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine), compounds derivatives of N-sulfonyl substituted of 1,3-oxazole (№5 - 2-phenyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile and №6 - 2-tolyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile), and phytohormone auxin NAA on the biometric indexes of 20^{th}-day-old soybean seedlings
A – number of germinated seeds (%), B – length of seedlings (cm), C – total number of roots (pcs), D – total length of roots (mm)

The biometric indexes of 20^{th}-day-old soybean seedlings grown on the 10^{-9}M water solution of the compound №2 - 2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one were as generally higher than the biometric indexes of soybean seedlings grown on the distilled water (control) as follows: according with length of seedlings – at the 8% as compared with control; according with total length of roots – at the 2.5 times as compared with control; according with total number of roots – at the 2.2 times as compared with control (Fig. 2).

The biometric indexes of soybean seedlings grown on the 10^{-9}M water solution of compound №3 - 5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one were as generally higher than the biometric indexes of soybean seedlings grown either on the distilled water (control) or on the 10^{-9}M water solution of auxin NAA as follows: according with total length of roots – at the 7.4 times as compared with control and at the 2.47 times as compared with NAA; according with total number of roots – at the 4.4 times as compared with control, and at the 52% as compared with NAA, respectively (Fig. 2).

The biometric indexes of soybean seedlings grown on the 10^{-9}M water solution of compound №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine were as generally higher than the biometric indexes of soybean seedlings grown either on the distilled water (control) or on the 10^{-9}M water solution of auxin NAA as follows: according with length of seedlings – at the 8% as compared with control; according with total length of roots – at the 6.4 times as compared with control and at the 2.15 times as compared with NAA; according with total number of roots – at the 2.59 times as compared with control, and at the 55% as compared with NAA, respectively (Fig. 2).

The biometric indexes of soybean seedlings grown on the 10^{-9}M water solution of compound №5 - 2-phenyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile were as generally higher than the biometric indexes of soybean seedlings grown either on the distilled water (control) or on the 10^{-9}M water solution of auxin NAA as follows: according with length of seedlings – at the 21% as compared with control; according with total length of roots – at the 11.7 times as compared with control and at the 3.9 times as compared with NAA; according with total number of roots – at the 7.7 times as compared with control, and at the 2.7 times as compared with NAA, respectively (Fig. 2).

The biometric indexes of soybean seedlings grown on the 10^{-9}M water solution of compound №6 - 2-tolyl-5-(piperidin-1-

ylsulfonyl)-1,3-oxazole-4-carbonitrile were as generally higher than the biometric indexes of soybean seedlings grown either on the distilled water (control) or on the 10^{-9}M water solution of auxin NAA as follows: according with length of seedlings – at the 7% as compared with control; according with total length of roots – at the 6.8 times as compared with control and at the 2.3 times as compared with NAA; according with total number of roots – at the 4.1 times as compared with control, and at the 73% as compared with NAA, respectively (Fig. 2).

Thus, the comparative analysis of biometric indexes of 20th-day-old soybean seedlings grown on the 10^{-9}M water solution of heterocyclic compounds showed that the highest growth stimulating activity from tested compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine revealed compounds: №3 - 5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one and №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine. At the same time the compounds №1 - 7-amino-2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidine and №2 - 2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one demonstrated lower growth stimulating activity. The obtained results of different growth stimulating activity of compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine obviously may be explained by the presence of phenyl substituents at the 5th and 7th positions of pyrimidine fragment in these heterocyclic compounds.

The highest growth stimulating activity from tested compounds derivatives of N-sulfonyl substituted of 1,3-oxazole revealed compound №5 - 2-phenyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile. It is possible to suppose that the high growth stimulating activity of compound №5 obviously can be explained by the presence of phenyl substituent at the 2nd position of oxazole. While the compound №6 - 2-tolyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile, which has a similar to compound №5 structure, but differs by the presence of tolyl substituent at the 2nd position of oxazole, showed lower activity than the compound №5 and at the same time higher that the activity of auxin NAA. The obtained data witness that the various substituents at the 2nd position of oxazole impact on the activity of N-sulfonyl substituted of 1,3-oxazole.

3.2 Stimulating effect of chemical heterocyclic compounds and auxins IAA and NAA on the growth and development of wheat seedlings

In our experiments we also studied impact of chemical heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and N-sulfonyl substituted of 1,3-oxazole as well as phytohormones auxins IAA and NAA on the germination of seeds and growth of wheat (*Triticum aestivum* L.) of cultivar Zimoyarka. The high stimulating effect of all tested heterocyclic compounds and phytohormones auxins IAA and NAA on the growth of 20th-day-old wheat seedlings and development of their root system was observed at their using in concentration 10^{-9}M/l of distilled water (Fig. 3).

Fig 3: Impact of chemical heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine (№1 - 7-amino-2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidine, №2 - 2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, №3 - 5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine), compounds derivatives of N-sulfonyl substituted of 1,3-oxazole (№5 - 2-phenyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile and №6 - 2-tolyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile), and phytohormones auxins IAA and NAA on the root formation of the 20th-day-old wheat seedlings as compared to control (C) wheat seedlings

The comparative analysis of biometric indexes of 20th-day-old wheat seedlings (i.e. number of germinated seeds (%), length of seedlings (cm), total number of roots (pcs), total length of roots (mm)) showed that the biometric indexes of seedlings grown on the 10^{-9}M water solution of chemical heterocyclic compounds were similar or higher than the biometric indexes seedlings grown on the 10^{-9}M water solution of phytohormones auxins IAA and NAA used at the same concentration as compared to lower biometric indexes seedlings grown on the distilled water (control). The results of stimulating effect of the heterocyclic compounds on the biometric indexes of 20th-day-old wheat seedlings are shown on the Fig 4.

Particularly it was found that the biometric indexes of wheat seedlings grown on the 10^{-9}M water solution of compound №1 - 7-amino-2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidine were as generally higher than the biometric indexes of wheat seedlings grown either on the distilled water (control) or on the 10^{-9}M water solution of auxins IAA and NAA as follows: according with length of seedlings – at the 17% as compared with control; according with total length of roots – at the 32% as compared with control; according with total number of roots – at the 85%, 51% and 20% as compared with control, IAA and NAA, respectively (Fig. 4).

The biometric indexes of 20th-day-old wheat seedlings grown on the 10^{-9}M water solution of the compound №2 - 2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one were as generally higher than the biometric indexes of wheat seedlings grown either on the distilled water (control)) or on the 10^{-9}M water solution of auxins IAA and NAA as follows: according with length of seedlings – at the 13% as compared with control; according with total length of roots – at the 89%, 45% and 34% as compared with control, IAA and NAA, respectively; according with total number of roots – at the 30% as compared with control (Fig. 4).

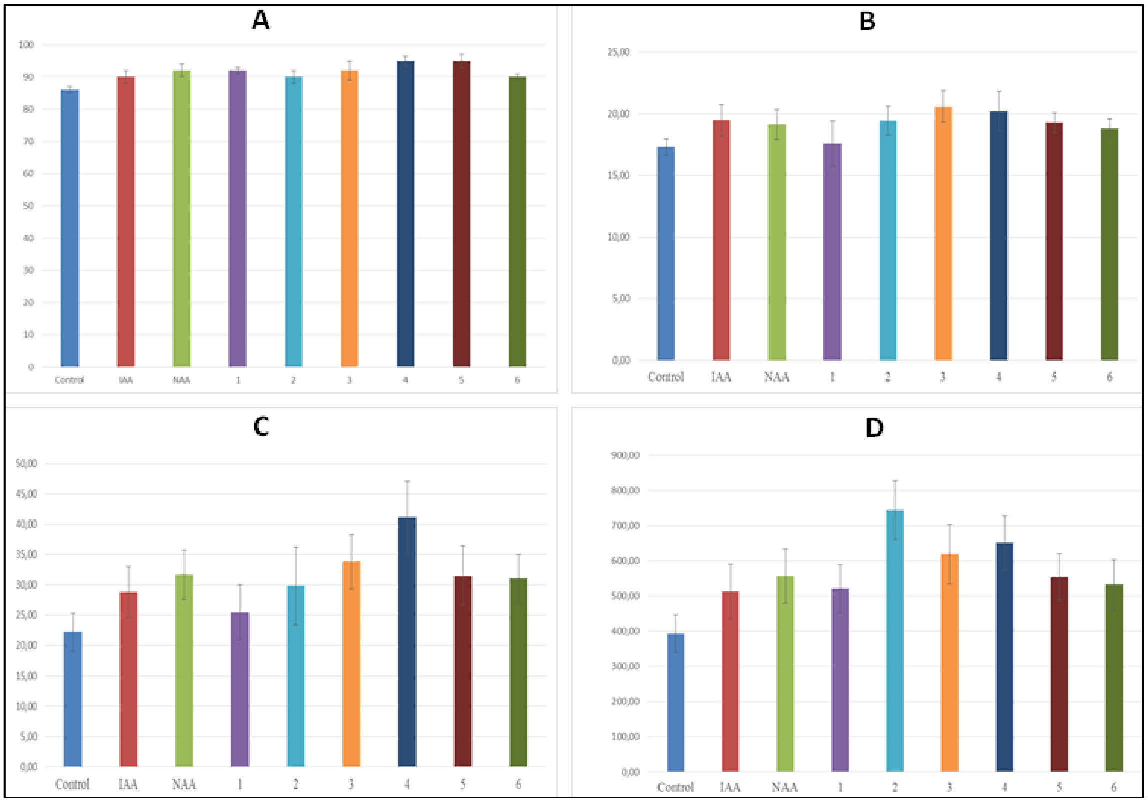


Fig 4: Impact of chemical heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine (№1 - 7-amino-2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidine, №2 - 2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, №3 - 5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine), compounds derivatives of N-sulfonyl substituted of 1,3-oxazole (№5 - 2-phenyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile and №6 - 2-tolyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile), and phytohormones auxins IAA and NAA on the biometric indexes of 20th-day-old wheat seedlings
A – number of germinated seeds (%), B – length of seedlings (cm), C – total number of roots (pcs), D – total length of roots (mm)

The biometric indexes of wheat seedlings grown on the 10^{-9}M water solution of compound №3 - 5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one were as generally higher than the biometric indexes of wheat seedlings grown either on the distilled water (control) or on the 10^{-9}M water solution of auxins IAA and NAA as follows: according with length of seedlings – at the 20%, 6% and 8% as compared with control, IAA and NAA, respectively; according with total length of roots – at the 57%, 21% and 11% as compared with control, IAA and NAA, respectively; according with total number of roots – at the 57%, 24% and 16% as compared with control, IAA and NAA, respectively (Fig. 4).

The biometric indexes of wheat seedlings grown on the 10^{-9}M water solution of compound №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine were as generally higher than the biometric indexes of wheat seedlings grown either on the distilled water (control) or on the 10^{-9}M water solution of auxins IAA and NAA as follows: according with length of seedlings – at the 16% as compared with control; according with total length of roots – at the 66%, 27% and 17% as compared with control, IAA and NAA; according with total number of roots – at the 65%, 31% and 23% as compared with control, IAA and NAA, respectively (Fig. 4).

The biometric indexes of wheat seedlings grown on the 10^{-9}M water solution of compound №5 - 2-phenyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile were as generally higher than the biometric indexes of wheat seedlings grown either on the distilled water (control) or on the 10^{-9}M water solution of auxin IAA as follows: according with length of seedlings – at the 13% as compared with control; according with total length of roots – at the 41% and 8% as compared with control and IAA, respectively; according with total number of roots – at the 53% as compared with control (Fig. 4).

The biometric indexes of wheat seedlings grown on the 10^{-9}M water solution of compound №6 - 2-tolyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile were as generally higher than the biometric indexes of wheat seedlings grown on the distilled water (control) as follows: according with length of seedlings – at the 10% as compared with control; according with total length of roots – at the 36% as compared with control; according with total number of roots – at the 10% as compared with control (Fig. 4).

Thus, the comparative analysis of biometric indexes of 20th-day-old wheat seedlings grown on the 10^{-9}M water solution of heterocyclic compounds showed that the highest growth stimulating activity from tested compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine revealed compounds: №3 - 5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one and №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine. The obtained results obviously may be explained by the presence of different substituents at the 7th position of pyrimidine fragment: of oxygen - at the compound №3 or amino group - at the compound №4, respectively.

At the same time the compounds №1 - 7-amino-2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidine and №2 - 2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one revealed lower growth stimulating activity on the wheat seedlings.

These compounds that are derivatives of the compounds №3 and №4 contain also phenyl substituent at the 5th position and amino group at the 7th position of pyrimidine fragment.

Obviously that growth stimulating activity of compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine may be depended from substituents at the 5th and 7th positions of pyrimidine fragment.

The results of our experiments showed that the minor growth stimulating activity on the wheat seedlings demonstrated compounds derivatives of N-sulfonyl substituted of 1,3-oxazole: compound №5 - 2-phenyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile and compound №6 – 2- tolyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile, which was not significantly differed between these compounds, therefore correlation between chemical structure and biological activity has not been found in these compounds.

3.3 Stimulating effect of chemical heterocyclic compounds and auxins IAA and NAA on the growth and development of flax seedlings

In our laboratory experiments we also studied stimulating effect of chemical heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and N-sulfonyl substituted of 1,3-oxazole as well as phytohormones auxins IAA and NAA on the growth and development of flax (*Linum usitatissimum* L.) of cultivar Svitanok. Our results demonstrated that all tested heterocyclic compounds and phytohormones auxins IAA and NAA used in concentration 10^{-9}M/l of distilled water revealed high stimulating effect on the germination of seeds and growth of 20th-day-old flax seedlings, and on the formation of their root system (Fig. 5).

Fig 5: Impact of chemical heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine (№1 - 7-amino-2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidine, №2 - 2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, №3 - 5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine), compounds derivatives of N-sulfonyl substituted of 1,3-oxazole (№5 - 2-phenyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile and №6 - 2-tolyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile), and phytohormones auxins IAA and NAA on the root formation of the 20th-day-old flax seedlings as compared to control (C) flax seedlings

The comparative analysis of biometric indexes of 20th-day-old flax seedlings (i.e. number of germinated seeds (%), length of seedlings (cm), total number of roots (pcs), total length of roots (mm)) showed that the biometric indexes of seedlings grown on the 10^{-9}M water solution of chemical heterocyclic compounds were similar or higher than the biometric indexes seedlings grown on the 10^{-9}M water solution of phytohormones auxins IAA and NAA used at the same concentration as compared to lower biometric indexes seedlings grown on the distilled water (control). The results of impact of the heterocyclic compounds on the biometric indexes of 20th-day-old flax seedlings are shown on the Fig. 6.

Particularly it was found that the biometric indexes of flax seedlings grown on the 10^{-9}M water solution of compound №1 - 7-amino-2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidine were as generally higher than the biometric indexes of flax seedlings grown either on the distilled water (control) or on the 10^{-9}M water solution of auxins IAA and NAA as follows: according with total length of roots – at the 46%, 10% as compared with control and IAA, respectively; according with total number of roots – at the 66%, 18% and 4% as compared with control, IAA and NAA, respectively (Fig. 6).

The biometric indexes of flax seedlings grown on the 10^{-9}M water solution of compound №2 - 2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one were as generally higher than the biometric indexes of flax seedlings grown either on the distilled water (control) or on the 10^{-9}M water solution of auxins IAA and NAA as follows: according with total length of roots – at the 24% as compared with control; according with total number of roots – at the 66%, 18% and 4% as compared with control, IAA and NAA, respectively (Fig. 6).

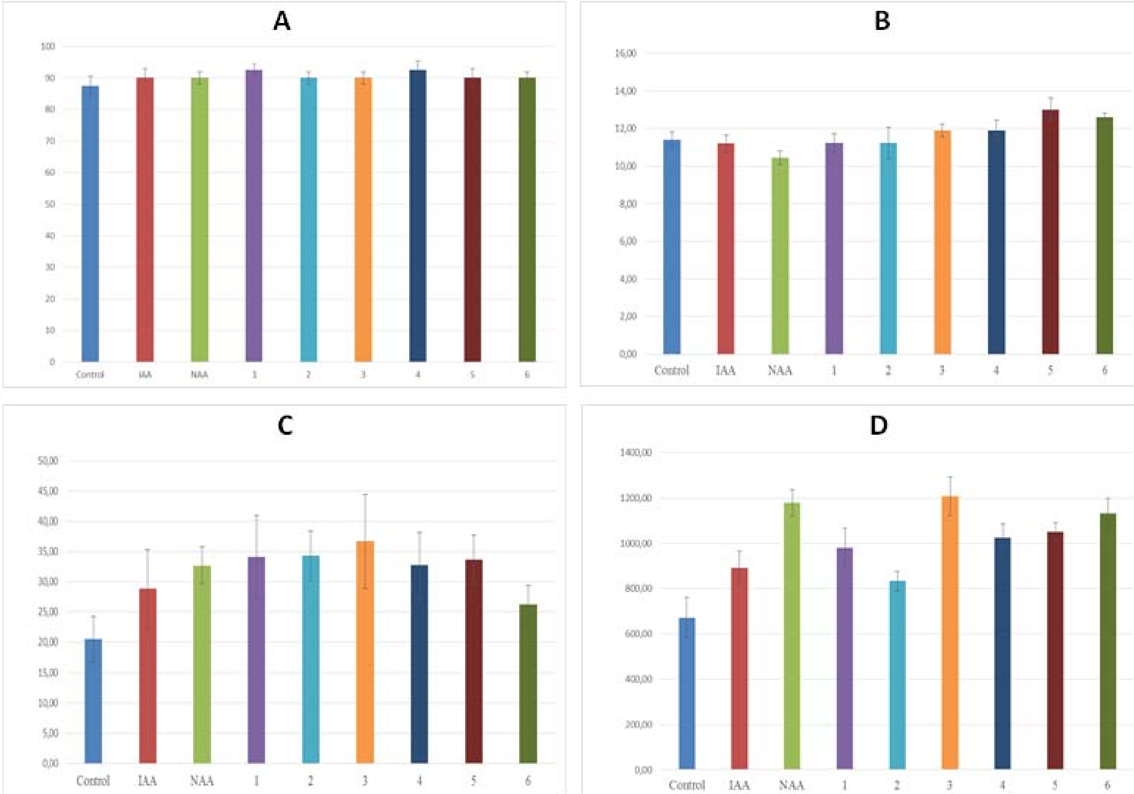


Fig 6: Impact of chemical heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine (№1 - 7-amino-2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidine, №2 - 2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, №3 - 5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine), compounds derivatives of N-sulfonyl substituted of 1,3-oxazole (№5 - 2-phenyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile and №6 - 2-tolyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile), and phytohormones auxins IAA and NAA on the biometric indexes of 20th-day-old flax seedlings
A – number of germinated seeds (%), B – length of seedlings (cm), C – total number of roots (pcs), D – total length of roots (mm)

The biometric indexes of flax seedlings grown on the 10^{-9}M water solution of compound №3 - 5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one were as generally higher than the biometric indexes of flax seedlings grown either on the distilled water (control) or on the 10^{-9}M water solution of auxins IAA and NAA as follows: according with total length of roots – at the 80% та 35% and 3% as compared with control, IAA and NAA, respectively; according with total number of roots – at the 79%, 27% and 12% as compared with control, IAA and NAA, respectively (Fig. 6).

The biometric indexes of flax seedlings grown on the 10^{-9}M water solution of compound №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine were as generally higher than the biometric indexes of flax seedlings grown either on the distilled water (control) or on the 10^{-9}M water solution of auxins IAA and NAA as follows: according with total length of roots – at the 53% and 15% as compared with control and IAA, respectively; according with total number of roots – at the 60% та 14% as compared with control and IAA, respectively (Fig. 6).

The biometric indexes of flax seedlings grown on the 10^{-9}M water solution of compound №5 - 2-phenyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile were as generally higher than the biometric indexes of flax seedlings grown either on the distilled water (control) or on the 10^{-9}M water solution of auxins IAA and NAA as follows: according with length of seedlings – at the 14%, 16% and 24% as compared with control, IAA and NAA, respectively; according with total length of roots – at the 56% and 18% as compared with control and IAA, respectively; according with total number of roots – at the 64% and 17% as compared with control and IAA, respectively (Fig. 6).

The biometric indexes of flax seedlings grown on the 10^{-9}M water solution of compound №6 - 2-tolyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile) were as generally higher than the biometric indexes of flax seedlings grown either on the distilled water (control) or on the 10^{-9}M water solution of auxins IAA and NAA as follows: according with length of seedlings – at the 11%, 13% and 21% as compared with control, IAA and NAA, respectively; according with total length of roots – at the 68% and 27% as compared with control and IAA, respectively; according with total number of roots – at the 28% as compared with control (Fig. 6).

The obtained results of biometric indexes of 20th-day-old flax seedlings witness that the highest growth stimulating activity showed compound derivative of [1,3]oxazolo[5,4-*d*]pyrimidine: №3 - 5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one. Possibly, the high stimulating effect of this compound on the growth of flax seedlings may be explained by the presence 4-ethylphenyl substituent at the 5th position and oxygen at the 7th position of pyrimidine fragment of this compound.

At the same time the compound №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine, which contains amino group at the 7th position of pyrimidine fragment, and compound №2 - 2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, which contains phenyl substituent at the 5th position of pyrimidine fragment, revealed lower activity than the compound №3.

Obviously that growth stimulating activity of compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine may be depended from substituents at the 5th and 7th positions of pyrimidine fragment.
Among the compounds derivatives of and N-sulfonyl substituted of 1,3-oxazole the highest growth stimulating activity revealed compound №5 - 2-phenyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile, which contains phenyl substituent at the 2th position of oxazole.
At the same time, the compound №6 - 2-tolyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile, which contains tolyl substituent at the 2th position of oxazole, showed lower activity. Thus, the growth stimulating activity of these compounds may be depended from the presence of different substituents at the 2th position of oxazole.

3.4 Stimulating effect of synthetic heterocyclic compounds on the growth of biomass of the isolated cotyledons of pumpkin

In our researches we also studied stimulating effect of heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and N-sulfonyl substituted of 1,3-oxazole on the growth of muscat pumpkin (*Cucurbita moschata* Duch. et Poir.) of cultivar Gilea using specific bioassay on cytokinin-like activity conducted on the isolated cotyledons of this plant.
It was found that according to indexes of growth of biomass of the isolated cotyledons of pumpkin during the 16 days all tested compounds used in concentration 10^{-9}M/l of distilled water showed expressive cytokinin-like activity, which was similar or higher than the activity of phytohormone cytokinin Kinetin used in the same concentration.
The comparative analysis of biomass of the isolated cotyledons of pumpkin showed that the highest growth stimulating activity revealed compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine: №2 - 2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one and №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimi-dine, and compound derivative of N-sulfonyl substituted of 1,3-oxazole: №6 - 2- tolyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile (Fig. 7).

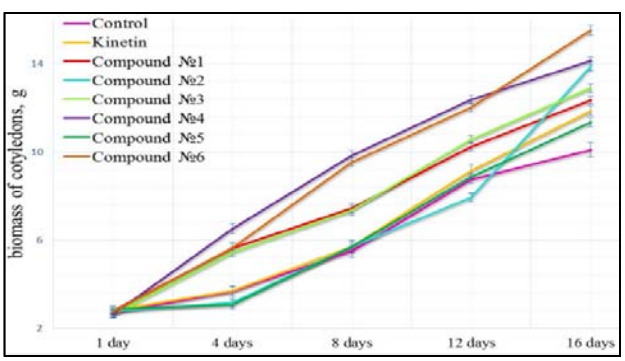


Fig 7: Impact of chemical heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine (№1 - 7-amino-2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidine, №2 - 2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, №3 - 5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine), compounds derivatives of N-sulfonyl substituted of 1,3-oxazole (№5 - 2-phenyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile and №6 - 2-tolyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile), and phytohormone cytokinin Kinetin on the growth of biomass of the isolated cotyledons of pumpkin during the 16 days with the interval of each 4 day

Among the compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine the compound №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine, which contains amino group at the 7th position of pyrimidine fragment, showed the highest activity; the indexes of growth of biomass of the isolated cotyledons of pumpkin grown on the 10^{-9}M water solution of compound №4 were higher at the 40% and 19% than the indexes of growth of biomass of the isolated cotyledons of pumpkin grown either on the distilled water (control) or on the 10^{-9}M water solution of cytokinin Kinetin, respectively (Fig. 7).
The high activity demonstrated also compound №2 - 2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, which contains phenyl substituent at the 5th position of pyrimidine fragment; the indexes of growth of biomass of the isolated cotyledons of pumpkin grown on the 10^{-9}M water solution of compound №2 were higher at the 38% and 17% than the indexes of growth of biomass of the isolated cotyledons of pumpkin grown either on the distilled water (control) or on the 10^{-9}M water solution of cytokinin Kinetin, respectively (Fig. 7).
The lower activity showed compound №3 - 5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, which contains 4-ethylphenyl substituent at the 5th position and oxygen at the 7th position of pyrimidine fragment; the indexes of growth of biomass of the isolated cotyledons of pumpkin grown on the 10^{-9}M water solution of compound №3 were higher at the 28% and 9% than the indexes of growth of biomass of the isolated cotyledons of pumpkin grown either on the distilled water (control) or on the 10^{-9}M water solution of cytokinin Kinetin, respectively (Fig. 7).
The lower activity showed also compound №1 - 7-amino-2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidine, which contains phenyl substituent at the 5th position and amino group at the 7th position of pyrimidine fragment; the indexes of growth of biomass of the isolated cotyledons of pumpkin grown on the 10^{-9}M water solution of compound №1 were higher at the 22% and 4% than the indexes of growth of biomass of the isolated cotyledons of pumpkin grown either on the distilled water (control) or on the 10^{-9}M water solution of cytokinin Kinetin, respectively (Fig. 7).
Among the compounds derivatives of N-sulfonyl substituted of 1,3-oxazole the compound №6 – 2-tolyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile that contains tolyl substituent at the 2th position of oxazole, showed highest activity; the indexes of growth of biomass of the isolated cotyledons of pumpkin grown on the 10^{-9}M water solution of compound №6 were higher at the 54% and 31% than the indexes of growth of biomass of the isolated cotyledons of pumpkin grown either on the distilled water (control) or on the 10^{-9}M water solution of cytokinin Kinetin, respectively (Fig. 7).
At the same time the compound №5 - 2-phenyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile that contains phenyl substituent at the 2th position of oxazole revealed lower activity; the indexes of growth of biomass of the isolated cotyledons of pumpkin grown on the 10^{-9}M water solution of compound №5 were higher at the 23% than the indexes of growth of biomass of the isolated cotyledons of pumpkin grown on the distilled water (control) (Fig. 7).
Obviously that the growth stimulating cytokinin-like activity of compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine may be depended from substituents at the 5th and 7th positions of pyrimidine fragment, while as activity of compounds

derivatives of N-sulfonyl substituted of 1,3-oxazole may be depended from substituents at the 2th position of oxazole.

4. Discussion

Today the numerous studies are devoted to impact of different classes of regulatory compounds of synthetic or natural origin as well as organic and mineral fertilizers for improving of growth and increase of productivity of important for agriculture crops such as soybean [71-74], wheat [75-81], flax [82-86] and pumpkin [87, 88]. The new promising approach is the elaboration of new classes of regulatory substances created on the base of low molecular weight heterocyclic compounds as effective environmentally safe substitutes of phytohormones and traditional plant growth regulators for acceleration of growth of these crops and improving quality of production.

Our previous researches confirmed high stimulating effect of heterocyclic compounds derivatives of pyridine, pyrimidine, pyrazole and isoflavones on shoot organogenesis of flax *in vitro* and on vegetative growth of maize [58, 89]. At the same time numerous literature data witness about widespread application in the agricultural practice of different classes of low molecular weight heterocyclic compounds derivatives of pyridine, pyrimidine, pyrazole, triazine, oxazole, oxazolo-pyrimidine and isoflavones as new effective plant growth regulators, herbicides, fungicides and antibacterial agents [15-25, 96-107]. Taking into account the results of our previous researches and literature data the great theoretical and practical interest is study the possibility of using of low molecular weight heterocyclic compounds for intensification of growth and development of soybean, wheat, flax and pumpkin plants.

The results of this work indicate that low molecular weight five and six-membered heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and N-sulfonyl substituted of 1,3-oxazole used at very low concentration 10^{-9}M/l of distilled water demonstrated high auxin-like and cytokinin-like stimulating effect on the growth of the important for agriculture crops such as soybean, wheat, flax and pumpkin. It was found that growth stimulating activity of these compounds was various depending on plant species and different substituents in the chemical structure of heterocyclic compounds.

Study of stimulating activity of heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and N-sulfonyl substituted of 1,3-oxazole on the growth of 20th-day-old seedlings of soybean (*Glycine max* L.) of cultivar Valuta showed that highest activity revealed compounds №3 - 5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine and №5 - 2-phenyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile.

Obviously, high growth stimulating activity of these compounds may be explained by the presence of phenyl substituents at the 5th and 7th positions of pyrimidine fragment in the compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and presence of phenyl substituent at the 2nd position of oxazole in the compounds derivatives of N-sulfonyl substituted of 1,3-oxazole.

Comparative analysis of stimulating activity of heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and N-sulfonyl substituted of 1,3-oxazole on the growth of wheat (*Triticum aestivum* L.) of cultivar Zimoyarka indicated that highest activity revealed compounds: №3 - 5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, which contains oxygen at the 7th position of pyrimidine fragment and №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine, which contains amino group at the 7th position of pyrimidine fragment of oxazole. Obviously, growth stimulating activity of compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine may be depended from substituents at the 5th and 7th positions of pyrimidine fragment.

Investigation of stimulating activity of heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and N-sulfonyl substituted of 1,3-oxazole on the growth of flax (*Linum usitatissimum* L.) of cultivar Svitanok showed that highest activity revealed compounds: №3 - 5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, which contains 4-ethylphenyl substituent at the 5th position and oxygen at the 7th position of pyrimidine fragment and №5 - 2-phenyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile, which contains phenyl substituent at the 2th position of oxazole. Possibly, the high stimulating effect of these compounds may be depended from substituents at the 5th and 7th positions of pyrimidine fragment in the compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and substituents at the 2th position of oxazole in the compounds derivatives N-sulfonyl substituted of 1,3-oxazole.

Specific bioassay on cytokinin-like activity showed that among heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and N-sulfonyl substituted of 1,3-oxazole the highest stimulating effect on the growth of biomass of isolated cotyledons of muscat pumpkin (*Cucurbita moschata* Duch. et Poir.) of cultivar Gilea demonstrated compounds: №2 - 2,5-diphenyl[1,3]oxazolo[5,4-*d*]pyrimidin-7(6*H*)-one, which contains phenyl substituent at the 5th position of pyrimidine fragment, №4 - 7-amino-5-(4-ethylphenyl)-2-phenyl[1,3]oxazolo[5,4-*d*]pyrimidine, which contains amino group at the 7th position of pyrimidine fragment, and №6 - 2-tolyl-5-(piperidin-1-ylsulfonyl)-1,3-oxazole-4-carbonitrile, which contains tolyl substituent at the 2th position of oxazole.

Obviously, the growth stimulating cytokinin-like activity of these compounds may be depended from substituents at the 5th and 7th positions of pyrimidine fragment in the compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine, while as activity of compounds derivatives of N-sulfonyl substituted of 1,3-oxazole may be depended from substituents at the 2th position of oxazole.

5. Conclusion

The stimulating activity of low molecular weight five and six-membered heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and N-sulfonyl substituted of 1,3-oxazole on the growth of soybean (*Glycine max* L.) of cultivar Valuta, wheat (*Triticum aestivum* L.) of cultivar Zimoyarka, flax (*Linum usitatissimum* L.) of cultivar Svitanok plants and growth of biomass of isolated cotyledons of muscat pumpkin (*Cucurbita moschata* Duch. et Poir.) of cultivar Gilea was studied. According to obtained biometric indexes of plant growth and growth of biomass of isolated cotyledons it was shown that heterocyclic compounds used in concentration 10^{-9}M/l of distilled water demonstrated auxin- and cytokinin-like activity, which was similar or higher than the activity of phytohormones auxins IAA and NAA, and cytokinin Kinetin. The growth stimulating activity of these compounds was various depending on plant species and different substituents in the chemical structure of heterocyclic compounds. Obtained data confirmed the possibility of practical application in the agricultural industry of heterocyclic compounds derivatives of [1,3]oxazolo[5,4-*d*]pyrimidine and N-sulfonyl substituted of 1,3-oxazole as new effective stimulators of growth and development of soybean, wheat, flax and pumpkin plants.

6. References

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