Study of the potential use of a bentonite clay-sulfur composite in the organic agriculture

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ABSTRACT

Organic production is growing annually both worldwide and in Georgia, driven by its critical importance for a healthy environment and sustainable future. However, to achieve the desired outcomes in organic agriculture, it is essential to replace synthetic pesticides and agrochemicals with bio-preparations and inputs permitted in organic farming. The present study addresses one of such environmentally safe alternative developed at the Georgian Institute of Organic Chemistry: a bentonite clay-sulfur composite. The effect of an aqueous suspension of this composite on various vegetable crops and grapevines was evaluated between 2022 and 2025 at the Tsilkani and Jighaura experimental bases of the LEPL, Scientific-Research Center of Agriculture. The experiments were conducted in three replications, using experimental, standard and control variants.

The study demonstrated that the use of a standard sulfur preparation (Sulfolak) reduced the incidence of powdery mildew on pumpkin by an average of 49.5% compared to the control. A similar result was achieved using a 2% suspension of the bentonite clay-sulfur composite, while combining it with a 6% suspension of Makvaneti kaolin increased the efficacy to 57.4% relative to the control. The bentonite clay-sulfur composite suppressed powdery mildew even more effectively on grapevines; disease prevalence on the leaves and berries in the experimental variants did not exceed 5–7%, whereas it reached 75–80% in the untreated control variant.

Additionally, the population of tomato russet mites was reduced by an average of 60% using both the experimental bio-preparation and Sulfolac individually, while 6% kaolin suspension enhanced this reduction to 75%.

Regarding crop yield, the reduction of pests and diseases through the application of the bentonite clay-sulfur suspension led to a 51.2% increase in tomato yield and a 96.9% increase in pumpkin yield compared to the control. Composition of kaolin further improved these yields to 67.6% and 124.7%, respectively.

Key words: Ecology, bentonite, vegetable crops, grapevine, organic production

INTRODUCTION

Organic agriculture is an alternative to today's conventional intensive agriculture and offers ecological and economic and social efficiency. Today, when the world is facing environmental challenges and food security problems, organic production is becoming increasingly relevant. Eco – farming does not use synthetic pesticides and agrochemicals, synthetic growth regulators, synthetic food additives, artificial preservatives, dyes, flavorings, chemical enzymes and additives. The use of genetically modified organisms is also prohibited. Accordingly, organic farming produces organic products and scientific research have shown, have a number of advantages. In particular, it has a high nutritional value. Organic products often contain much more antioxidants, vitamins and minerals than products produced in conventional farming. In addition, since the plant itself has to deal with pests and diseases, it produces more protective substances. It produces phytochemicals, which have a positive effect on human immunity. It is also safe. The consumer is protected from pesticide residues that can cause allergies, hormonal disorders and a number of other diseases. The use of synthetic chemicals in conventional farming changes the taste characteristics of the crop. Natural aromas and flavors can only be preserved in organic farming. Due to the high content of phytochemicals, it has a pronounced, natural aroma and spicy taste. Also, unlike conventional products, organic products contain more dry matter and the taste is more concentrated and intense. In organic farming, healthy soil provides plant roots with minerals that plants fed with artificial fertilizers lack. Fruits rich in minerals create a more complex and diverse taste bouquet. The market for organic products is growing every year. The world is moving towards to the sustainable agriculture. Organic production, both worldwide and in Georgia, is growing every year, and this is natural, since organic production is critically important for a healthy environment and the future. For the development of organic agriculture and the production of organic products, it is very important to expand the range of alternative, environmentally safe means of biopreparations and pesticides, and to select and use them correctly.

The presents research concerns one such environmentally safe means, which was created at the Georgian Institute of Organic Chemistry and is a bentonite clay-sulfur (50% diatomite + 50% sulfur) composite. The study of the effect of the water-suspension of this composite on some vegetable crops and vines was conducted in 2022-2025 at the Tsilkani and Jighaura experimental bases of the Agricultural Scientific Research Center.

MATERIALS AND METHODS

The aim of the research was to develop, test and disseminate new environmentally safe means in organic and conventional agriculture. In the research, we used methods adopted in organic agriculture and plant protection. The experiments were conducted in test, etalon and control variants with equal areas in 3-3 replications [1]. In each replication, 30 plants were recorded.

In the test variants, we used a 2% suspension of bentonite clay-sulfur composite, and in one of the variants, we added a 6% kaolin solution in combination. In the control variant, no treatments were carried out, while the inorganic sulfur fungicide and acaricide Sulfolac (at a dosage of 3 kg/ha) was used as a standard.

For monitoring, visual observation and a hand lens were used. Disease diagnostics was carried out both on the basis of visual observation and in laboratories using the humid chamber method, by inoculating diseased samples into an artificial nutritional area and using microscopic analysis [2, 3]. Disease prevalence was recorded from April to October every 10 – 15 days on a 5-point scale. The percentage of disease prevalence was calculated using the formula: $I=a/N\times100$, where I is the disease prevalence in %, a is the number of diseased plants, N is the total number of plants being examined [4].

Samples of diseased plants stems, leaves and fruits identified during monitoring were placed in special packages and were taken to the laboratory of Plant Pathology where a detailed analysis was conducted. The study was conducted on selected vegetable crops (tomato variety 'Kharisgula' and pumpkin) and grapevines (varieties 'Khikhvi' and 'Goruli Mtsvane'). Spraying of the product on vegetables was made before flowering, with the subsequent two applications carried out at two-week intervals. For grapevines, spraying was conducted five times on an as-needed basis, with intervals of 7–10 days. Monitoring was conducted on pests and diseases (ash was recorded on pumpkin and grapevine, and mites were recorded on tomatoes), as well as on plant growth and development and harvest volume.

RESULTS AND DISCUSSION

In 2022, no powdery mildew symptoms were observed in any of the experimental treatments due to the hot and dry climatic conditions, which were unfavorable for disease development. Consequently, it was not possible to evaluate the effect of the biopreparation on disease suppression during that growing season.

In contrast, in 2023, frequent rainfall created highly favorable conditions for powdery mildew development. Although the disease developed despite the treatments, its severity was lower in the treated plots than in the untreated control, which was reflected in improved yield performance.

During 2024–2025, climatic conditions were also conducive to powdery mildew development and the disease was observed in all treatments. However, disease severity remained consistently lower in the treated plots compared with the untreated control.

Fig. 1 Use of a bentonite clay biopreparation on pumpkin

Fig 2. Pumpkin variant: combination of bentonite clay with sulfur (2% suspension) + Makvaneti kaolin (6% suspension)

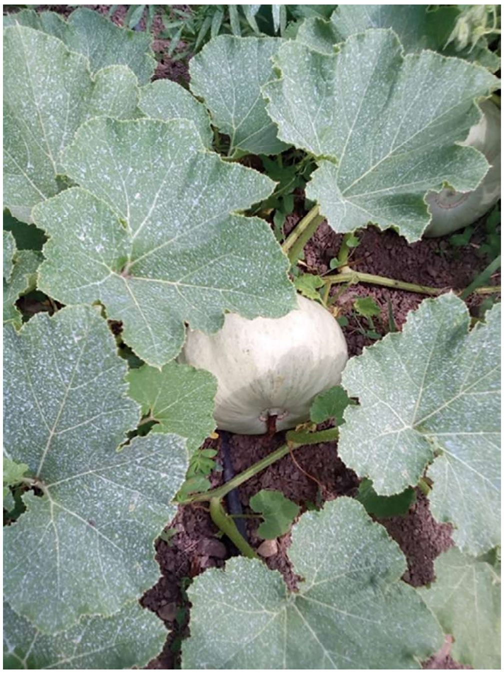


Fig 3. Control variant of Pumpkin

The study found that the use of a sulfur biopreparation (Sulfolak) in the standard variant reduced the percentage of ash development on pumpkin by an average of 49.5% compared to the control. A 2% suspension of bentonite clay-sulfur composite showed the same result, while the combination with a 6% suspension of Makvaneti kaolin increased the difference with the control to 57.4%.

Table 1. The influence of bentonite clay biological preparation on powdery mildew in pumpkins

Tested variant	Powdery mildew prevalence (%)					Intensity of disease development (scale)					Average difference vs. control group (%)
	2022 year	2023 year	2024 year	2025 year	average	2022 year	2023 year	2024 year	2025 year	average	
Bentonite clay with sulfur (2% suspension)	_	34.0	20.0	11.0	21.7	_	2.0	1.0	1.0	1.3	49.5
Bentonite clay with sulfur (2% suspension) + Makvaneti kaolin (6% suspension)	_	28.0	18.0	9.0	18.3	_	2.0	1.0	1.0	1.3	57.4
Control (untreated)	_	67.0	42.0	20.0	43.0	_	4.0	2.0	2.0	2.7	_
Standard (Sulfolac)	_	33.0	20.0	12.0	21.7	_	2.0	1.0	1.0	1.3	49.5

Under the influence of bentonite clay-sulfur, powdery mildew was even more sharply limited on the vine and its distribution on the leaves and grapes of the vine in the experimental variants did not exceed 5-7%, while in the control variant (untreated) this indicator was 75-80%. See Figure N 4, 5.

Fig. 4. Results of the test of bentonite clay-sulfur preparation on grapevine powdery mildew, variety "Goruli Mtsvane": 1 – grapes in the test variant, 2 – grapes in the control variant, 3 – grapes in the standard variant

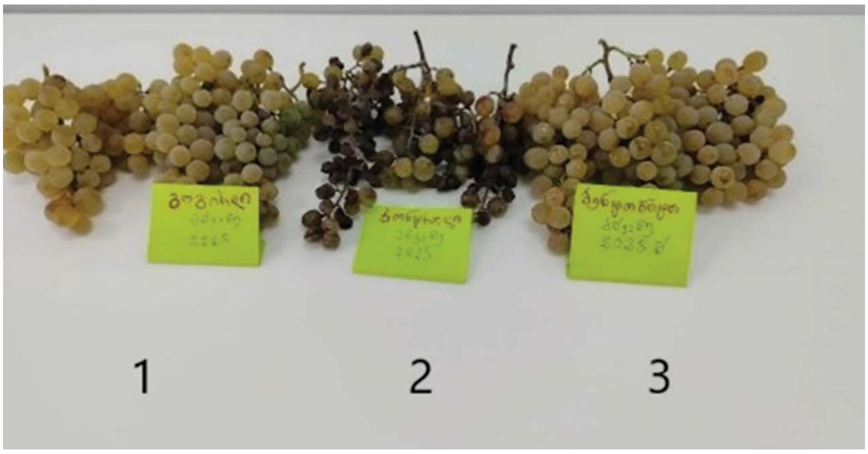


Fig. 5. Results of the test of bentonite clay-sulfur preparation on grapevine powdery mildew, variety „Khikhvi": 1 – grapes in the test variant, 2 – grapes in the control variant, 3 – grapes in the standard variant

As for the effect of the new bentonite clay biopreparation on mites, in the tomato trial variants the average number of Spider mites did not exceed 3-4 individuals per leaf. The same indicator was also in the standard, where we sprayed Sulfolac. In the control variant, the number of pests was almost doubled (Table 2).

Table 2. The influence of bentonite clay biological preparation on Tomato Spider mites – Tetranychus urticae Koch.

Treatment variant	Mean max. spider mite population per leaf (individuals)			Difference from control (individuals)	Difference from control (%)
	2022 year	2022-2025 years	average		
Bentonite clay with sulfur (2% suspension)	5	3	4.0	6.0	60.0
Bentonite clay with sulfur (2% suspension) + Makvaneti kaolin (6% suspension)	3	2	2.5	7.5	75.0
Control (untreated)	13	7	10.0	-	_
Standard (Sulfolac)	5	3	4.0	6.0	60.0

Thus, the study biopreparation, as well as Sulfolac taken alone, reduced the number of tomato spider mites on tomatoes by an average of 60%, while the addition of a 6% kaolin suspension increased the difference to 75%.

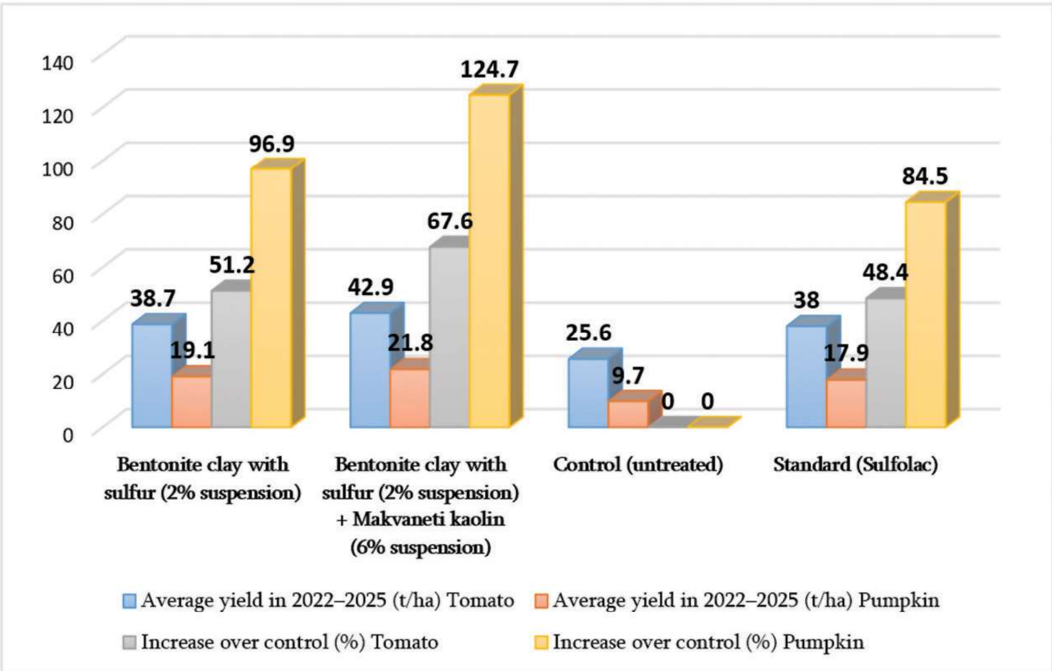
Fig 6. Tomato treatment variant: combination of bentonite clay with sulfur (2% suspension) + Makvaneti kaolin (6% suspension)

During the experiments conducted on tomatoes and pumpkins with the specified preparation between 2022 and 2025, no phytotoxicity was observed and no negative changes in plant growth and development were detected.

Regarding to the effect of this drug on the crop, the results are presented in Diagram 1.

Diagram 1

The effect of sulfur-bentonite clay bio-preparation on tomato and pumpkin yields



The study showed that spraying bentonite clay-sulfur suspension to reduce pests resulted in a 51.2% increase in tomato yield and a 96.9% increase in pumpkin yield compared to the control. The combination with kaolin improved these figures to 67.6% and 124.7%, respectively.

CONCLUSION

Thus, the conducted experiments show that the bentonite clay-sulfur composite—in which the amount of sulfur is reduced by 50% compared to other conventional sulfur preparations—not only maintains but even increases the effectiveness of the active substance despite the halved concentration; this is highly significant for organic agriculture, where the use of sulfur is subject to certain limit norms.

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