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Use Of Synthetic Plant Growth Regulators In Combination With Fertilizers to Improve Wheat Growth

Research Article

Tsygankova V.A.[1*], Andreev A.M.[1], Andrusevich Ya.V.[1], Pilyo S.G.[1], Klyuchko S.V.[1], Brovarets V.S.[1]

[1] Department for Chemistry of Bioactive Nitrogen-Containing Heterocyclic Compounds, V.P. Kukhar Institute of Bioorganic Chemistry and Petrochemistry, National Academy of Sciences of Ukraine, 1, Academician Kukhar str., 02094, Kyiv, Ukraine.

Abstract

An urgent task of modern agricultural biotechnology is the development of new environmentally friendly plant growth regulators to improve the growth and increase the yield of the important cereal crop wheat (*Triticum aestivum* L.). In our experiments, the effect of new synthetic plant growth regulators Methyur, Kamethur and Ivin, as well as Rostok Extra and Radix Tim forte plus fertilizers, applied separately or in combination, on the growth parameters of 30-day-old winter wheat (*Triticum aestivum L.*) variety Shestopalivka was studied.The highest values of growth parameters of wheat plants were obtained with the separate use of each of the synthetic plant growth regulators Methyur, Kamethur and Ivin, as well as fertilizer Radix Tim forte plus, or with the use of each of the synthetic plant growth regulators in a complex with fertilizers: Methyur with Rostok extra, Kamethur with Rostok extra, Methyur with Radix Tim forte plus, Kamethur with Radix Tim forte plus, Ivin with Radix Tim forte plus. To improve the vegetative growth of winter wheat (*Triticum aestivum* L.) variety Shestopalivka, it is suggested to use each of the synthetic plant growth regulators Methyur, Kamethur and Ivin separately or in combination with Rostok Extra and Radix Tim forte plus fertilizers.

Keywords: Wheat (*Triticum aestivum* L.); Synthetic Plant Growth Regulators; Ivin; Methyur; Kamethur; Fertilizers; Rostok Extra; Radix Tim Forte Plus.

Introduction

An urgent problem of the modern agricultural biotechnology is the development of new efficient and environmentally friendly technologies for growing wheat - the most important grain crop for obtaining organic agricultural products and reducing environmental pollution [1-4].

Hans Braun, Head of the Global Wheat Program at the International Maize and Wheat Improvement Center (CIMMYT), predicts a coming food crisis, as world population rises to 9.2 billion people by 2050, especially in developing countries, Africa and South Asia [5]. He talks about the need for a "new green revolution" because he says that population growth is likely to outstrip wheat yields and calls for increased investment in wheat and other cereal crops to keep up with future demand.

Global climate change and abiotic and biotic stresses are key negative factors affecting agricultural crop production worldwide [6-9]. Currently, in order to solve this urgent problem, natural or synthetic plant growth regulators and fertilizers are used to improve the life processes of agricultural crops, namely for better assimilation of nutrients, improvement of plant growth and photosynthetic efficiency, which contributes to increased yield and plant's resistance to abiotic and biotic stress factors, and also allows the plant to make the most of its natural potential in the growth process [10-23]. The use of natural or synthetic plant growth regulators and fertilizers is one of the promising areas of the agricultural biotechnology, which will contribute to improving the quality of products, increasing the yield and plant stress tolerance, and economic efficiency of growing wheat crops [10-17, 20-23].The use of ecologically safe natural or synthetic growth regulators and fertilizers will help reduce the use of pesticides and fungicides that are toxic to human and animal health, improve the balance of natural ecosystems and the phytosanitary condition

***Corresponding Author**:
Tsygankova V.A,
Department for Chemistry of Bioactive Nitrogen-Containing Heterocyclic Compounds, V.P. Kukhar Institute of Bioorganic Chemistry and Petrochemistry, National Academy of Sciences of Ukraine, 1, Academician Kukhar str., 02094, Kyiv, Ukraine.
E-mail: vTsygankova@ukr.net

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of the soil, and improve the ecological condition of the entire agricultural system [24-29].

In modern conditions of growing shortage of food products and the need to increase the productivity of wheat crops against the background of adverse environmental factors, climate change, systemic depletion of soils, high prices for fertilizers and their shortage, negative balance of macro- and microelements, the creation of new multifunctional plant growth regulators is a very urgent task. Achievements in the field of preservation and improvement of the environment and sustainable development lie in the possibility of developing new plant growth regulators based on synthetic low molecular weight heterocyclic compounds, in particular, pyridine and pyrimidine derivatives.Today, pyridine and pyrimidine derivatives are widely used in agriculture as plant growth regulators, herbicides and fungicides [30-39].

The new plant growth regulators based on synthetic compounds, derivatives of N-oxide-2,6-dimethylpyridine (Ivin) and 6-methyl-2-mercapto-4-hydroxypyrimidine sodium and potassium salts (Methyur and Kamethur) were developed at the V.P. Kukhar Institute of Bioorganic Chemistry and Petrochemistry, of the NAS of Ukraine.These plant growth regulators have already been tested in laboratory and field conditions and have shown high efficiency in improving the growth of various agricultural and ornamental crops, increasing their productivity and adaptive properties to stress factors of abiotic and biotic nature [17-37, 40-45]. The advantage of their practical application is the wide specificity of the action on various agricultural crops when used in low environmentally friendly concentrations.This advantage makes it possible to reduce the negative impact of ecologically toxic pesticides and fungicides created on the basis of chemical compounds of other classes, the excess amount of which accumulates in the soil and in agricultural plants, which are products of human and animal consumption [24-29, 46].

The purpose of this work is to study the impact of new synthetic plant growth regulators based on pyridine and pyrimidine derivatives and their complexes with fertilizers on the growth and development of important cereal crop wheat (*Triticum aestivum* L.).

Materials and Methods

In our work, we investigated the regulatory effect of synthetic plant growth regulators based on pyridine and pyrimidine derivatives: Ivin (N-oxide-2,6-dimethylpyridine), Methyur (sodium salt of 6-methyl-2-mercapto-4-hydroxypyrimidine) and Kamethur (potassium salt of 6-methyl-2-mercapto-4-hydroxypyrimidine), which were used alone or in combination with fertilizers Rostok Extra and Radix Tim forte plus on the growth and development of winter wheat (*Triticum aestivum* L.) variety Shestopalivka grown in laboratory conditions.

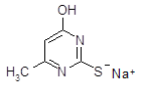
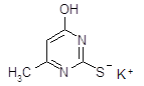
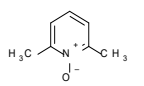
Plant growth regulators Methyur, Kamethur and Ivin were synthesized at the Department for Chemistry of Bioactive Nitrogen-Containing Heterocyclic Compounds, V.P. Kukhar Institute of Bioorganic Chemistry and Petrochemistry of the National Academy of Sciences of Ukraine (Table 1).

Fertilizer Rostok Extra produced by the LLc "Ukrainian Agrarian Resource" company is complex, liquid, chelated fertilizer intended for pre-sowing seed treatment, foliar fertilization and drip irrigation.It is a universal fertilizer that improves seed germination, plant resistance to stress factors, increases yield and improves the quality of products of most agricultural, vegetable, fruit and berry crops [47, 48]. Its chemical composition is as follows (g/l): Nitrogen (N) - 100, Phosphorus (P_2O_5) - 300, Potassium (K_2O) - 100, Magnesium (MgO) - 22, Sulfur (SO_3) - 55, trace elements (Mn - 10, B - 2, Zn - 25, Cu - 5), amino acids, humic substances [49].

Fertilizer Radix Tim forte plus produced by the "Forcrop" Company (Spain) is practically used as a root growth stimulator of fruit, berry, decorative and vegetable crops grown in open and closed soil, which provides the root system with activators and minerals for its proper development and rejuvenation, and also protects of the root system from stress and prevents the roots from fungal attacks that can harm its maximum development [50, 51]. It is used both for better rooting after transplanting and throughout the growing season of the plant to maintain the root system in a healthy and functional state. Its chemical composition is as follows (W/V): Nitrogen (N) - 3.7%, Potassium (K_2O) - 4.1% Phosphorus (P_2O_5) - 11.3%, free amino acids - 5.7%, trace elements (Zn, Mn, B, Mo and Fe) [50, 51].

To study the effect of synthetic plant growth regulators Methyur, Kamethur and Ivin, as well as fertilizers Rostok Extra and Radix Tim forte plus on the wheat growth and development, wheat seeds were treated with fertilizer Rostok Extra at a concentration

Table 1. Chemical structure and relative molecular weight of plant growth regulators Methyur, Kamethur and Ivin.

Plant growth regulator	Chemical structure	Chemical name and relative molecular weight
Methyur		Sodium salt of 6-methyl-2-mercapto-4-hydroxypyrimidine MW=165.17
Kamethur		Potassium salt of 6-methyl-2-mercapto-4-hydroxypyrimidine MW=181.28
Ivin		N-oxide-2,6-dimethylpyridine MW=125.17

of 100 ml per 1 liter of distilled water or fertilizer Radix Tim forte plus at a concentration of 50 ml per 1 liter of distilled water, or each of the synthetic plant growth regulators: Methyur, or Kamethur, or Ivin at a concentration of 10^{-7}M per l liter of distilled water, or a combination of each of the synthetic plant growth regulators Methyur, or Kamethur, or Ivin with the fertilizers Rostok Extra and Radix Tim forte plus used in the above mentioned concentrations. The treated seeds were placed in a thermostat for germination in the dark at a temperature 22-23°C for 48 hours. After this procedure, germinated wheat seeds were placed in a climatic chamber, where wheat seedlings were grown in a light/dark regime of 16/8 hours, at a temperature of 22-23 °C, a light intensity of 3000 lux and an air humidity of 60-80 %. The growth parameters of wheat plants (average length of the shoots and roots (cm), average length of the longest root (cm), and average biomass of 10 plants (g)) were measured on the 30th day of growing wheat plants according to the methodology [52].

Statistical processing of the data of the experiments performed in three replications was carried out according to the Student's-t variance test with a significance level of $P \leq 0.05$; the values are average ± SD [53].

Results and Discussion

The main factor in increasing the quantity and quality of agricultural products is the rational use of each hectare of arable land, first of all due to a scientifically based fertilization system. According to the FAO, Western Europe and the USA get a third of their crops due to the use of fertilizers [54]. The implementation of intensive technologies for the introduction of fertilizers into agricultural practice will allow obtaining high yields with good product quality in almost all climatic zones [13, 18-20, 23, 47, 51, 54-56].

Today, there is a great demand for new effective natural or synthetic plant growth regulators that show biological activity related to natural phytohormones to improve the growth and development of the important cereal crop - wheat and increase its yield [10-12, 14-17, 21, 22].

In our previous studies, conducted in laboratory and field conditions, the stimulating effect of the new synthetic plant growth regulators Ivin (N-oxide-2,6-dimethylpyridine), Methyur (sodium salt of 6-methyl-2-mercapto-4-hydroxypyrimidine) and Kamethur (potassium salt of 6-methyl-2-mercapto-4-hydroxypyrimidine) on improving the growth and development of grain, industrial and ornamental crops (corn, barley, oats, sorghum, miscanthus, rose), increasing their productivity as well as their adaptation to abiotic stress factors was shown [17, 37, 40-45]. Thus, a very promising issue is the study of the effect of synthetic plant growth regulators Methyur, Kamethur and Ivin used alone or in combination with fertilizers Rostok Extra and Radix Tim forte plus, on the growth and development of an important cereal crop – wheat. It is this issue that was studied in the present work.

The results of our experiments have shown that both the synthetic plant growth regulators Methyur, Kamethur and Ivin, as well as the Rostok Extra and Radix Tim forte plus fertilizers, which were used separately or in combination have a positive effect on the growth and development of shoots and roots of winter wheat (*Triticum aestivum* L.) variety Shestopalivka, which was grown for 30 days under laboratory conditions (Fig. 1).

Statistical analysis of growth parameters of 30-day-old wheat plants showed that the parameters of the average length of shoots (cm) increased both with the separate application of fertilizers: Radix Tim forte plus - by 34.38% and Rostok Extra - by 25.68%, or plant growth regulators: Ivin - by 37.89%, Methyur - by 48.82 %, Kamethur – by 53.22%, as well as with complex application of fertilizers with plant growth regulators: Ivin+Radix Tim forte plus – by 18.55%, Ivin+Rostok Extra – by 15.04%, Methyur+Radix Tim forte plus – by 53.91%, Methyur+Rostok Extra – by 34.67%, Kamethur+Radix Tim forte plus – by 52.05%, Kamethur+Rostok Extra – by 39.16%, respectively, compared to similar parameters of control wheat plants (Fig. 2).

The parameters of the average length of roots (cm) increased

Figure 1. The effect of plant growth regulators Methyur, Kamethur, Ivin and fertilizers Rostok Extra and Radix Tim forte plus on the growth of shoots and roots of 30-day-old winter wheat (*Triticum aestivum L.*) variety Shestopalivka.

both with the separate application of fertilizer: Radix Tim forte plus - by 67.58% or plant growth regulators: Ivin - by 72.80%, Methyur - by 58.84 %, Kamethur – by 153.28%, as well as with complex application of fertilizers with plant growth regulators: Ivin+Radix Tim forte plus – by 44.54%, Methyur+Radix Tim forte plus – by 18.32%, Methyur+Rostok Extra – by 12.54%, Kamethur+Radix Tim forte plus – by 78.72%, Kamethur+Rostok Extra – by 17.27%, respectively, compared to similar parameters of control wheat plants (Fig. 3).

The parameters of the average length of the longest root (cm) increased both with the separate application of fertilizer: Radix Tim forte plus - by 75.17% or plant growth regulators: Ivin - by 73.64%, Methyur - by 120.23%, Kamethur – by 160.33%, as well as with complex application of fertilizers with plant growth regulators: Ivin+Radix Tim forte plus – by 51.20%, Ivin+Rostok Extra – by 23.73%, Methyur+Radix Tim forte plus – by 86.70%, Methyur+Rostok Extra – by 44.94%, Kamethur+Radix Tim forte plus – by 91.42%, Kamethur+Rostok Extra – by 15.08%, respectively, compared to similar parameters of control wheat plants (Fig. 4).

The parameters of the average biomass of 10 plants (g) increased both with the separate application of fertilizers: Radix Tim forte plus - by 28.85% and Rostok Extra – by 57.69%, or plant growth regulators: Ivin - by 28.85%, Methyur - by 17.31%, Kamethur – by 23.08%, as well as with complex application of fertilizers with plant growth regulators: Ivin+Radix Tim forte plus – by 21.15%, Ivin+Rostok Extra – by 15.38%, Methyur+Radix Tim forte plus – by 25%, Methyur+Rostok Extra – by 30.77%, Kamethur+Radix Tim forte plus – by 38.46%, Kamethur+ Rostok Extra – by 17.31%, respectively, compared to similar parameters of control wheat plants (Fig. 5).

Thus, summarizing the obtained data, it should be noted that the highest values of growth parameters of wheat plants were obtained with the separate use of each of the synthetic plant growth regulators Methyur, Kamethur and Ivin, as well as fertilizer Radix

Figure 2. The effect of plant growth regulators Methyur, Kamethur, Ivin and fertilizers Rostok Extra and Radix Tim forte plus on the average length of shoots (cm) of 30-day-old winter wheat (*Triticum aestivum L.*) variety Shestopalivka.

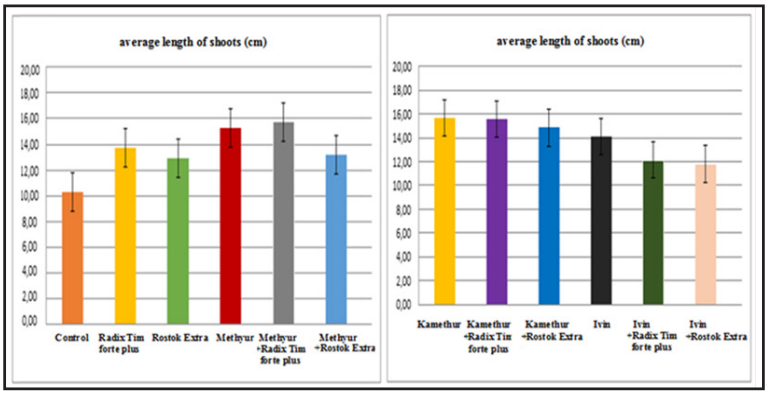


Figure 3. The effect of plant growth regulators Methyur, Kamethur, Ivin and fertilizers Rostok Extra and Radix Tim forte plus on the average length of roots (cm) of 30-day-old winter wheat (*Triticum aestivum L.*) variety Shestopalivka.

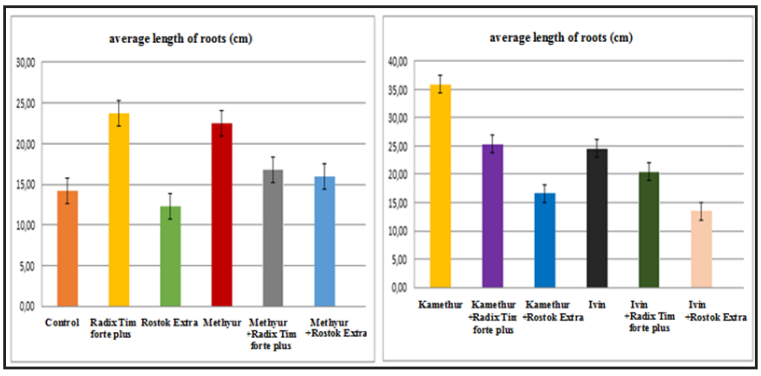


Figure 4. The effect of plant growth regulators Methyur, Kamethur, Ivin and fertilizers Rostok Extra and Radix Tim forte plus on the average length of the longest root (cm) of 30-day-old winter wheat (*Triticum aestivum L.*) variety Shestopalivka.

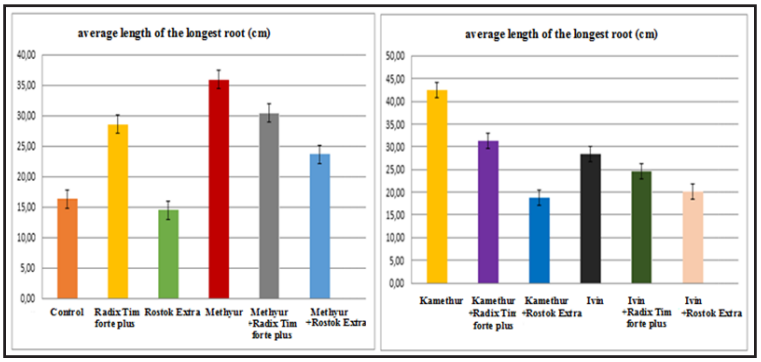
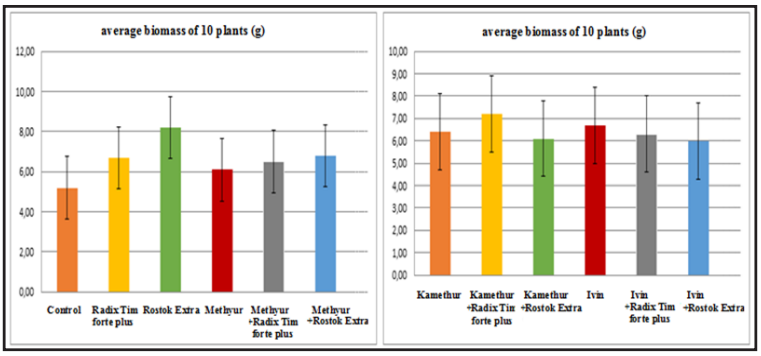


Figure 5. The effect of plant growth regulators Methyur, Kamethur, Ivin and fertilizers Rostok Extra and Radix Tim forte plus on the average biomass of 10 plants (g) of 30-day-old winter wheat (*Triticum aestivum L.*) variety Shestopalivka.



Tim forte plus, or with the use of each of the synthetic growth regulators in a complex with fertilizers: Methyur with Rostok extra, Kamethur with Rostok extra, Methyur with Radix Tim forte plus, Kamethur with Radix Tim forte plus, Ivin with Radix Tim forte plus.

Conclusion

The conducted studies showed the prospects of using synthetic plant growth regulators Methyur, Kamethur and Ivin, developed at the V.P. Kukhar Institute of Bioorganic Chemistry and Petrochemistry, of the NAS of Ukraine separately or in combination with fertilizers Rostok Extra produced by the LLc"Ukrainian Agrarian Resource Company" (Ukraine) and Radix Tim forte plus produced by the "Forcrop" Company (Spain) for improvement of growth and development of shoots and roots of winter wheat (*Triticum aestivum L.*) variety Shestopalivka during the vegetative stage.

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