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Proceeding Paper

Enhancing Sorghum Productivity with Methyur, Kamethur, and Ivin Plant Growth Regulators †

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Abstract: Sorghum is one of the most important foods, fodder, and technical crops grown in the world. Global climate change and environmental pollution with toxic industrial and agricultural waste are the most unfavorable environmental factors affecting the growth and development of sorghum, which leads to a decrease in product quality. The development of new environmentally friendly plant growth regulators to improve growth and increase the productivity of sorghum is an urgent task of modern agriculture. Currently, considerable attention is paid to the development of new environmentally friendly plant growth regulators based on 6-methyl-2-mercapto-4-hydroxypyrimidine sodium and potassium salts (Methyur and Kamethur) and N-oxide-2,6-dimethylpyridine (Ivin). Thanks to the use of plant growth regulators Methyur, Kamethur, and Ivin, it is possible to increase the productivity of agricultural crops and their adaptive properties to stress factors of abiotic nature. This work examines the use of plant growth regulators Methyur, Kamethur, and Ivin to increase the productivity of sorghum. Field experiments were carried out on grain sorghum (*Sorghum bicolor* L.) cv. Yarona and sweet sorghum (*Sorghum saccharatum* L.) cv. Favorite. Seeds sterilized with 1% $KMnO_4$ solution were treated either with distilled water (control sample) or with solutions of any plant growth regulators Methyur, Kamethur, or Ivin, applied at a concentration of 10^{-7} M for 24 h (experimental sample). Each control and experimental sample contained 50 plant seeds; the experiments were carried out in triplicate. Then the soaked seeds were planted in the soil. Yield indicators such as panicle length (in cm) and fresh weight of grain (in grams), determined in experimental samples of sorghum plants, were calculated as % in relation to similar indicators determined in control samples of sorghum plants. It was shown that the yield indicators of sorghum plants grown for 4 months in the field, treated with Methyur, Kamethur, and Ivin at a concentration of 10^{-7} M exceeded those of control plants. Panicle length (in %) of experimental grain sorghum (*Sorghum bicolor* (L.) Moench) cv. Yarona increased by 7%—in plants treated with Kamethur, 20%—in plants treated with Methyur, and 17%—in plants treated with Ivin, compared to the control. Panicle length (in %) of experimental sweet sorghum (*Sorghum saccharatum* (L.) Moench) cv. Favorite increased by 36%—in plants treated with Kamethur, 37%—in plants treated with Methyur, and by 25%—in plants treated with Ivin, compared to the control. Grain fresh weight (in %) of experimental grain sorghum (*Sorghum bicolor* (L.) Moench) cv. Yarona increased by 22%—in plants treated with Kamethur, 26%—in plants treated with Methyur, and 13%—in plants treated with Ivin, compared to the control. Grain fresh weight (in %) of experimental sweet sorghum (*Sorghum saccharatum* (L.) Moench) cv. Favorite increased by 24%—in plants treated with Kamethur, 38%—in plants treated with Methyur, and 35%—in plants treated with Ivin, compared to the control. Based on the results obtained, a conclusion was made about the high growth-stimulating effect of plant growth regulators, similar to the phytohormones auxins and cytokinin, and the dependence of their effect on their composition. It is proposed to use new environmentally friendly plant growth regulators Methyur, Kamethur, and Ivin to improve growth and increase the productivity of sorghum while reducing the use of

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environmentally toxic agrochemicals for plant protection and improving the environmental condition of the entire agricultural system.

Keywords: productivity of sorghum; plant growth regulators; Methyur; Kamethur; Ivin

1. Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the important cereal foods, fodder, and technical crops grown in many countries around the world [1,2]. Sorghum ranks fifth in the world after wheat, rice, corn, and barley. Currently, sorghum is grown on almost all continents; over the past 50 years, the sorghum sown areas in the world amount to almost 44 million hectares [2].

The main advantage of sorghum is its high drought tolerance and unpretentiousness to soils, which makes this crop especially important in the context of global climate change [3]. However, there are problems with growing sorghum under adverse environmental conditions; for this purpose, plant growth regulators are used to improve growth and increase the productivity of sorghum [4,5].

This article describes the results of our previous work [6], in which the effect of new plant growth regulators based on pyrimidine and pyridine derivatives, such as Methyur (sodium salt of 6-methyl-2-mercapto-4-hydroxypyrimidine), Kamethur (potassium salt of 6-methyl-2-mercapto-4-hydroxypyrimidine) and Ivin (N-oxide-2,6-dimethylpyridine), synthesized in 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, on growth and productivity of grain sorghum (*Sorghum bicolor* L.) cv. Yarona, and sweet sorghum (*Sorghum saccharatum* L.) cv. Favorite was studied in the field.

2. Materials and Methods

The chemical structure and relative molecular weight of new plant growth regulators Methyur and Kamethur (derivatives of sodium and potassium salts of 6-methyl-2-mercapto-4-hydroxypyrimidine) and Ivin (N-oxide-2,6-dimethylpyridine) are shown in Figure 1.

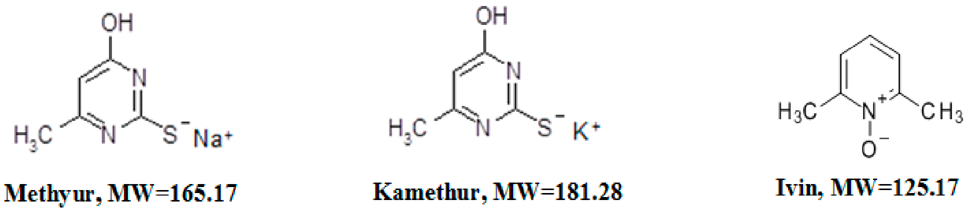

Figure 1. Chemical structure and relative molecular weight of plant growth regulators Methyur, Kamethur, and Ivin.

Field experiments were carried out on grain sorghum (*Sorghum bicolor* L.) cv. Yarona, and sweet sorghum (*Sorghum saccharatum* L.) cv. Favorite. Seeds sterilized with 1% $KMnO_4$ solution were treated either with distilled water (control sample) or with solutions of any plant growth regulators Methyur, Kamethur, or Ivin, applied at a concentration of 10^{-7} M for 24 h (experimental sample). Each control and experimental sample contained 50 plant seeds. Then the soaked seeds were planted in the soil. The analysis of growth parameters: the average length of root (in mm) and the average fresh weight (in gram) of sorghum grown for 2 months in the field, and productivity parameters: the average panicle length (in cm) and the average fresh weight of grain (in gram) of sorghum grown for 4 months in the field was carried out according to the guidelines [7]. Statistical processing of the data of the experiments performed in three replications was carried out according to the Student's *t*-test for variance with a significance level of $p \leq 0.05$; the values are average $\pm$ SD [8].

The growth parameters (the average length of root (in mm) and the average fresh weight (in gram)) of sorghum grown for 2 months in the field and productivity parameters (the average panicle length (in cm) and the average fresh weight of grain (in gram)) of sorghum grown for 4 months in the field, determined in experimental samples of sorghum plants, were calculated as % in relation to similar indicators determined in control samples of sorghum plants.

3. Results

3.1. Study of the Effect of Plant Growth Regulators on Sorghum Growth

Field studies have shown that the growth indicators of experimental grain sorghum (*Sorghum bicolor* (L.) Moench) cv. Yarona exceeded that of control plants (Figure 2A–C). Root length (in mm) increased by 15% – in plants treated with Kamethur, 14% – in plants treated with Methyur, and 29% – in plants treated with Ivin, compared to the control. Plant fresh weight (in gram) increased by 67% – in plants treated with Kamethur, 53% – in plants treated with Methyur, and 21% – in plants treated with Ivin, compared to the control.

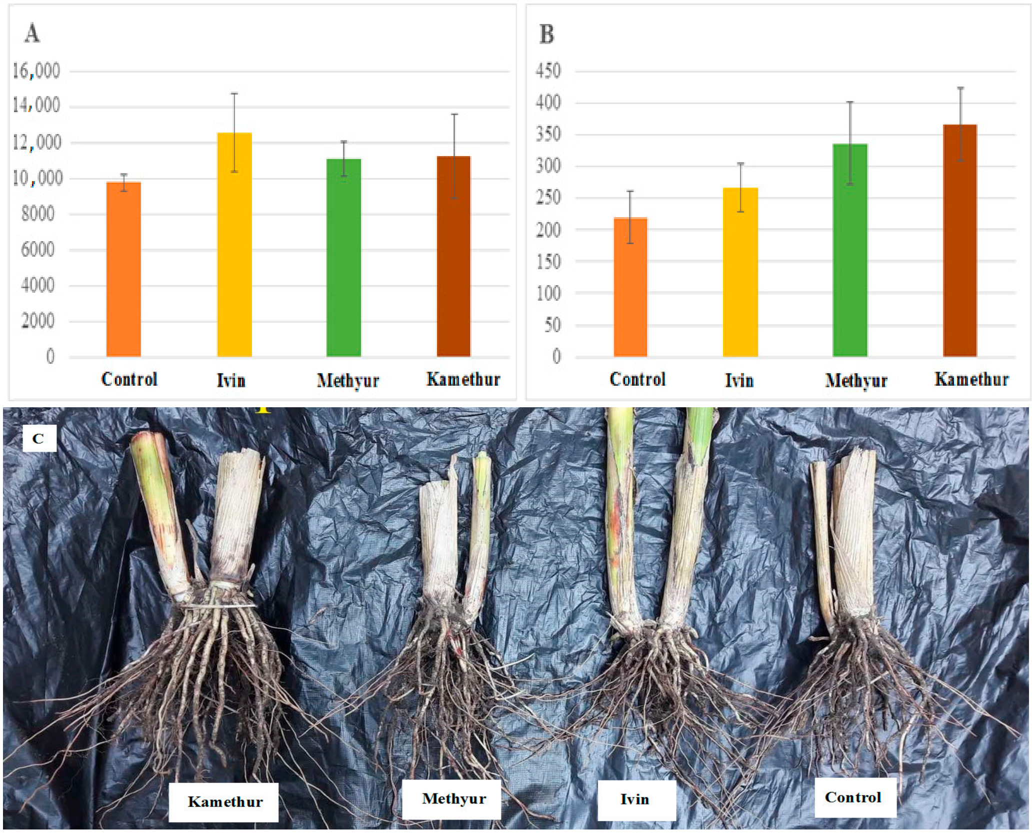

Figure 2. Growth indicators of 2-month-old grain sorghum (*Sorghum bicolor* (L.) Moench) cv. Yarona grown in the field: (**A**) root length (in mm), (**B**) plant fresh weight of (in gram), and (**C**) sorghum roots.

Growth indicators of experimental sweet sorghum (*Sorghum saccharatum* (L.) Moench) cv. Favorite exceeded that of control plants (Figure 3A–C). Root length (in mm) increased by 20%—in plants treated with Kamethur, 40%—in plants treated with Methyur, and 25%—in plants treated with Ivin, compared to the control. Plant fresh weight (in gram) increased by 7%—in plants treated with Kamethur, 57%—in plants treated with Methyur, and 30%—in plants treated with Ivin, compared to the control.

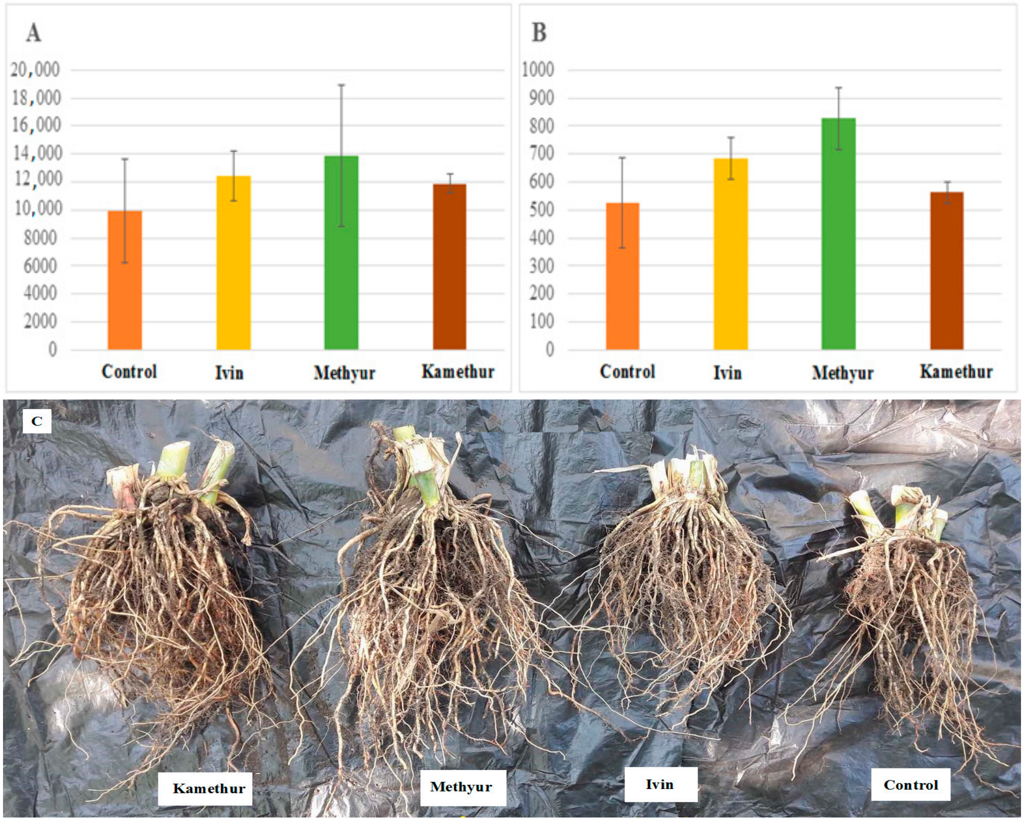

Figure 3. Growth indicators of 2-month-old sweet sorghum (*Sorghum saccharatum* (L.) Moench) cv. Favorite grown in the field: (**A**) root length (in mm), (**B**) plant fresh weight of (in gram), and (**C**) sorghum roots.

3.2. Study of the Effect of Plant Growth Regulators on Sorghum Yield

Field studies have shown that the yield indicators of experimental grain sorghum (*Sorghum bicolor* (L.) Moench) cv. Yarona exceeded that of control plants (Figure 4A–C). Panicle length (in cm) increased by 7%—in plants treated with Kamethur, 20%—in plants treated with Methyur, and 17%—in plants treated with Ivin, compared to the control. Grain fresh weight (in gram) increased by 22% in plants treated with Kamethur, 26%—in plants treated with Methyur, and 13%—in plants treated with Ivin, compared to the control.

Yield indicators of experimental sweet sorghum (*Sorghum saccharatum* (L.) Moench) cv. Favorite exceeded that of control plants (Figure 5A–C). Panicle length (in cm) increased by 36%—in plants treated with Kamethur, 37%—in plants treated with Methyur, and 25%—in plants treated with Ivin, compared to the control. Grain fresh weight (in gram) increased by 24%—in plants treated with Kamethur, 38%—in plants treated with Methyur, and 35%—in plants treated with Ivin, compared to the control.

Summarizing the data obtained, it should be concluded that synthetic plant growth regulators Methyur, Kamethur, and Ivin have a highly stimulating effect on the growth and development of sorghum shoots and roots in the vegetative phase, as well as on the growth and development of sorghum panicles and grain formation in the reproductive phase. Their high growth-stimulating effect may be explained by their auxin-like and cytokinin-like effects on the processes of proliferation, elongation, and differentiation of plant cells [9–11]. In addition, the composition of synthetic plant growth regulators has a positive effect on plant growth and development. A plant growth regulator Ivin contains the macronutrient nitrogen, and Kamethur contains the macronutrients nitrogen, potassium, and sulfur, which are necessary for plant growth and metabolism, and plant adaptation to biotic and abiotic stress factors [12,13]. Plant growth regulator Methyur, containing the macronutrients nitrogen, sulfur, and the chemical element sodium, promotes plant growth and productivity, as well as plant adaptation to salt and osmotic stress [14–16].

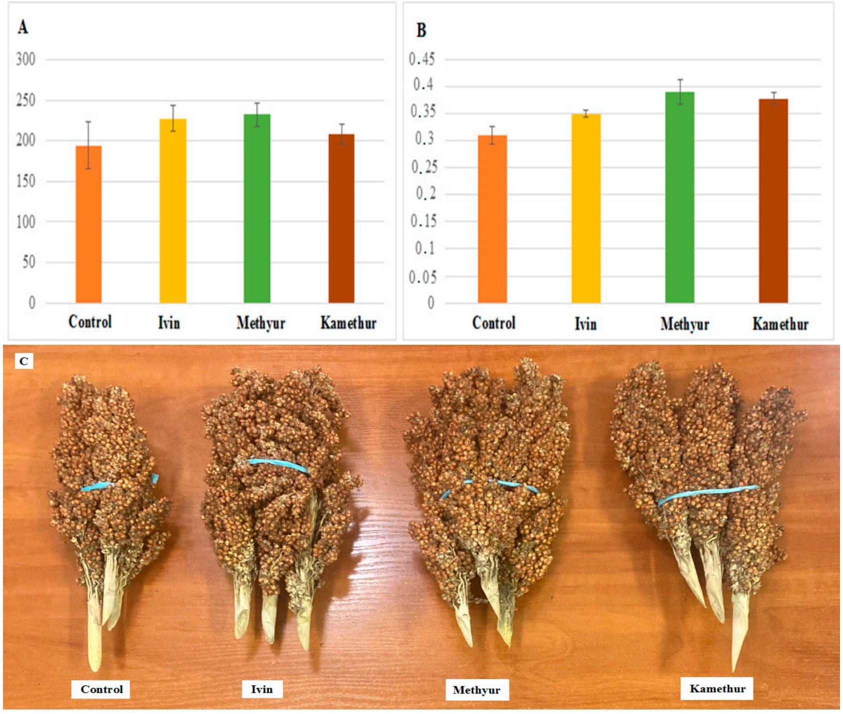

Figure 4. Yield indicators of 4-month-old grain sorghum (*Sorghum bicolor* (L.) Moench) cv. Yarona grown in the field: (**A**) panicle length (in cm), (**B**) grain fresh weight (in gram), and (**C**) panicles with sorghum grains.

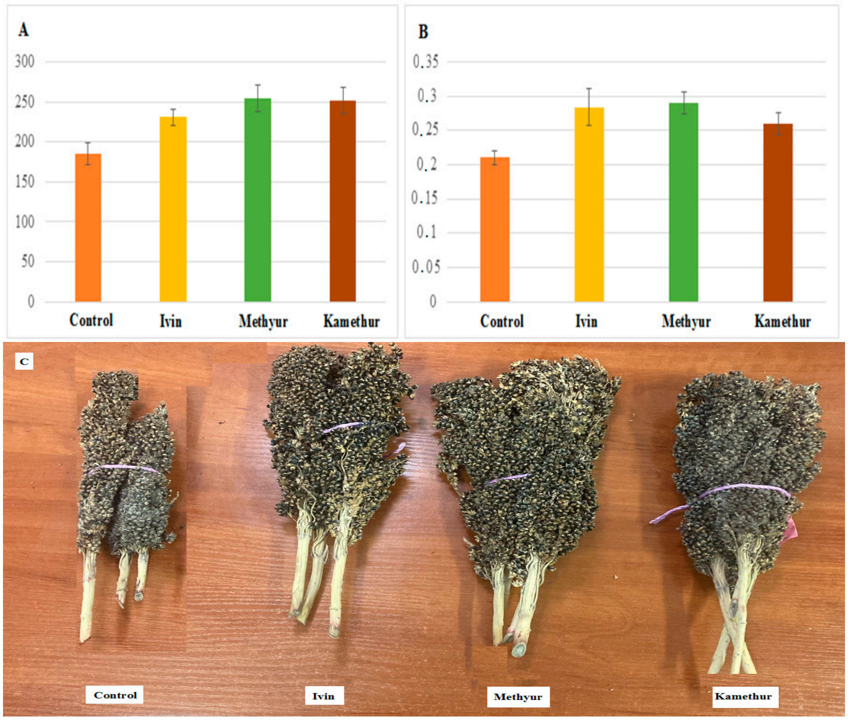

Figure 5. Yield indicators of 4-month-old sweet sorghum (*Sorghum saccharatum* (L.) Moench) cv. Favorite grown in the field: (**A**) panicle length (in cm), (**B**) grain fresh weight (in gram), and (**C**) panicles with sorghum grains.

4. Conclusions

The results of field studies confirmed the possibility of practical application of the new environmentally friendly plant growth regulators based on 6-methyl-2-mercapto-4-hydroxypyrimidine sodium and potassium salts (Methyur and Kamethur) and N-oxide-2,6-dimethylpyridine (Ivin) to improve the growth and increase the productivity of sorghum. Due to the use of these environmentally friendly plant growth regulators in a nanomolar, environmentally non-toxic concentration of 10^{-7} M to treat seeds before planting in the soil, it will be possible to improve the growth and increase the productivity of sorghum and its adaptation to stress factors, while reducing the use of environmentally toxic agrochemicals for plant protection and improving the environmental condition of the entire agricultural system.

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