донны обыкновенной. Представлены данные об экономической эффективности выращивания растений сорта Прэкрасная пани, адаптированного к условиям лесостепной зоны Украины, которые показали прямую зависимость продуктивности этого сорта (урожайность воздушносухого сырья с показателями.) Установлено, что несмотря на более высокие производственные затраты на формирование биомассы сорта Прекрасная пани на 4417 грн. по сравнению с Красавкой, прибыль первого на 1 га была на 30 583 грн. Выше чем в контрольном варианте. Результаты исследований показали, что выращивание вновь созданного сорта с высокоприбыльным в условиях Лесостепи Украины, (уровень рентабельности составляет 259,1 %).
Ключевые слова: селекция, продуктивность, сорт, морозостойкость, качественные показатели.

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POSSIBILITIES OF USING CHEMICAL PRODUCTS FOR THE PROTECTION OF *RHODODENDRON SP.* AGAINST *PHYTOPHTHORA PLURIVORA*

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Considering the continuous intensification of production of ornamental plants (Rhododendron sp.), losses caused by species from genus Phytophthora, and limited possibilities of chemical protection, research was undertaken for the purpose of development of effective chemical methods of protection of rhododendron against Phytophthora with consideration of the way of their application. The objective of this study was the assessment of the usefulness of seven fungicides in the protection of rhododendron against Phytophthora plurivora. The research was conducted on rhododendron of Nova Zembla cultivar (Rhododendron 'Nova Zembla') in the University of Life Sciences in Lublin, Poland.

Under laboratory conditions, the activity of the tested products was assessed based on the growth of P. plurivora on agar containing fungicides, and the size of necrosis of inoculated rhododendron leaves. In greenhouse tests, the growth and

degree of infestation of plants planted in infested substrate was evaluated.
The research showed that the introduction to the agar of 1 µg/ml of active substances of Infinito 687.5 S.C. and Previcur Energy 840 SL limited growth of P. plurivora. Complete inhibition of its development was observed after the application of Infinito 687.5 S.C. and Acrobat MZ 69 WG at a concentration of 10 µg/ml, and Previcur Energy 840 SL and Mildex 711.9 WG at the highest concentration of 100 µg/ml.
Irrespective of concentration, the applied products Acrobat MZ 69 WG and Infinito 686.5 SC after four and six days of incubation protected rhododendron leaves against P. plurivora. Mildex 711.9 WG and Previcur Energy 840 SL inhibited the development of phytophthorosis at concentrations of 0.15 % and 0.2 %.
Differences were evidenced in the efficiency of the analysed agents depending on the application method. The height of experimental rhododendrons was considerably greater in comparison to control plants only in the case of agents applied in the form of spraying. A stimulating effect on the number of developed leaves was observed in the group of plants watered with Previcur Energy 840 SL.
Key words: Phytophthora plurivora, rhododendron, chemical agents

Introdution. Over the recent years, the problem of diseases caused by fungous microorganisms, including those belonging to genus *Phytophthora*, has become increasingly important. The reason is the continuously growing international turnover of plant material [Brasier 2008]. The increasing economic losses are substantial. The problem concerns both garden and forest plants, because *Phytophthora* species occur on plants cultivated under covers, in fields, and natural ecosystems.

Rhododendron (Rhododendron sp.) is one of plants the most sensitive to phytophthorosis. It has been evidenced to be a host plant for 15 species from genus *Phytophthora*, where as next to *P. cinnamomi*, *P. cactorum*, *P. citricola*, and *P. ramorum*, *P. plurivora* is isolated the most frequently. The species causes dying of apical shoots of rhododendron. The disease often spreads from shoots to petiole sticks and lobes which become brown in colour. This drastically reduces the quality of plants, and eliminates them from commercial turnover. Cultivation losses can exceed 30 % [Korzeniowski and Orlikowski 2008].

Fungicides were used for the protection of rhododendrons against *Phytophthora* spp. already in the 1980's [Benson 1980]. The efficiency of the tested substances was largely varied. Therefore, research is still conducted on effective means of protection of the plants. Elliott et al. [2015], assessing fungicides for protection of rhododendrons against P. ramonum, proved systemic fungicides to be the most efficient in limiting the development of the mycelium and spore germination. The authors, however, determined the occurrence of resistance of pathogens to certain chemical substances.

Considering the continuous intensification of production of ornamental plants, losses caused by species from genus *Phytophthora*, and limited possibilities of chemical protection, research was undertaken for the purpose of development of effective chemical methods of protection of rhododendron against *Phytophthora* plurivora with consideration of the way of their application.

Material and methods. The research assessed the effectiveness of seven chemical plant protection products specified in Table 1. The experiment applied isolates of *P. plurivora* T. Jung & T.I. Burgess obtained from the collection of the Laboratory

of Diseases of Ornamental Plants of the Institute of Gardening in Skierniewice. The research was conducted on rhododendron of Nova Zembla cultivar (Rhododendron 'Nova Zembla').

The assessment of the effectiveness of the selected products in the protection of rhododendron against *P. plurivora* was performed in laboratory and greenhouse experiments.

Laboratory assessment of the effectiveness of the analysed products. The effect of the aforementioned products on the linear growth of *P. plurivora* was analysed under in vitro conditions. The research applied seven-day cultures of the species growing on Potato Dextrose Agar at a temperature of 25 ºC in the dark. The studied chemical agents were added to flasks with sterilised PDA cooled down to 50 ºC to obtain the concentration of the active substance amounting to 1, 10, and 100 ppm, respectively. Control was agar with no fungicide addition. Agar with the product was mixed, and then distributed by 25 ml to Petri dishes with a diameter of 90 mm. The Petri dishes were placed in a laminar flow cabinet for 24 hours until complete solidification of the substrate. Next, agar discs with a diameter of 5 mm overgrown by *P. plurivora* hyphae were placed in the middle part of the Petri dishes. On the bottom side of the Petri dishes, two perpendicular lines were drawn, crossed at the right angle in the centre of the inoculum. The Petri dishes were placed in an incubator, and incubated at 25 ºC. Observations of the growth of the thallus were performed after eight days of incubation. The diameter of the colonies was measured along the drawn lines. For each combination, the experiment was conducted in four repetitions, one Petri dish each. The experiment was conducted twice at a two-week interval.

The second stage of the laboratory research involved the evaluation of the effectiveness of the tested products in limiting the colonisation of rhododendron inoculated with *P. plurivora*, in accordance with the methodology described by Orlikowski and Szkuta [2002]. The inoculation involved the application of seven-day cultures of *P. plurivora* growing on V8 vegetable juice agar at a temperature of 25 ºC. Solutions of the tested plant protection products at concentrations of 0.1 %, 0.15 %, and 0.2 % were prepared in glass beakers. Young rhododendron leaves were soaked in the analysed solutions for two minutes, and then placed in trays (with dimensions 32.5x25.5x5.5 cm), lined with moist, sterile, synthetic mat covered with plastic mesh so that they do not come in direct contact with the moist substrate.

Rhododendron leaf blades were inoculated with the studied pathogen through a puncture in the middle of the leaf blades by means of a dissecting needle. The trays were covered with thin foil, and incubated on laboratory tables at a temperature of 22-24 ºC. Each time, the tests included a non-infected control in which organs of the plants were inoculated with clean agar discs, and an infected control where fragments of plants were soaked in only distilled water, and then infected with *P. plurivora* hyphae. The tests were reviewed every day, and depending on the rate of development of decay, readings of the size of necrosis were performed. The measure of the effects of the analysed products on the pathogen was the diameter of necrotic stains on the leaves.

The experiments were conducted in an entirely random system in four repetitions, with 5 leaf blades each. The experiments were conducted twice in a two-week interval.

Assessment of the activity of the analysed products in greenhouse conditions. *P. plurivora* cultures were prepared with the application of a method described by Orlikowski [1999] on oat medium (OM). Agar overgrown with the pathogen was

homogenised with an addition of distilled water (150 ml per 1 Petri dish). The resulting uniform suspension was mixed with peat substrate in the following proportion: content of 1 Petri dish per 1 litre of peat substrate. The substrate was placed in bags and incubated in a greenhouse for 14 days. Then, rooted rhododendron seedlings (with 4-5 leaves) were planted in 0.6 litre pots filled with infected peat substrate, and placed on sills in the greenhouse. Next, the plants were treated with the tested plant protection products (Table 1). Two ways of application of the products were used: in the first one the seedlings were watered with 25 ml of working liquid, and in the second one they were thoroughly sprayed.

1. List of the analysed plant protection products.

№	Commercial name of product	Active substances and their content (g/kg or l)	Registration for protection of ornamental plants / way of application
1.	Acrobat MZ 69 WG	dimethomorph (90 g/kg), mankozeb (600 g/kg)	No
2.	Infinito 687.5 SC	propamocarb-HCl (625 g/l), fluopicolide (62.5 g/l)	No
3.	Luna Sensation 500 SC	fluopyram (250 g/l), trifloxystrobin (250 g/l)	No
4.	Pyton Consento 450 SC	propamocarb-HCl (375 g/l), fenamidone (75 g/l)	No
5.	Ridomil Gold MZ Pepite 67.8 WG	metalaxyl-M (38.8 g/kg), mankozeb (640 g/kg)	Yes / watering
6.	Mildex 711.9 WG	Fosetyl-aluminium (667 g/kg), fenamidone (44 g/kg)	Yes / spraying
7.	Previcur Energy 840 SL	propamocarb-HCl (530 g/l), fosetyl-aluminium (310 g/l)	Yes / watering

Each time, the research included a non-infected control (without the pathogen) and an infected control (infected substrate with no application of a product). In control samples, plants were sprayed/watered only with clean water.

The plants were cultivated for eight weeks at a temperature of 17-26 °C and relative air moisture of 54-75 %. During the experiment, after four and eight weeks from planting, the number of leaves per plant and height of plants was determined.

The experiments were established in a system of random blocks in four repetitions with 10 plants each, and repeated twice in a two-week interval.

After the completion of the laboratory and greenhouse experiments, the causal factor was isolated from tissues of plants with manifestations of the disease and from substrate sampled from under the plants. The factor was again identified to the species.

Statistical analysis. The obtained results were subject to statistical processing by means of the analysis of variance. The significance of differences between the mean values was determined by means of the Duncan test at the significance level $\alpha = 0.05$.

Study results. The assessment of the biological activity of the products in Petri dish tests showed that the introduction to the agar of 1 µg/ml of active substances of Infinito 687.5 S.C. and Previcur Energy 840 SL limited growth of *P. plurivora* (Fig. 1). Complete inhibition of its development was observed after the application of Infinito 687.5 S.C. and Acrobat MZ 69 WG at a concentration

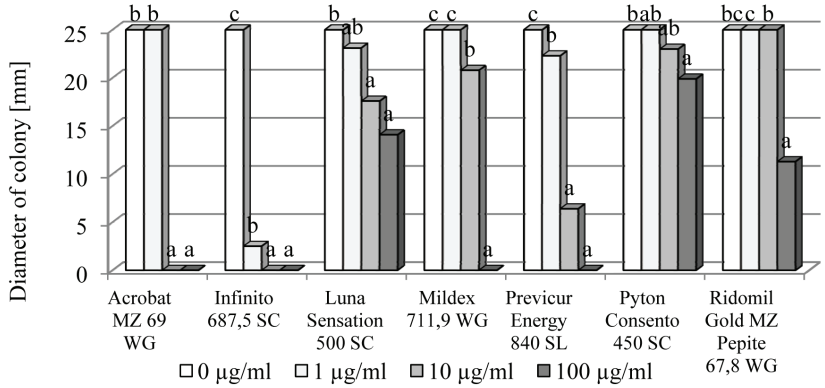

Fig 1. Effect of the concentration of tested products on the growth of *P. plurivora* after 8 days of incubation.

of 10 µg, and Previcur Energy 840 SL and Mildex 711.9 WG at the highest concentration of 100 µg/ml.

Irrespective of concentration, the applied products Acrobat MZ 69 WG and Infinito 686.5 SC after four and six days of incubation protected rhododendron leaves against *P. plurivora* (Fig. 2 and 3). Mildex 711.9 WG and Previcur Energy 840 SL inhibited the development of phytophthorosis at concentrations of 0.15 % and 0.2 %. In the case of application of Luna Sensation 500, no limiting of phytophthorosis development was observed on infected rhododendron leaf blades, irrespective of the time and applied concentration.

During the eight-week cultivation of rhododendrons infected with *P. plurivora*, no occurrence of evident disease symptoms were observed (Table 2).

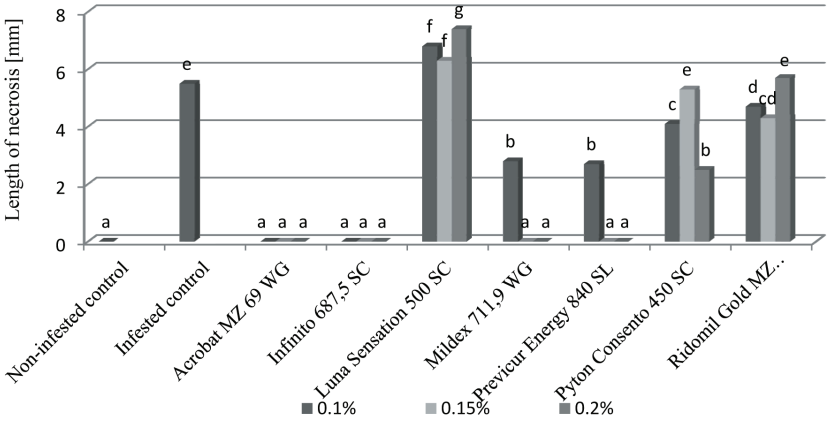

Fig. 2. Relationship between the analysed plant protection products and colonisation of leaves of rhododendron of Nova Zembla cultival by P. *plurivora* after four days of incubation.

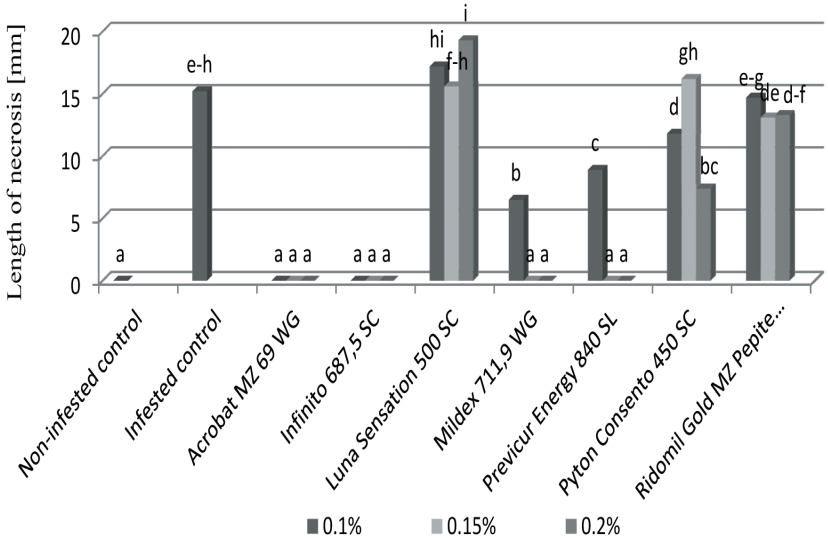

Fig. 3. Relationship between the analysed plant protection products and colonisation of the leaves of rhododendron of Nova Zembla cultivar by P. *plurivora* after six days of incubation.

The comparison of the height of experimental rhododendrons with control plants showed that the application of Pyton Consento 450 SC, soil application of Infinito 687.5 S.C., and foliar application of Previcur Energy 840 SL protected the cultivations against *P. plurivora* in the first weeks. The mean height of the plants was significantly greater in comparison to the infected plants from the control group, and did not statistically differ from the mean value measured in the group of non-infected plants.

After eight weeks, the mean height of experimental rhododendrons was significantly higher than that of control plants only for Infinito 687.5 S.C. Previcur Energy 840 SL and Mildex 711.9 WG applied by spraying.

At the end of the experiment, the majority of the applied products protected rhododendrons against loss of leaves. Lack of significant effect on plants was observed in the case of Acrobat MZ 69 WG, Ridomil Gold 68 WG, and soil-applied Infinito 687.5 S.C. A stimulating effect on the number of developed leaves was observed in the group of plants watered with Previcur Energy 840 SL. The performed assessment showed a significantly higher number of leaves in comparison to the non-infected control group.

Discussion. The study involved testing of seven two-component plant protection products containing eight different active substances, including procamocarb-HCL, dimethomorph, fluopicolide, fluopyram, fosetyl-aluminium, mankozeb, metalaxyl, and trifloxystrobin. Among the studied products, no expected effect was observed only for Ridomil Gold 68 WG (metalaxyl-M and mankozeb), Pyton Consento 450 SC (procamocarb-HCL and fenamidone) and Luna Sensation 500 SC (fluopyram and trifloxystrobin).

Géheskqire et al. [2009], investigating the resistance of *P. ramorum*, a

2. Efficiency of products in the protection of rhododendron "Nova Zembla" against P. *plurivora*

Protection products	Concentration, %	Way of application	Height of plants after weeks from planting, mm		Number of leaves after weeks from planting	
			4	8	4	8
Non-infected control	-	-	32.8 f-i	57.8 a-c	7.9 b-d	11.5 a-d
Infected control	-	-	30.3 de	55.4 ab	7.7 bc	10.5 a
Acrobat MZ 69 WG	0.2	spraying	24.9 bc	58.4 a-c	7.2 b	10.5 a
	0.2	watering	17.2 a	52.2 a	5.2 a	10.6 a
Infinito 687.5 SC	0.2	spraying	30.1 de	62.8 c	7.8 b-d	12.6 de
	0.2	watering	34.7 i	60.0 bc	7.6 bc	11.0 ab
Luna Sensation 500 SC	0.2	spraying	25.8 bc	57.6 a-c	7.9 b-d	11.9 b-d
	0.2	watering	24.0 b	58.0 a-c	7.3 b	11.9 b-d
Mildex 711.9 WG	0.2	spraying	31.1 d-f	62.7 c	7.9 b-d	11.9 b-d
	0.2	watering	31.5 d-g	57.5 a-c	7.5 bc	12.1 b-d
Previcur Energy 840 SL	0.2	spraying	33.6 g-i	63.3 c	8.1 b-d	12.6 de
	0.2	watering	26.6 c	59.0 a-c	8.7 de	13.6 e
Pyton Consento 450 SC	0.2	spraying	34.2 hi	60.7 bc	8.4 cd	11.9 b-d
	0.2	watering	32.1 e-h	61.0 bc	9.3 e	12.4 d
Ridomil Gold 68 WG	0.2	spraying	25.8 bc	59.9 bc	7.1 b	11.2 a-c
	0.2	watering	29.2 d	60.1 bc	7.8 b-d	11.0 ab

Notice: Mean values in the columns marked with the same letter do not differ significantly (5 %) according to the Duncan test.

pathogen of rhododendrons, to various active substances, evidenced the presence of numerous isolates resistant to metalaxyl. The authors emphasised that the frequency of application of mono-component products with a narrow scope of activity is a factor favouring an increase in resistance. This may cause an increase in resistance to other active substances.

In own research, the combination of substances such as procamocarb-HCL with fluopicolide (Infinito 687.5 S.C) or with fosetyl-aluminium (Previcur Energy 840 SL), and fosetyl-aluminium with fenamidone (Mildex 711,9 WG), or dimethomorph with mankozeb (Acrobat MZ 69 WG) effectively inhibited the development of *P. plurivora*. The substances also protected shoots against colonisation in tests on infected tissues. In greenhouse research, the effects were not confirmed only in the case of application of dimethomorph and mankozeb (Acrobat MZ 69 WG).

Korzeniowski and Orlikowski [2008] confirmed the protective effect of fosetyl-aluminium, propamocarb-HCL, and fenamidone on rhododendrons also against *P. ramonum* and *P. citricola*. The authors evidenced that it was a result of the inhibition of development of zoosporangia and chlamydospores of *P. ramonum* on rhododendron leaves. The experiment by Lindermann and Davies [2008] on the application of fungicides and phosphite fertilisers in the protection of rhododendrons against *P. citricola*, *P. cactorum*, and *P. ramonum* also showed an inhibition of the development of the disease, but no elimination of pathogens.

Orlikowski [2004] evidenced that a mixture of fenamidone with fosetyl-aluminium (Mildex 711.9 WG) had the strongest inhibiting effect on the

development of chlamydospores of the species on discs from foliar sticks and blades sampled from protected rhododendrons. The effect of both of the active substances on the pathogen was significantly greater than that of fosetyl-aluminium and its mixture with propamocarb. Erwin and Ribeiro [1996] point out that products based on systemic substances such as propamocarb-HCL or fosetyl-aluminium usually limit sporulation and disease symptoms, but do not completely eliminate *Phytophthora* spp.

Own research showed that the way of application had a substantial effect on the growth of infected plants. Growth stimulation was observed in the group of plants sprayed with Infinito 687.5 S.C., Previcur Energy 840 SL and Mildex 711.9 WG. Meanwhile, Orlikowski and Korzeniowski [2007] determined low variability of the efficiency of Previcuru Energy 840 SL in the case of its application by spraying. Also in research by Muszyńska and Orlikowski [2010], Previcur Energy 840 SL applied for watering seedlings of Lawson's cypress rooted in infected substrate limited the development of *P. cinnamomi* in more than 80 %. The experiments also showed that the product stimulated the growth and development of protected plants.

According to Lindermann and Davies [2008], high efficiency of one active substance against the selected species of *Phytophthora* does not guarantee comparable efficiency against other species or the same species on another plant. The risk of an increase in the resistance of *Phytophthora* species to the applied chemical plant protection products should also be taken into account. Due to this, products with different active substances and different mechanisms of action should be applied, including those contained in Infinito 687.5 SC, Mildex 711.9 WG, and Previcur Energy 840 SL which can be used for rotation in integrated protection of ornamental plants.

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МОЖЛИВОСТІ ВИКОРИСТАННЯ ХІМІЧНИХ ПРОДУКТІВ ДЛЯ ЗАХИСТУ РОДОДЕНДРОНА (*RHODODENDRON* SP.) ВІД ФІТОФТОРИ (*PHYTOPHTHORA PLURIVORA*)

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Метою даного дослідження було оцінити ефективність семи фунгіцидів для захисту рододендрона від Phytophthora plurivora. В лабораторних умовах активність досліджуваних речовин оцінювали на підставі розростання колоній P. plurivora на агарі, що містив фунгіциди, та за розміром некрозу інокульованих листків рододендрона. У тепличних тестах оцінювали ріст і ступінь зараження рослин, висаджених в інокульований субстрат. Дослідження показали найвищу ефективність у обмеженні розвитку P. plurivora у випадку з Infinito 687,5 SC, Mildex 711,9 WG та Previcur Energy 840 SL. Було підтверджено значні відмінності рівня ефективності досліджуваних речовин залежно від способу застосування. Висота експериментальних рододендронів була значно більшою в порівнянні з контрольними рослинами тільки при використанні фунгіцидів, що застосовувались у вигляді розпилення. Стимулюючий вплив на кількість розвинених листків спостерігали в групі рослин, які поливали Previcur Energy 840 SL.
Ключові слова: *Phytophthora plurivora,* рододендрон, хімічні агенти.

ВОЗМОЖНОСТИ ИСПОЛЬЗОВАНИЯ ХИМИЧЕСКИХ ПРОДУКТОВ ДЛЯ ЗАЩИТЫ РОДОДЕНДРОНА (*RHODODENDRON* SP.) ОТ ФИТОФТОРЫ (*PHYTOPHTHORA PLURIVORA*)

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Целью данного исследования было оценить эффективность семи фунгицидов при защите рододендрона от Phytophthora plurivora. В лабораторных условиях активность исследуемых веществ оценивали на основании разрастаний колоний P. plurivora на агаре, содержащем фунгициды, и по размеру некроза инокулированных листьев рододендрона. В тепличных тестах оценивали рост и степень заражения растений, высаженных в инокулированный субстрат. Исследования показали наивысшую эффективность в ограничении развития P. plurivora при употреблении Infinito 687,5 SC, Mildex 711,9 WG и Previcur Energy 840 SL. Были подтверждены значительные различия уровня эффективности исследуемых веществ в зависимости от способа применения. Высота экспериментальных рододендронов была значительно больше по сравнению с контрольными растениями только при использовании фунгицидов, которые применялись в виде распыления. Стимулирующее влияние на количество развитых листьев наблюдали в группе растений, которые поливали Previcur Energy 840 SL.

Ключевые слова: *Phytophthora plurivora,* рододендрон, химические агенты.

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