Conifer foliage extractive substances in plant protection

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The possibilities of manufacturing plant protection agents from extractive substances of pine and spruce needles are considered, including the evaluation of the agent's fungicidal and insecticidal properties. A description of phytopreparation "Fitoekols IF" is presented. It is devoid of toxicity, posseses fungicidal and insecticidal properties, is effective against pathogenic fungus infections and sucking insects for under-cover and field crops. The possible use of conifer foliage extractive substances, and the salts of resinous and fatty acids in particular, for developing environment-friendly plant protection agents applicable in systems of biological farming is demonstrated.

Key words: plant protection, conifer foliage extractive substances, fungicidal and insecticidal properties of extractive substances, phytopreparation "Fitoekols IF".

Introduction

Growing concern about environment protection and more rigorous standards for farm product quality have resulted in new features required of preparations and methods used in plant protection. Recently, in the business of plant protection, integrated systems based on the combination of biological and technological methods, complemented by man made chemicals in case of urgency only, grow in popularity. An active search for new plant protection means having no ill effect to man and the environment is under way all over the world, systems of biological farming become well accepted.

In gardening the use of vegetable origin substances for suppressing pests and diseases is known since time immemorial. For example, infusions (water extracts) of garlic, tops of tomato, marigold, tobacco, etc. are well known in folk tradition for killing aphid. To disorient pests, crops are also known to be planted out in different patterns and mixes, following the principle "let one crop protect another".

Similar ways and methods for plant protection are considered environment-friendly and harmless to man, although we have virtually no science-based data on the toxic properties, for example, of tomato top or tobacco infusions. The specific odours of the mentioned plants is believed to repel the pest, orient it away from the stuff it feeds on or create an ambit unfavourable for the respective disease. In the systems of biological forming, similar vegetable origin preparations for plant protection are favoured over synthetic ones.

However, very few markets offer volume-produced plant protection agents having a vegetable-origin substance as the active ingredient, readily decomposable in biological processes. This is accounted for by the costs for cultivating the plants known for their fungicidal or insecticidal properties (garlic, marigold, african marigold, etc.) prohibitively high, the manufacturing depending on the season of the year, the lack of science-based knowledge and the like.

Already by the end of the 80s the Latvian Forestry Research Institute "Silava" (LFRI "Silava") put forward a hypothesis that it should be possible to use in plant protection the substances recovered from conifer needles. The philosophy followed implies that in terms of plant protection the transfer of natural substances found in one ecosystem (forest) to another (garden, greenhouse) should result in a higher repelling effect than a similar transfer within the same ecosystem. The use of tree foliage as raw material for phytopreparations would come cheaper than cultivating special crops for this need; moreover, the raw material resources are sufficient to organize volume production. A repellent under the trade name SM-87 launched in the 80ies (conifer needle meal) is effective against strawberry weevil and other pests; it became popular with the customers, but, unfortunately, was phased out in the early 90s.

Research on the recovery of phytopreparations from forest raw materials was started in 1992 as a co-effort between the LFRI "Silava" and the Institute of Biology with the Latvian University.

The literature sources quote the conifer needles to contain substances effective against pests and/or slowing down fungus infections or reducing their harmful effect (Micales, Hans, Davis, Young, 1994; Ohira, Tatsuro, Yatagai, Mitsuyoshi, 1993; Vyrodov, Solodkaya, Nikolaeva, Smirnova, 1987; Theander, 1982; Harvey, Grahan, 1969, etc.).

The substances referred to are mainly volatile oils and resinous acids, intensively emitted by conifers in case of disease or damage inflicted to the tree. The chemical composition of the above substances and those found in agricultural crops differs widely and, consequently, the former are alien to the pests and diseases of farm crops. The process of recovering resinous acids has been tested in industrial production. However, the application of the mentioned substances in practice has so far been limited as compared to other groups of foliar substances.

The related research work on the fungicidal and insecticidal properties of tree foliage products, the toxicological and ecological evaluation of the prototype preparations, elaborating technologies for manufacturing the respective products, working out the documentation and application recipes – all this had a single end in view – an availability of highly effective natural preparations for plant protection, harmless to man and the environment.

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Materials and methods

The material used in the given study – phytopreparation "Fitoekols – IF" represents a mix of resinous and fatty acids recovered at the LFRI "Silava" laboratory, complemented by the water soluble salts of the mentioned acids. In addition to the resinous and fatty acids, "Fitoekols – IF" holds an emulsifier good for plant protection, a surface-active agent and a pH regulator, providing for the required consistency, viscosity, wettability and adhesiveness of the preparation.

1. Determining biological activity.

The biological activity of individual organic substances and the preparation as such was tested under laboratory conditions for their fungicidal and insecticidal properties. The phytopreparation was also field tested, including tests for crops under glass cover.

The fungicidal properties were laboratory-tested by using the Czapek's medium. The cultures of common mildew (*Erysphe Communis*) and grey rot (*Botritis cinerea*) were placed on the medium's surface (Variant 1) or mixed into the substance (Variant 2) before and after treating the medium with a 2% suspension of the test substance, with no treatment of the media used as control. The samples were kept in an ambit favouring the fungus growth: the temperature 18° to 20°C, humidity 90 to 95%. The preparation's efficacy, using a five point scale, was evaluated following the size of the fungus colony and its growth rates, compared to the control.

Evaluation	Points
No development of fungi infection	0
Infection, very slight	1
Slight	2
Moderate	3
Heavy	4
Test and control media identical	5

• Determining fungicidal properties.

In the tests, tomatoes and cucumbers growing under glass cover were used as host plants, preventively treated with a 2% solution of the mentioned preparation and subsequently infected with a pure culture of:

grey rot (*Botrytis cinerea*),

• common mildew (*Erysphe communis*) et al.

The average test temperature was 18° to 24°C, the relative air humidity – 70 to 75%. The degree of infection was, by using a 5-point scale, evaluated following the degree of damage visible on the leaf's surface:

Evaluation	Points
No damages	0
Damage up to 10%	1
Damage 11 to 25%	2
Damage 26 to 50%	3
Damage above 50%	4

The testing was done in 3 variants:

Variant 1 – before the infestation the crops were preventively spray-treated with the preparation

Variant 2 – the preparation was applied at the degree of infection 1

Variant 3 – no preparation applied.

The preparation's efficacy was field-tested for the following crops and fungus diseases, respectively: potatoes – *Phytophtora infestans*; tomatoes – grey rot and mildew; ornamental crops – mildew. The results were compared with the control.

• Determinig insecticidal properties.

For the crops under cover (tomatoes and cucumbers) the preparation's insecticidal properties were tested in respect to *Trialeurodes vaporariorum* and *Myzodes persicae* (green peach aphid). In the field tests, the crops and the pest in respect to which the preparation was tested were the following: beans – *Aphis fabae* (bean aphid); roses – *Macrosiphyus rosae* (rose aphid); apple trees – *Psylla mali* and *Aphis pomi* (apple aphid); plum trees – *Hyalopterus arundinis* (plum aphid). The preparation's efficacy, compared with the control, is expressed in per cent terms and calculated following the Abbot's formula.

2. The effect of "Fitoekols IF" on plant physiology.

Laboratory experiments for determining the amount of chlorophyll and transpiration intensity for the test specimens and the control were meant to find out whether "Fitoekols IF" comprising extractive substances of pine needles (natural salts of resinous and fatty acids), had any ill effect on the plant.

The amount of chlorophyll was determined spectrophotometrically by evaluating the optical density at 664 and 647 nm. Chlorophyll "a" was calculated following the formula:

$$C_a = 11.78D_{664} - 2.29D_{647},$$

Chlorophyll "b":

$$C_b = 20.05D_{647} - 4.77D_{664}.$$

The experiment was done in three variants with four replications in each. The data were processed mathematically by using the method of dispersion analysis and evaluated following the Fisher's criterion. Chlorophyll "a" and "b" was determined for untreated tomato leaves after 12 h and after a week since the time of treatment. Transpiration intensity in the plants was determined by using the Ivanov's method of prompt weighing. The experiment was done in two variants with four replications in each.

3. Determining physico-chemical properties

• Preparation samples were taken following the standard GOST 5445 – 79 (of the former Soviet Union).

• Qualitative and quantitative characteristics determined following the methods used in analytical chemistry.

• Outer appearance, colour, odour, determined organoleptically (GOST 5472 – 50).

• Humidity determined following the conventional procedure: desicator (the temperature range 40° to 200°C), balance, exsiccator, crucible tongs, weighing beakers.

• Water content (w) determined in per cent by the formula:

$$W = \frac{(m_2 - m_1) \times 100}{n}, \text{ where}$$

m_1 – mass of the test substance, in g

m_2 – mass of the leaves containing the sample before drying

n – number of measurements.

The result is the arithmetic mean of three parallel measurements.

• The pH number is determined for a 2% solution of the preparation by using a pH-meter, the analysis is conducted at 18° to 20°C.

• Evaluating wettability. It is evaluated by measuring the time the solution stirred remains in a suspended state and by determining the degree of suspension; evaluation by a 5-point scale:

Evaluations	Points
Very poor (91 to 100 sec)	1
Poor (71 to 90 sec)	2
Moderate (51 to 70 sec)	3
Good (31 to 50 sec)	4
Very good (10 to 30 sec)	5

• The suspension's stability, when prepared for application is determined following the degree of sedimentation over time (30, 60 and 90 min.); evaluation in per cent; evaluation by a 5-point scale:

Evaluation	Points
Very unstable (sedimentation 71 to 100%)	1
Unstable (sedimentation 41 to 70%)	2
Moderate (sedimentation 31 to 40%)	3
Stable (sedimentation 11 to 20%)	4
Very stable (sedimentation up to 10%)	5

• The adhesion ability is evaluated by keeping in a squirt of water per 10 min a sample of the preparation applied to a surface (glass, leaf) and let it dry at room temperature, subsequently determining the mass of the matter retained and evaluating it in per cent of the dry matter originally applied to the mentioned surface; evaluation by a 5-point scale.

Evaluation	Points scored
Very poor (per cent of the matter retained below 10%)	1
Poor (below 20%)	2
Moderate (within 40 to 60%)	3
Good (up to 80%)	4
Very good (up to 100%)	5

• Determining viscosity.

It is done by using a viscosimeter (as well as by placing a drop (1 ml) of the suspension on the leaf's surface and measuring (in cm^2) the size of the spill, evaluation by using a 5-point scale:

Evaluation	Points scored
Very low (spill size 0.5 to 1.0 cm^2; poises 31 to 50)	1
Low (respectively 1.1 to 1.5 cm^2; 21 to 30)	2
Moderate (1.6 to 2.0 cm^2; 10 to 20)	3
High (2.1 to 2.5 cm^2; 6 to 10)	
4	
Very high (2.6 to 3.0 cm^2; 1 to 5)	5

• Phytopreparation's stability in storage.I

It was evaluated over a 2-year storage period by determining the changes in the preparation's chemical composition each 30 days.

4. Toxicological evaluation.

The toxicological evaluation was done following the OECD Guidelines for Testing of Chemicals (Paris, 1984); 401 Acute Oral Toxicity; 405 Acute Eye Irritation; 404 Acute Dermal Irritation; 406 Skin Sensitisation. The tests included determining LD_{50} to wistar rats (n = 10), eye mucous membrane irritation to rabbits (n = 4), dermal irritation to guinea pigs (n = 20) and skin sensitization effect to guinea pigs (n = 20).

Also has been investigated is the impact of the preparation on the soil and water micro- and macrofauna by evaluating the variations and repairability dynamics of nitrogen-fixing bacteria and trichoderma at the moment of 24, 120 and 336 h after the preparation (concentrations 0.2%, 0.5%, 1.0%, 2.0%, 3.0%) was applied; for earthworms the time of evaluation was 12, 24 and 36 h after the preparation was applied.

Results and discussion

1. Determining biological activity

The biological activity of individual resinous and fatty acids recovered from pine and spruce needles is found to be by 25 to 30% less as compared to the activity of the same acids in a mix. The optimum ratio of fatty to resinous acids in the preparation is close to the natural one for the conifer needles. The preparation's biological activity and efficacy can be increased by complementing the mix of pine and spruce needle extractive substances by emulsifiers, surface-active substances and by regulating pH.

The result of evaluating the phytopreparation's biological activity are summarized in the table.

As seen from Table 1, "Fitoekols IF" in a 2% concentration acts preventively against the fungus disease, as it covers the substrate surface before the fungus can get into an immediate contact with the host plant (efficacy 70 to 100%). The efficacy is 20 to 30% less in case the fungus at its initial stages of the growth had no direct contact with the preparation; the beneficial fungus *Trichoderma*, which can also be used for suppressing fungus infections may, as seen from the data, get inactivated to some extent (by 40 to 50%), when in direct contact with the above preparation. Hence, it seems inappropriate to use the two plant protection agents concurrenly.

2. Determining fungicidal properties in respect to crops under glass cover.

The results of evaluating the preparation's fungicidal properties for crops under glass cover are summarized in Table 2.

As seen from Table 2, "Fitoekols IF" in a 2% concentration is an effective agent to preventively suppress

Table 1. Determining "Fitoekols IF" biological activity

Variant	Way of applying the fungus	Fungi used	Degree of fungus development, in points	Preparation's efficacy, %
1	Placed on the medium	Mildew	0	90 - 100
	before treating with the	Grey rot	1	70 - 80
	preparation	Trichoderma	2	40 - 50
2	Admixed to the medium	Mildew	1	70 - 80
	before treating	Grey rot	2	40 - 50
		Trichoderma	3	20 - 30
3	No treatment with the	Mildew	5	-
	preparation	Grey rot	5	-
		Trichoderma	5	-

Table 2. The efficacy of "Fitoekols IF" in suppressing infection by fungus diseases for the greenhouse and field crops

Crop	Average air t, °C	Relative air humidity, %	Pathogenic fungus	Working suspension, %	Degree of infection, effect compared to the control		Efficacy
					Points	%	
Cucumbers	22-26	85-95	Grey rot (*Botrytis cinerea*)	1.0	III	50-70	average
				2.0	II	70-75	considerable
			Mildew (*Pseudoperonospora cutensis*)	1.0	II	65-75	considerable
				2.0	I	I	good
			Grey rot	control - no treatment	IV		
			Mildew		IV		
Tomatoes	18-22	75-85	*Cladosporium fulvum*	1.0	IV	20-30	insignifi-cant average
				2.0	III	50-70	considerable
			Grey rot	1.0	II	70-73	considerable
			"	2.0	II	72-75	good
			Mildew	1.0	I	75-85	very good
				2.0	I	85-95	
			Grey rot	Bordeaux- 2.0	II	70-75	considerable
			Mildew		I	80-85	good
			Cladosporium fulvum	control - no treatment	IV		
			Grey rot		IV		
			Mildew		IV		

fungus diseases for the crops under glass cover. Its efficacy in respect to individual infections (Grey rot, false mildew) is from 70 to 85%. The development of some fungi, more resistant to the preparation (*Cladosporium fulvum*) is slowed down by 20 to 30%. Hence, repeated applications of the preparation over the growing season may reduce the infection by fungus diseases below the critical limit, in comparison to that achieved by using the Bordeaux liquid.

3. Determining fungicidal properties in respect to field crops.

"Fitoekols IF" in a 2% concentration was field-tested to control phytophtora in potatoes tops (varieties

'*Laimdota*' and '*Madara*'). The treatment was preventively applied before the infection had started; the air temperature during the test period was 25° to 28°C, air humidity – 50 to 70%. The preparation's efficacy did not exceed 50% and showed no marked difference as compared with the control. However, the results cannot be considered final, as the weather conditions were unfavourable for intensive growth of phytophtorosis. The test results are tabulated below.

As shown in Table 3, a single treatment of the field crops by "Fitoekols IF" in the climatic conditions of Latvia results in reduction of the most wide-spread fungus diseases by 40 to 74%. Application of mentioned preparation 3 to 4 times over the growing season may, observing the recipes and mixing formulae worked out, reduce the related infections by 80 to 90% even in the years favourable for the fungus development. Our observations show "Fitoekols IF" in many situations to be more effective than the Bordeaux liquid.

resistant to "Fitoekols IF"; the effect after a single treatment stays below 25 to 30%. More recent inquiries among the practicians using the preparation (in 1996, 1997) show "Fitoekols IF" to be efficient over a much wider spectrum of pests and diseases than known earlier; the references for the most part were positive.

5. The action of "Fitoekols IF"

• Fungicidal action.

The preparation prevents the growth of fungus' spores resulting in an increased granularity of their cytoplasm, accompanied by membrane chapping and rupturing; it also creates an oxygen-deficient atmosphere destructive to an optimum humidity regime on the spore surface.

• Insecticidal action.

The preparation, when in contact with the plants surface, prevents the movement of tiny sucking insects and keeps them away from feeding on plant saps.

Table 3. The efficacy of "Fitoekols IF" in suppressing the fungus diseases in field crops (a single, preventive treatment with a 2% suspension)

4. "Fitoekols IF" efficacy to control sucking insects for under-cover and field crops.

The results of evaluating the preparation's pesticidal properties to control the sucking insects are summarized in Table 4.

As seen from Table 4, "Fitoekols IF" shows some insecticidal properties, too, a phenomenon considered by us a side effect. The preparation's efficacy is different depending on the type of pest; it is highest for *Trianlerodes vapororium* and rose aphids (75 to 80%). However, some aphids, especially those of beans, are more

The agent admixed to the plant sap through the insect's sucker works into its intestines and via haemolymph poisons its entire organisms, thus interfering with a number of physiological and biochemical processes, inactivating ferments and disrupting the functions of sulphahydral groups; substantially affecting the processes of protein, hydrocarbon, lipid formation and the related metabolism, resulting in a sharp decrease of the mentioned substances in the insect's body which in its turn leads to dewatering of its organism, lower feeding intensity and the insect's dieback.

Table 4. The efficacy of "Fitoekols IF" to control the sucking insects on the greenhouse and field crops

Pest	Crop	Average air temperature °C	Relative air humi-dity, %	Concen-tration of suspen-sion, %	Pest, mortality over different periods after the treatment %					Efficacy, %
					6 h.	12 h	24 h	48 h	72 h	
Greenhouse crops										
Trialeurodes vaporariorum	cucumbers	18-21	80-90	1.0	0	6.0	10.0	18.5	30.5	65.0
"	"	"	"	2.0	2.0	5.5	5.0	20.0	46.5	78.0
"	"	"	"	Control	0	0	0	0	0	0
Myzodes persicae	"	"	"	1.0	0	0	0	12.5	6.0	35.5
"	"	"	"	2.0	4	7.5	8.0	10.5	10.3	40.8
"	"	"	"	Control	0	0	0	0	0	0
Trialeurodes vaporariorum	tomatoes	17-20	75-85	1.0	0	2.0	32.3	30.0	11.0	75.3
"	"	"	"	2.0	0	10.5	15.0	35.0	10.0	70.5
"	"	"	"	Control	0	0	0	0	0	0
Field crops										
Macrosiphum rosae	roses	17-21	65-75	1.0	0	10.0	10.0	32.5	27.5	80.0
"	"	"	"	2.0	0	5.0	5.0	40.5	25.0	75.5
"	"	"	"	Control	0	0	0	0	0	0
Aphis pomi	apples	"	"	1.0	0	5.0	5.0	15.5	10.0	35.5
"	"	"	"	2.0	0	0	10.0	7.0	10.3	27.3
"	"	"	"	Control	0	0	0	0	0	0
Aphis fabae	beans	15-20	65-75	1.0	0	0	2.5	10.5	12.5	25.5
"	"	"	"	2.0	0	0	5.0	5.0	10.0	20.0
"	"	"	"	Control	0	0	0	0	0	0

6. "Fitoekols IF" effect on the plant physiology.

The experimental results show no substantial difference between the amount of chlorophyll "b" for the plants treated with the preparation and untreated. The data processing by mathematical methods, too, shows the content of chlorophyll "a" in the leaves before and after treatment to be practically identical:

$$F_{act.} < F_{est} \qquad F_{act.} = 6.73; \quad F_{est.} = 9.55.$$

the arithmetic mean standard error: $S_x = \pm 0.49$.

Hence, the application of "Fitoekols IF" has no substantial effect on the chlorophyll content in the plants, as compared with the control (Table 5).

Table 5. The chlorophyll content in tomato leaves (mg/l) for "Fitoekols IF" treated and untreated plants

Chlorophyll	Chlorophyll content in tomato leaves, mg/l		
	Untreated plants	In 12 h after treatment	In one week after treatment
"a"	7.93	8.85	6.33
"b"	3.29	3.33	3.19

7. Toxicological evaluation

The toxicological evaluation of "Fitoekols IF" proves it to provoke virtually no mucous membrane irritation, dermal irritation or skin sensitization effects. Hence, the preparation may be characterized as low hazard substance falling in Toxicity Class 4.

Research data on the preparation's effect on soil microflora show that at low concentrations (0.2 to 0.5%) the microflora activity stays within the limits of 50 to 78%, while at average concentrations "Fitoekols IF" may reduce it up to 50%. However, in two weeks' time after the treatment the mentioned activity may be recreated within 50 to 80% of the original level.

The application of the preparation in the concentrations recommended (between 1 to 2%) is found to have no toxic effect on earth worms.

Follow-up of the "Fitoekols IF" stability in storage over a 2-year period show no substantial changes of its chemical composition; storage is possible in plastic or glass packaging.

8. Physico-chemical properties

The physico-chemical properties of the preparation in its different forms are summarized in Tables 6 and 7.

As it follows from the table, a suspension ready for application can most promptly be obtained by using the preparation in the form of aqueous suspension; the time needed for making the solution in the longest with the crystalline powder. The rate of wetting of the preparation

Table 6. Physico-chemical properties of the preparation's different forms

can be increased by using warm water (30° to 40°C) and stirring.

9. The suspension's stability when prepared for application

Regardless of the form used in making the solution for immediate application, the preparation is evaluated as stable (4 points) or very stable (5 points). After 90 min. the degree of sedimentation is below 10%.

10. Sticking ability

Following the laboratory tests according to the method described earlier and field observations for different crops, the preparation's sticking ability was evaluated as "good" (4 points) and "very good" (5 points). A wax-like substance, added to the preparation as specified by the mixing formula, intensifies its sticking ability.

11. Viscosity (surface tension)

Following the two methods described earlier the viscosity of the preparation ready for application was, depending on the crop type, evaluated between "average" (3 points) and "good" (4 points) (the size of the drop's spill 1.6 to 2.5 cm^2). In spray-treating the crops, the recommended droplet weight is 90 to 100 mg, which can be achieved by using a sprayer with a nozzle diameter 1.6 to 2.0 mm at the air pressure of 1.5 to 2 atm.

Heavier droplets tend to flow together, thus reducing the preparation's stability on the surface it is applied to.

The transpiration intensity from the leaves, determined for the plants before treatment by "Fitoekols IF" and after 24 h following the treatment, was on the average 111.24 g/m^2 per h for the plants treated and 111.33 g/m^2 per h for untreated. Hence, the above preparation has no substantial effect on transpiration process in plants.

Conclusions

1. Extractive substances of pine and spruce needles, predominantly resinous acids, as vegetable origin substances safe to man and the environment, hold promise to control pests and diseases in garden and farm crops.

2. A novel and effective preparation "Fitoekols IF" of vegetable origin has been developed. It is devoid of toxicity, posseses fungicidal and partly insecticidal properties. The preparation is recommended for suppressing fungus diseases (mildew, grey rot, moulds, etc.) as well as controlling sucking insects (*Trianleurode vaporariorum*, aphid, thrips, etc.).

3. For the crops under cover, the phytopreparation's efficacy in suppressing fungus diseases is from 70 to 80%; for the field crops the efficacy in respect to sucking insects is up to 75%.

4. In farming and horticulture "Fitoekols IF" opens up new possibilities for developing systems of biological farming, as well as for complex utilization of tree foliage.

5. Research on new and more diversified uses of foliar substances is continued.

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НОВЫЙ ЭКОЛОГИЧЕСКИ БЕЗОПАСНЫЙ БИОЛОГИЧЕСКИЙ ПРЕПАРАТ "ФИТОЭКОЛ – ИФ" С ФУНГИЦИДНЫМИ СВОЙСТВАМИ

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Резюме

Рассмотрены возможности использования экстрактивных веществ хвои при защите растений и создании препаратов с фунгицидными и инсектицидными свойствами. Приведены результаты испытаний препарата "Фитоэколс – ИФ", созданного на базе солей смоляных и жирных кислот хвойных при защите растений от грибных заболеваний и сосущих вредителей. Показано, что фитопрепарат "Фитоэколс – ИФ" не загрязняет окружающую среду и продукцию, не токсичен для человека и животных, и достаточно эффективен при защите растений как в теплицах так и на открытых площадях. Препарат соответствует требованиям для применения в интегрированных системах защиты растений, в т.ч. для биологических схемах сельского хозяйства. Показаны новые возможности использования древесной зелени хвойных.

Ключевые слова: грибные заболевания, защита растений, фитопрепарат "Фитоэколс – ИФ"