

Secondary plant metabolites as promising pesticides for increasing crop yields

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Abstract. This article presents the results of biological tests in rice growing, cotton growing, sericulture, as well as against termites of insecticidal, mutagenic and growth activity of a number of ecologically safe effective plant terpenoids.

1 Introduction

It is known that chemical agents occupy a significant place in the plant protection system. Currently, synthetic pesticides are used in large quantities. Along with them, herbal preparations are also used, which have advantages over synthetic ones. When using synthetic pesticides, the waiting period should be strictly observed, while herbal preparations can be used until harvesting [1].

Pesticide plants for widespread use are readily available and widespread on the territory of our republic. However, at present, innovative research in this direction is not being carried out in full. In order to find and introduce new highly effective medicines and pesticides, it is necessary to expand the development of methods for obtaining biologically active compounds from wild and medicinal plants [1, 2].

Currently, the class of terpenoids, including sesquiterpene lactones, are attracting the attention of a wide range of researchers, not only by interesting chemical and structural features, but mainly by a wide spectrum of biological action. Sesquiterpene lactones, being a large group of secondary metabolites, are widespread in plants, and at present, the structure of more than 4000 of their representatives with acyclic, mono-, di- and tricyclic carbon skeletons has been isolated and established [3-5].

Mono- and bicyclic sesquiterpene γ -lactones are widespread in flowering plants of the *Asteraceae* family, and they are valuable, readily available and renewable raw materials for the production of a wide variety of biologically active substances and medicines. Among the sesquiterpene lactones we isolated from plants of the *Asteraceae* family, compounds with insecticidal, growth-regulating, antifungal, antiparasitic, mutagenic activities were identified, and therefore scientific research in this direction is relevant and promising [6].

On a global scale, the production of living cocoons is growing, along with this, due to dangerous infectious diseases; 15-20% of the harvest of cocoons is damaged [4, 6]. To

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solve this problem, several investigations are being carried out in leading research centers of Uzbekistan [5, 8]. In this regard, the identification of genes resistant to various infections of the silkworm, the identification of productive forms from populations of various origins, the creation of environmentally friendly natural remedies against diseases and the development of preventive measures are one of the most important tasks. There is evidence that the sources of antibacterial, antiviral, antiprotozoal medicines are medicinal plants containing various classes of natural compounds (alkaloids, quinones, polyphenols, saponins, terpenoids, sesquiterpene lactones) [7, 9].

Thus, the aim of our research was to test extracts (sum of sesquiterpene lactones) isolated from various plants against silkworm nosematosis.

2 Materials and methods

Currently, various plant growth stimulants are used in agriculture and they significantly increase the productivity of various crops than organic and mineral fertilizers. A specific feature of plant growth bioregulators is their ability to influence processes that cannot be regulated by conventional agrotechnical methods of crop cultivation, such as irrigation, the use of fertilizers, etc. The use of plant growth regulators with a versatile spectrum of action contributes to a significant reduction in the use of plant protection products from diseases and pests. Therefore, an integrated approach to the use of plant growth bioregulators, which have both growth-regulating and immunostimulating effects in the system of other elements of technology, is still relevant today.

Such studies [3, 4] describe the growth-regulating activity of a number of isoprenoids related to sesquiterpenoids with different types of carbon skeleton. The research results showed that the sesquiterpenoids α - santonine (1), zerumbone (2) and C16-guayanolide (3) (Figure 1), isolated from plants, increase the yield of rice after one-day soaking of seeds in their solutions at a dilution of 1: 10,000 compared to the control by 14.17% (α -santonine, zerumbone) and 7.5% (C16-guayanolide).

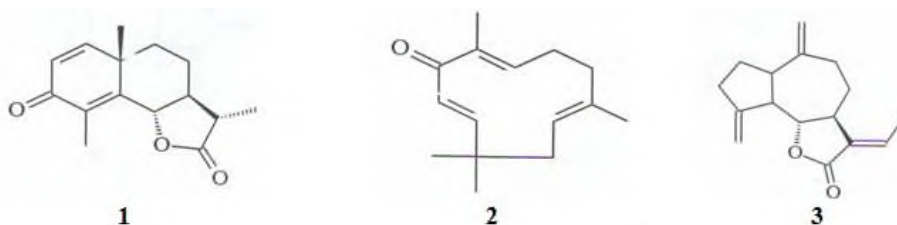


Fig. 1. Sesquiterpenoids: α - santonine (1), zerumbone (2), and C16-guayanolide (3)

It should be noted that the aforementioned α -santonine (1) is produced in major quantities by plants of the genus *Artemisia* belonging to the subgenus *Seriphidium* (Bess) Rouy, such as *A ferganensis*, *A diffusa*, *A halophila*, *A leucodes*, *A turanica*, *A terrae-albae*, *A serotina*, and *A tenuisecta* [10]. These types of wormwood are the main edificators of plant communities in arid and semi-arid zones of Uzbekistan and form wormwood pastures over a vast territory exceeding 15 million hectares, and which can be used as raw materials for the production of α -santonine in the necessary quantities for its use as a growth stimulating agent.

In connection with the above, we have considered the growth-regulating activity of a number of terpenoids (including α -santonine) isolated by us from plants of the flora of Uzbekistan [5, 8, 11]. The following technique was used to examine the growth of stimulatory activity. A weighed portion of a terpenoid was dissolved in a small amount of

alcohol and diluted with water to volume in a ratio of 1: 10000. Then, the rice seeds were immersed in the resulting solution of each terpenoid separately for 24 hours. The yield was determined by dry weight and the results were compared with the control. As the results showed, the most active growth regulators were α -santonine, monoterpenoid liganolide (1), repine (2), which significantly increased the yield of rice by an average of 12.5%, and graniline (3) and artabine (4) - to 10% (Figure 2).

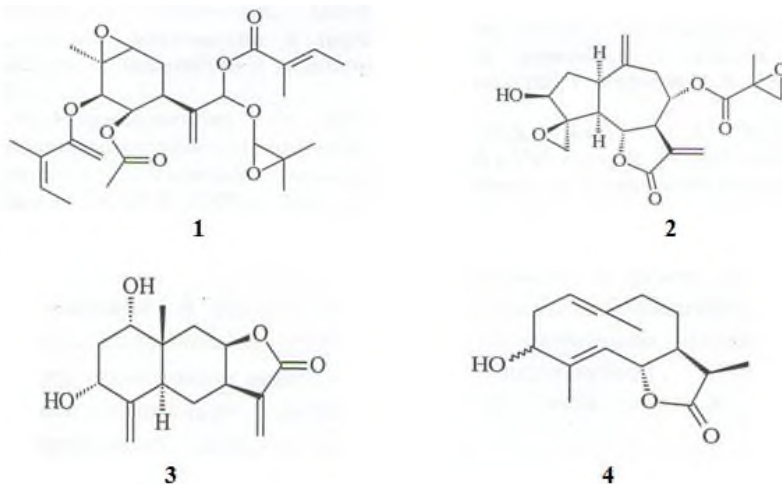


Fig. 2. Sesquiterpenoids: most active growth regulators

Currently, a serious problem is the Turkestan and large Transcaspien termites, which cause enormous damage to buildings, structures, including historical cultural monuments. The chemical preparations used against termites currently have a temporary effect, since they have a short-term effect (no more than 3-5 days). In addition, due to growing environmental and health concerns, many are completely banned. Despite the ongoing large-scale work to reduce the population of termites, the scale of their distribution and the damage caused to them is growing every year. In this regard, there is a need to develop new methods and means of combating termites using poisonous food baits of intestinal prolonged action, which kill termites within 40-45 days. Recent studies have shown that mono- and sesquiterpenoids produced by plants of the *Asteraceae* family are the most promising anti-termite medicines.

At the first stage of the study of thermicidal activity, we studied sesquiterpene lactones with a germacranane skeleton, isolated from plants of the genus *Centaurea* growing in Uzbekistan. As a result of biological studies of natural sesquiterpene lactones, it was found that a number of germacranolides have high thermicidal activity of intestinal prolonged action. As a result of food processing of termites from cellulose, 0.001 and 0.01% solutions of sesquiterpene lactones, it was found that a number of germacranolides have high thermicidal activity. For example, the sesquiterpene lactones cnicin and salonitenolide, isolated from *Centaurea squarrosa* and *Jurinea maxima*, lead to more than 87% death of termites.

Continuing research on the creation of anti-termite agents, the sesquiterpene lactones *coumambriin A*, *artemisinine* and *artemisinine B* were isolated, which, when used individually, lead to 96-100% death of termites on days 6-10 [6-8].

In the selection of the starting material in cotton growing, ionizing radiation and chemical mutagens are mainly used. The use of mutagens of plant origin makes it possible in a short time to obtain a valuable source material for breeding purposes.

Earlier, when studying the mutagenic effect of extractives *Artemisia absinthium* (in medicine "PRP") on cotton, we obtained mutant lines. It was found that at different concentrations, PRP has a pronounced biostimulating and mutagenic activity. Seeds of cotton varieties C-6524, C-6532, C-9070, and others were treated with a preparation of various concentrations (2.0; 1.5; 1.0; 0.5%) and sown in the field. The following indicators were analyzed: seed germination, plant survival and the degree of development of traits characterizing productivity. In experimental variants, at concentrations of 1.0 and 0.5%, there is a pronounced stimulation, in particular, by the accumulation of fruit organs on a bush, an increase in the weight of raw cotton per plant, due to an increase in the number and weight of bolls.

This medicine in concentrations of 2 and 1% was used as a modifier to relieve depression during irradiation of seeds. For the study, cultivar C-6524 was taken, as mutagenic factors - gamma rays Co60 and PRP at a concentration of 1 and 0.5%. For control served unirradiated seeds, simply soaked in water and the second control - just irradiated seeds.

3 Results and discussion

As a result of research, a promising breeding material in the form of mutant lines and varieties has been obtained. A number of promising mutagenic lines are being studied in the laboratory and in nurseries of radiation mutagenesis. Two mutant lines are being tested in competitive and station variety trials. A new water-soluble individual guaian sesquiterpene lactone with mutagenic activity was isolated from this plant [9-11].

After treatment of egg with agents representing the sum of the sesquiterpene lactones ATEN, AANN, AREP, SESK, only in variant 4 there was a decrease in the yield of caterpillars in comparison with the control by an average of 8.25%. In the rest of the variants, the revivability of the egg was higher than in the control and ranged within 81.5-89.0%. Obviously, the revitalization of egg depends to a certain extent on the agent used. The higher the concentration of the agent, the lower the percentage of caterpillar yield (Table 1).

Table 1. Revitalization of egg after treatment with the sum of lactones

#	Unit and concentration, %	Egg revivability after treatment, %			Compared to control	
					Growth	Decrease
		$\bar{X} \pm S_{\bar{x}}$	Cv	Pd	abs. %	abs. %
1	ATEN 0.5	84.7±0.20	0.4	0.999	4.50	-
2	ATEN 1.0	81.5±0.32	0.7	0.999	1.25	-
3	AANN 0.5	85.5±0.45	0.4	0.999	5.25	-
4	AANN 1.0	72.0±0.32	0.8	0.999	-	8.25
5	SESK 0.5	89.0±0.76	1.5	0.999	8.75	-
6	AREP 0.5	81.5±0.26	0.3	0.999	1.25	-
7	SESK+AREP+ ATEN+AANN (each 0.5)	82.0±0.08	0.1	0.999	1.75	-
8	Control (water)	80.25±0.462	1.0			

Higher concentrations of solutions of the studied agents, as in medicine with pharmaceuticals, had a depressing effect on a living organism - silkworm eggs. In cases with the use of higher concentrations of extracts (2, 4), a slight increase in vivacity was recorded (ATEN 1.0 - 1.25%) or a serious decrease (AANN 1.0 - 8.25%). In variants (1, 3, 5), where green grass was treated in solutions of agents with a lower concentration, an increase in the yield of caterpillars (revitalization) was observed by 4.50-8.75 absolute percent. In terms of production of egg, this is a fairly high percentage, indicating a significant increase in the quality of egg.

In the same experiment, another, much more important indicator of the quality of egg was taken into account - its infection with Nosematosis, or rather, a decrease in infection under the influence of tested agents.

Table 2 shows the results of infection of caterpillars after treatment with egg in solutions of sesquiterpene lactones.

Table 2. Infection of caterpillars with nosematosis after treatment with the sum of sesquiterpene lactones

#	Unit and concentration, %	Infestation of caterpillars- revivals, %	Decrease in infestation compared to control	
			abs. %	rational, %
1	ATEN 0.5	4.5	3.6	44.4
2	ATEN 1.0	1.8	6.3	77.8
3	AANN 0.5	3.2	4.9	60.5
4	AANN 1.0	2.4	5.7	70.4
5	SESK 0.5	0.9	7.2	88.9
6	AREP 0.5	2.6	5.5	67.9
7	SESK+AREP+ ATEN+AANN (each 0.5)	2.4	5.7	70.4
8	Control (water)	8.1	-	-

The analysis of the results obtained, presented in Table 2, indicates that after treatment of the Nosematosis-infected eggs with solutions of the sum of sesquiterpene lactones, in all variants the Nosematosis infection in the emerging revived caterpillars decreased. Each caterpillar emerging from the treated eggde was microscoped individually. Treatment with solutions of extracts infected with Nosematosis Egg, reduced the infection of hatched caterpillars in comparison with the control by 3.6-7.2% absolute, or 44.4-88.9 relative percent. The most effective, with a high anti-earth effect, turned out to be funds with the code names SESK in 0.5% concentration, ATEN in 1.0% concentration and AANN in 1.0% concentration.

These funds are isolated from finely dissected wormwood, annual wormwood and cornflower widespread and have antihelminthic, antiprotozoal, antimalarial, as well as anti-inflammatory and immunostimulating properties. The causative agent of silkworm nosematosis, which is in the greenhouse, belongs to the group of protozoal insect diseases. The results obtained on a decrease in the infection of revived caterpillars with nosematosis indicate an active effect of the sum of sesquiterpene lactones on the causative agent of silkworm protozoal disease. An increase in the yield of caterpillars from the groin treated with the above preparations indicates the immunostimulating effect of the tested agents. The results obtained on the effect of the sum of sesquiterpene lactones on the infection of egg with nosematosis were processed by a mathematical method. Mathematical processing

of the results of the experiment on the revivability of egg and the infestation of caterpillars of revivals with nosematosis testifies to their reliability.

For clarity, we present the infestation of revived caterpillars with silkworm nosematosis, hatched from an egg, slightly infected with nosematosis and treated with herbal preparations (Figure 3).

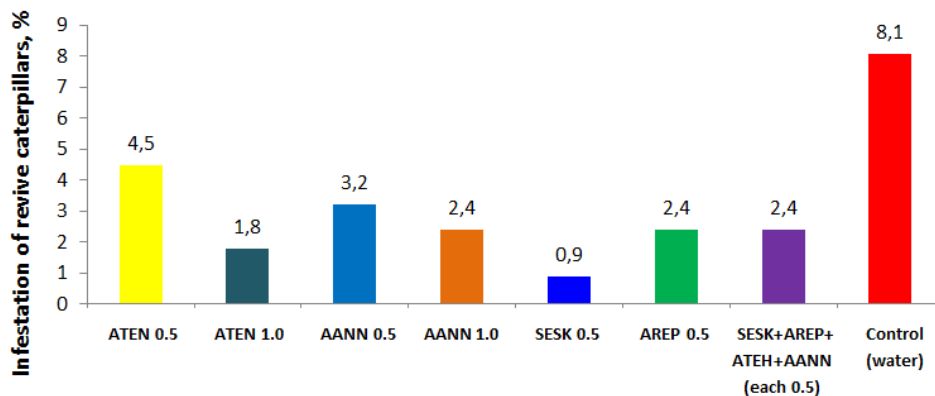


Fig. 3. Nosematosis infection of revived caterpillars emerging from weakly infected and treated with medicines egg

As can be seen in Figure 3, the lowest infection with nosematosis is observed in revived caterpillars that emerged from a weakly infected cepa treated with SESK (0.9%), ATEN 1.0 (1.8%), and AANN 1.0 (2.4%). It should be noted that the use of plant biostimulants in high concentrations of ATEN 1.0 and AANN 1.0 caused a decrease in the revitalization of egg within the experiment, that is, it had a depressing effect on the development of the embryo (Table 1). The same terpenoids caused a decrease in the infestation of revived caterpillars by 6.3 and 5.7 absolute or 77.8 and 70.4 relative percent, respectively (Table 2). Consequently, sesquiterpene lactones have a detrimental effect on silkworm nosematosis, while simultaneously suppressing biochemical processes in the organism of the spore carrier.

Thus, it becomes clear that when using biostimulants, one should be careful when choosing medicine concentrations in order to maintain a balance between the stimulating and suppressing effects of sesquiterpene lactones.

4 Conclusion

According to the above, the expansion and deepening of phytochemical studies of terpenoids in the flora of Uzbekistan will lead to the creation of new highly effective ones which are considered as environmentally friendly natural pesticides. This makes it possible to efficiently use local plant materials, preserve biodiversity, and solve environmental problems, which indicates the relevance and prospects of this direction.

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