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USING SYNTHESISED ORGANIC COMPOUNDS AS ENVIRONMENTALLY FRIENDLY RETARDANTS FOR ORNAMENTAL PLANTS

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ABSTRACT

The pre-sowing treatment of scarlet sage (*Salvia splendens* Ker Gawl.) seeds with 4-methyl-2-piperidin-1-yl-pyrimidine-5-carboxylic acid at concentrations of 0.01, 0.05, and 0.1% proved to have an obvious inhibiting effect. Prior to sowing, the seeds of *Salvia splendens* were soaked in a water suspension of 4-methyl-2-piperidin-1-yl-pyrimidine-5-carboxylic acid and 4-methyl-2-morpholin-4-pyrimidine-5-carboxylic acid with concentrations of 0.01%, 0.05%, and 0.1% for 18 hours. On the 42nd day of the experiment, the seedlings, having been preliminarily hardened for 12 days, were removed from the greenhouse and planted on the field. The pre-sowing treatment of *Salvia splendens* seeds with 4-methyl-2-morpholin-4-pyrimidine-5-carboxylic acid proved to have the inhibiting effect at concentrations of 0.01 and 0.05%. The height of the seedlings decreased by 13.3-43.7%. It was revealed that 4-methyl-2-piperidin-1-yl-pyrimidine-5-carboxylic acid at concentrations of 0.01, 0.05, and 0.1% decreased the growth of the seedlings by 30.4-43.7%, and 4-methyl-2-morpholin-4-pyrimidine-5-carboxylic acid at concentrations of 0.01 and 0.05% decreased the growth of the seedlings by 13.3-22.2%. By contrast, the effect of pyrimidinecarboxylic acids on seed germination and plant height of another annual flower – spreading marigold (*Tagetes patula* L.) was stimulating. It was investigated some different concentrations from 0.01 to 0.05 %. The same concentrations of identical compounds were tested, but effects from them were opposite for *Tagetes patula,* and *Salvia splendens* seedlings. Consequently, the species-specific effect of pyrimidinecarboxylic acids on seed germination and plant height for ornamental grasses takes place. Therefore,4-methyl-2-piperidin-1-yl-pyrimidine-5-carboxylic acid and 4-methyl-2-morpholin-4-pyrimidine-5-carboxylic acid are recommended as growth retardants for *Salvia splendens*.

Keywords: *synthesized organic compounds, pyrimidinecarboxylic acids, grasses, retardants*.

1. INTRODUCTION

To cultivate scrubby and compact plants, special growth regulators – retardants, are used, which inhibit the plant growth. The most commonly used retardants are: chlorcholine chloride ((2-chloroethyl)-trimethylammonium chloride), alar (succinic mono-(N,N-dimethylhydrazide)), and ethephon ((2-chloroethyl)phosphonic acid) (http:// www.valleyflora.ru/53-1.html). Chlorcholine chloride is the basis for a plant growth regulator – “Toor”, which used to be very popular in Russia and its neighboring countries (today the regulator is manufactured under the name Atlet® by PCC Rokita SA (Poland). (2-chloroethyl)phosphonic acid is used all over the world to synthesize various preparative forms of growth retardants, such as Ethephon (commercial formulation Ethrel® produced by Bayer CropScience AG (Germany)). Ethephon is used to synthesize growth retardants which efficiently induce the production of ethylene. These regulators contain disodium salts of ethephon together with hydrazine (hydrel) and dimethylhydrazine (dihydrel). 2,2-Dimethylhydrazide of succinic acid is also commonly used (Sherer, Gadiev, 1991).

Over the last years, attempts have been made to synthesize new organic compounds that can be used as growth regulators (Dlugosz, Dus, 1996; Abdel-Gawad *et al.*, 2005; Shujiang *et al.*, 2005; Marjani *et al.*, 2011; Ostroshenko, Ostroshenko, 2011). Such compounds should be more effective than the existing commercial formulations (Vasin *et al.*, 2008; 2009). Several

heterocycles have shown a potent antibacterial effect (El-Sayed *et al.*, 2002a,b, 2004; Brown *et al*., 2004). The genotoxicity of some heterocyclic compounds has been verified using cytogenetic indicators, and they were recognized as environmentally friendly (Butorina *et al.*, 2002). The effect of pyrimidinecarboxylic acids on seed germination and plant height was studied using another annual flower – spreading marigold (*Tagetes patula* L.) (Vostrikova *et al*., 2012). However, the effect of pyrimidinecarboxylic acids on the growth of other plants has not been studied yet. They may appear to have an inhibiting effect and thus can function as retardants used to reduce the height of plants and cultivate low growing ornamental grasses.

It is studied the effect of synthesized organic compounds of pyrimidinecarboxylic acids when used for pre-sowing seed treatment of the ornamental grass plant scarlet sage (*Salvia splendens* Ker Gawl.).

2. MATERIALS AND METHODS

The research was conducted at the B.M. Kozo-Polyansky Botanical Garden of Voronezh State University (geographic coordinates: 39°22' N, 51°40' E; 168.2 meters above sea level).

In the study, it was used the annual ornamental plant the “Hot fire” variety of scarlet sage (*Salvia splendens* Ker Gawl.), which is often planted in urban gardens.

In the research, it was focused on the effect of synthesized organic (heterocyclic) compounds of pyrimidinecarboxylic acids on the height of seedlings of *S. splendens.* The following heterocyclic compounds were used: 4-methyl-2-piperidin-1-yl-pyrimidine-5-carboxylic acid, 2-benzylamino-4-methyl-pyrimidine-5-carboxylic acid, and 4-methyl-2-morpholin-4-pyrimidine-5-carboxylic acid synthesized at the Department of Organic Chemistry of Voronezh State University.

2-Substituted 4-methylpyrimidine-5-carboxylic acids [4-methylpyrimidine-5-carboxylic acids] are synthesized by condensation of the corresponding caboximidamides (1-piperidinecarboxamide, benzylguanidine, and 4-morpholinecarboximidamide) with ethyl ethoxymethyleneacetoacetate in boiling ethanol. Acid hydrolysis of ethyl esters 2-R-4-methyl-5-pyrimidinecarboxylic acids obtained by this model to the desired 2-R-4-methylpyrimidine-5-carboxylic acids with a yield of 60-69% counting on the starting caboximidamides.

Prior to sowing, the seeds of *Salvia splendens* were soaked in a water suspension of 4-methyl-2-piperidin-1-yl-pyrimidine-5-carboxylic acid and 4-methyl-2-morpholin-4-pyrimidine-5-carboxylic acid with concentrations of 0.01%, 0.05%, and 0.1% for 18 hours. The control group included the same type of seeds soaked in tap water. In the case of each of the studied concentrations of the acids, as well as the control group, the experiment was conducted three times using a set of 100 seeds. The seeds of *Salvia splendens* were sown in containers filled with a mixture of soil and sand (3 parts soil/1 part sand) and kept in a greenhouse at 20 °C, as recommended in (Nikolaenko, 1971). On the 42nd day of the experiment, the seedlings, having been preliminarily hardened for 12 days, were removed from the greenhouse and planted on the field. The field experiment was designed according to B. A. Dospekhov (1985). The height of the seedlings was measured on the 42nd day using a ruler. The results were statistically processed using the STADIA software package. The procedures of data grouping and processing were described by A. P. Kulaichev (2006). The mean values were compared using Student's t-test. The coefficient of variation (Cv) was counted, according to G. F. Lakin (1990). If Cv was below 10%, it meant that the degree of variation was low, with Cv between 10 and 25% it was medium, and when Cv was over 25% - the degree of variation was high (Lakin, 1990). To estimate the influence of various concentrations of the chemical compounds on the height of the plants, a one-way analysis of variance was used. The power of influence was calculated according to Snedecor (in %).

3. RESULTS AND DISCUSSION:

When applied to *Salvia splendens* seeds, 4-methyl-2-piperidin-1-yl-pyrimidine-5-carboxylic acid at concentrations of 0.01, 0.05, and 0.1% demonstrated the inhibiting effect on the growth of plants. The same effect was observed for 4-methyl-2-morpholin-4-pyrimidine-5-carboxylic acid at concentrations of 0.01 and 0.05%. The height of the seedlings decreased by 30.4-43.7% in the former case and by 13.3-22.2 % in the latter, as compared to the seedlings in the control group (Table 1).

4-methyl-2-piperidin-1-yl-pyrimidine-5-car_

boxylic acid inhibits the growth of the seedlings at all the studied concentrations (0.01, 0.05, and 0.1%), with the effect being more obvious when the concentration was 0.1%. The height of the plants was 8.9±0.4 cm (at the concentration of 0.1%, P<0.001) and 11±0.5 cm (at the concentration of 0.01%, P<0.001). The height of the plants in the control group was 15.8±0.6 cm.

Earlier research studied the stimulating effect of 0.01–0.05 % 4-methyl-2-piperidin-1-yl-pyrimidine-5-carboxylic acid on the germination and growth of the seedlings of spreading marigold: with the concentration of 0.03-0.05 %, the height of the plants increased (differences with the control group are reliable, P<0.001). However, other compounds of pyrimidine-5-carboxylic acids at the studied concentrations demonstrated stronger stimulating effects (Vostrikova *et al*., 2012).

4-methyl-2-morpholin-4-pyrimidine-5-carboxylic acid at concentrations of 0.01 and 0.05% inhibits the growth significantly. The mean height of the plants was 12.3±0.3 and 13.7±0.4 cm, respectively (differences with the control group are reliable, P<0.001, P<0.01). The height of the plants in the control group was 15.8±0.6 cm. 4-methyl-2-morpholin-4-pyrimidine-5-carboxylic acid at the concentration of 0.01% did not affect the growth of the plants. The parameter “height of the seedlings” in the control group and in the experimental group (treated with 4-methyl-2-piperidin-1-yl-pyrimidine-5-carboxylic acid, excluding the 0.5% concentration) was characterized by the medium coefficient of variation (12.7-15.1%), which indicates the high level of intravarietal variability. When the seeds of *Salvia splendens* were treated with 4-methyl-2-morpholin-4-pyrimidine-5-carboxylic acid, the variability level was low, which is proved by low Cv (6.6–8.9 %). This indicates that individual seedlings show similar reactions to the compounds used.

The effect of the treatment of seeds with the synthesized organic compounds on the height of the seedlings was evaluated using the one-way analysis of variance (Table 2). The rate of the decrease in the height of *Salvia splendens* seedlings (in %) is shown in Table 1.

It was demonstrated that 4-methyl-2-piperidin-1-yl-pyrimidine-5-carboxylic acid at concentrations of 0.01, 0.05, and 0.1% decreased the growth of the seedlings by 30.4-43.7%, and 4-methyl-2-morpholin-4-pyrimidine-5-carboxylic acid at concentrations of 0.01 and 0.05% decreased the growth of the seedlings by 13.3-22.2%.

4. CONCLUSIONS:

The pre-sowing treatment of *Salvia splendens* seeds with 4-methyl-2-piperidin-1-yl-pyrimidine-5-carboxylic acid at concentrations of 0.01, 0.05, and 0.1% proved to have an obvious inhibiting effect. The pre-sowing treatment of seeds with 4-methyl-2-morpholin-4-pyrimidine-5-carboxylic acid proved to have the inhibiting effect at concentrations of 0.01 and 0.05%. Thus, synthesized organic compounds of pyrimidinecarboxylic acids can lower the height of *Salvia splendens* seedlings by 13.3-43.7%. It was revealed that 4-methyl-2-piperidin-1-yl-pyrimidine-5-carboxylic acid at concentrations of 0.01, 0.05, and 0.1% decreased the growth of the seedlings by 30.4-43.7%, and 4-methyl-2-morpholin-4-pyrimidine-5-carboxylic acid at concentrations of 0.01 and 0.05% decreased the growth of the seedlings by 13.3-22.2%. By the contrast, the effect of pyrimidinecarboxylic acids on seed germination and plant height of another annual flower – spreading marigold (*Tagetes patula* L.) was stimulating (Vostrikova *et al*., 2012). It was investigated some different concentrations from 0.01 to 0.05 %. The same concentrations of identical compounds were tested, but effects from them were opposite for *Tagetes patula,* and *Salvia splendens* seedlings. Consequently, the species-specific effect of pyrimidinecarboxylic acids on seed germination and plant height for ornamental grasses takes place. The genotoxicity of heterocyclic compounds has been tested previously, and they have been recognized as environmentally friendly. Therefore, the studied compounds at the said concentrations can be used for pre-sowing seed treatment as retardants which yield low-height and compact ornamental forms of *Salvia splendens* plants.

The data discussed in the Results and Discussion showing the relevance of the work and how different it is from other researches. Also, point out the benefits and improvements that can be observed in order to develop new scientific standards that can change something in the related field.

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Table 1. *The height of Salvia splendens seedlings after the pre-sowing seed treatment with the studied synthesized organic compounds*

Concentration, %	The average height of the plants, cm	Max - min, cm	Cv, %	Increase in the height of the plants, %
Control group	15.8±0.6	14 - 20	12.7	–
4-methyl-2-piperidin-1-yl-pyrimidine-5-carboxylic acid				
0,01%	11.0±0.5***	9 - 13	13.6	30.4
0,05%	10.0±0.9***	3 - 13	28.0	36.7
0,1%	8.9±0.4***	7 - 11	13.5	43.7
4-methyl-2-morpholin-4-pyrimidine-5-carboxylic acid				
0,01%	12.3±0.3***	11 - 14	8.9	22.2
0,05%	13.7±0.4**	12 - 15	8.8	13.3
0,1%	15.2±0.3	14 - 17	6.6	–

Reference: Cv – variation coefficient

** – differences with the control group are reliable ($p<0.01$);

*** – differences with the control group are reliable ($p<0.001$).

Table 2. *The power of influence (in %) of the retardant on the height of Salvia splendens on the 42nd day of the experiment*

retardant	as compared to the control group	as is
4-methyl-2-piperidin-1-yl-pyrimidine-5-carboxylic acid	6.0***	-
4-methyl-2-morpholin-4-pyrimidine-5-carboxylic acid	0.9***	3.3***

Reference: *** - the influence of the factor is reliable ($p<0.001$).

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