Original Research Article

Influence of biopesticides and natural preparations on the regulation of diseases and pests in the ecological protection of tomatoes (*Lycopersicon esculentum* L.) and cucumbers (*Cucumis sativus* L.)

ABSTRACT

The research was conducted in order to compare influence a preparations for plant protection allowed in organic agriculture and phytopharmaceutical preparations which are used in conventional agriculture and observation their effect in regulation of pests and diseases in tomato and cucumber production at open field.

In research were included variety of tomato „Volovsko srce (eng.Oxheart)“ and variety of cucumber „Dugi zeleni (eng. Long green)“ and cucumber was grown with a support net. Time of research was four months from planting to harvest (period: May 2020. – August 2020.) until more than 70% vegetation was completed.

The tests were perfomed at location in the rural part of the town of Živinice (Tupković) in an open field with and altitude of 250 m, during the vegetation of 2020. year.

The tests were performed on two separated plots. The plot in which were used phytopharmaceutical preparations was physically separated from the plot in which were used preparations allowed in organic agriculture. Temperature measurement was performed using TFA Dostmann thermometer (-25ºC to + 50 ºC) and it was set in a height of 2 meteres at open field. The temperature was measured three times at day. The amount of rainfall was monitored with TFA Dostmann rain gauge.

The results of treating plants with preparations allowed in organic agriculture gave similar effectiveness in protecting plants from economically important diseases and pests as like as treating plants with classic preparations used in conventional agriculture.

Keywords: Organic agriculture, biotechnical measures, biological control.

1. INTRODUCTION

The biggest obstacle for farmers in organic agriculture is the limited and insufficiently researched plant protection, considering that diseases or pests can completely destroy the crops. The essence of plant protection in organic agriculture is maintain the level of pests below the threshold of economic damage [1], which is achieved by preventive, agrotechnical and biotechnical measures. These measures are applicable through correctly crop rotation and mixed crops, selection of plots, perservation of useful organisms which will regulate pests, using of effective microorganisms (bacterias, viruses) and on the end comes the use of biopesticides and physical protection methods [2]. Organic farmers rely on natural pest control (for example biological control, using plants with pest control properties) rather than synthetic pesticides known to kill beneficial organisms which can also pollute water and soil. These methods of protection strive to obtain healthier product without harmful effect on the environment considering that biopesticides degrade quickly in plants or soil, but the difference between biopesticides and conventional pesticides is that they don't have rapid effectiveness againts pests and diseases. Usage of biopesticides is possible only after approval of the inspector of the relevant certification body for organic production. Tomatoes and cucumbers are economic the most important vegetables in Bosnia and Herzegovina because of high market demand. Intensive exploitation and convential breeding of these two species have affected on their reduced resistance to

external factors especially on the reduced immunity on diseases and pests. Growing at the open field cucumber plants are exposed on attack by different diseases and pests which every year cause large damages and the most important are: downy mildew (*Pseudoperonospora cubensis*), angular leaf spot (*Pseudomonas syringae pv lachrymans*), powdery mildew (*Erysiphe cichoracearum*), fusarium wilt (*Fusarium oxysporum*), and some pests are: aphids and red spider mite (*Panonychus ulmi*). In the case of tomatoes late blight (*Phytophtora infestans*) is the most common and the most harmful disease which can complety destroy crops and because of it tomato plant became addicted about fungicides [3]. Soil degradation and loss of organic matter caused increased incidence of root disease. High nitrogen concentrations and unbalanced fertilization caused larger susceptibility of root and shoot system of plant on diseases [4]. Compared to conventional plant protection, organic protection system have a lot of advantages, among other things there are: larger plant diversity in time and space, correctly crop rotation (which leads to greater organic matter content in the soil), higher biomass, better diversity and activity of soil microorganisms, increased soil capacity for water, improved cation exchange capacity. These differences between the organic and conventional protection have resulted in differences in the occurrence and intensity of plant diseases and pests [5]. Organic protection system is big challenge for farmers, especially at cultivation in the open field where plants are completely exposed to climate changes and they are susceptible to biotic and abiotic stresses, diseases and pests.

2. MATERIALS AND METHODS

Research work who examied the influence of conventional pesticides, biopesticides and natural preparations in plant protection was located in the rural part of the town Živinice (Tupković) at open field with and altitude of 250 m. It was tested tomato variety „Volovsko srce (eng. Oxheart)“ and cucumber variety „Dugi zeleni (eng. Long green)“ and cucumber was grown with a support net. Time of research was four months from planting to harvest (period: May 2020. – August 2020.) until more than 70% vegetation was completed. The tests were performed on two separated plots. The plot in which were used phytopharmaceutical preparations was physically separated from the plot in which were used preparations allowed in organic agriculture. Morphometric and physical analysis of the fruits icluded three parameters: shape, color and weight. The calculation of daily mean temperature was performed according to the formula: T1 = (T7 + T14 + 2xT21) / 4 [5].
Temperature measurement was performed using TFA Dostmann thermometer (-25º C to + 50º C) and it was set in a height of 2 meteres at open field. The temperature was measured three times at day in time: 07:00 am, 02:00 pm, 09:00 pm. The amount of rainfall was monitored with TFA Dostmann rain gauge.

3. RESULTS AND DISCUSSION

Research included two test areas which are important for organic agriculture:

1. Influence of commercial biopesticides on regulation diseases and pests,
2. Influence od natural preparations on regulation diseases and pests.

Tabela 1. – Labels of tests

Culture	Label	Interpretation	Number of plants
Cucumber	K-Pp	Test treated with natural preparations	30
Cucumber	K-Bp	Test treated with commercial biopesticides	30
Cucumber	K1	Control test of cucumber in organic protection	30
Cucumber	K-I	Test treated with conventional pesticides (1)	30

Cucumber	K-II	Test treated with conventional pesticides (2)	30
Cucumber	K2	Control test of cucumber in conventional protection	30
Tomato	P-Pp	Test treated with natural preparations	30
Tomato	P-Bp	Test treated with commercial biopesticides	30
Tomato	K3	Control test of tomato in organic protection	30
Tomato	P-I	Test treated with conventional pesticides (1)	30
Tomato	P-II	Test treated with conventional pesticides (2)	30
Tomato	K4	Control test of tomato in conventional protection	30

On tests where plant protection was applied according to the principles of organic production were used commercial biopesticides available to producers on the market of Bosnia and Herzegovina. Natural preparations were obtained from plants found in nature and allowed for use in organic plant protection. On tests with convential plant protection were used pesticides with two different protection programs and two different active substances for the same diseases or pests. The research monitored the occurrence of the most economically important diseases of tomatoes and cucumbers: tomato late blight (*Phytophtora infestans*), early blight (*Alternaria solani*), septoria leaf spot (Septoria *lycopersici*), fusarium wilt (*Fusarium oxysporum*), cucumber downy mildew (*Pseudoperonospora cubensis*), angular leaf spot (*Pseudomonas syringae py. lachrymans*). From pests it was monitored the occurrence of aphids especially: green peach aphid (*Myzus persicae*) and black bean aphid (*Aphis fabae*). The active substances of preparations and concentration of treatmens are listed in table 2 for diseases and table 3 for pests.

Table 2. – Active substances and treatment concentrations for diseases

Culture	**Label of test**	**Active substance (AS)**	**Concentration of AS in preparation**	**Dosage / Concentration of treatmens**
Cucumber	K-Pp	Milk + soda	-	10% + 0,4%
Cucumber	K-Bp	Copper(I)oxide	75% copper	0,15%
Cucumber	K1	- *control (no treatmens)*	-	-
Tomato	P-Pp	Milk + soda	-	10% + 0,4%
Tomato	P-Bp	Copper(I)oxide	75% copper	0,15%
Tomato	K3	- *control (no treatmens)*	-	-
Cucumber	K-I	Mancozeb + Copper	300 g/kg + 120 g/kg	4-5 kg/ha
Cucumber	K-II	Metalaxyl-M + Mancozeb	38,8 g/kg + 640 g/kg	1,5-2,5 kg/ha
Cucumber	K2	- *control (no treatmens)*	-	-
Tomato	P-I	Mancozeb + Copper	300 g/kg + 120 g/kg	4-5 kg/ha
Tomato	P-II	Metalaxyl-M + Mancozeb	38,8 g/kg + 640 g/kg	1,0-2,5 kg/ha
Tomato	K4	- *control (no treatmens)*	-	-

Table 3. – Active substances and treatment concentrations for pests

Culture	**Label of test**	**Active substance (AS)**	**Concentration of AS in preparation**	**Dosage / Concentration of treatmens**
Cucumber	K-Pp	Nettle leaf solution	-	10%
Cucumber	K-Bp	*Bacillus thuringiensis*	160 g/l	1,5 kg/ha
Cucumber	K1	- *control (no treatmens)*	-	-
Tomato	P-Pp	Nettle leaf solution	-	10%
Tomato	P-Bp	*Bacillus thuringiensis*	160 g/l	1,5kg/ha
Tomato	K3	- *control (no treatmens)*	-	-
Cucumber	K-I	Acetamiprid	20%	0,0125%
Cucumber	K-II	Imidacloprid	200 g/l	250 ml/ha
Cucumber	K2	- *control (no treatmens)*	-	-
Tomato	P-I	Acetamiprid	20%	0,0125%

Tomato	P-II	Imidacloprid	200 g/l	250 ml/ha
Tomato	K4	- *control (no treatmens)*	-	-

In table 4 is shown time of treatment application, total number of treatments and preparation withdrawal period. Biological insekticide with active substance Bacillus thuringiensis is allowed in organic plant protection primarily for regulation of caterpillar (for example: *Trialeurodes vaporariorum*) and some insekts larvaes, but in this research was examined his effectiveness on aphids.

Table 4. – Time, number of treatments and withdrawal period

Treatment	**Total number of treatments for tomato**	**Time of treatment for tomato**	**Total number of treatments for cucumber**	**Time of treatment for cucumber**	**Withdrawal period (WP)**
Nettle leaf solution	14	Every 7 days	13	Every 7 days	No WP
Bacillus thuringiensis	6	11.05. 26.05. 10.06. 25.06. 09.07. 24.07.	3	21.05. 05.06. 20.06.	No WP
Acetamiprid	2	11.05. 21.05.	2	23.05. 02.06.	3 days
Imidacloprid	2	11.05. 21.05.	2	23.05. 02.06.	14 days
Milk + soda	14	Every 7 days	13	Every 7 days	No WP
Copper(I)oxide	4	17.05. 28.05. 08.06. 21.06.	2	17.05. 28.05.	14 days
Mancozeb + Copper	3	17.05. 28.05. 08.06.	3	17.05. 28.05. 08.06.	14 days
Metalaxyl-M+Mancozeb		17.05. 28.05. 08.06.		17.05. 28.05. 08.06.	7 days on open field

Production success, the appearance of pahtogens and pests are greatly influenced by the amount of light, rainfalls and the number of rainy days. The optimal amount of water for tomato is 450-500 mm, while the need of cucumber for water is increased (about 800 mm during the growing season) [6] which was supplemented by irigation in this research. Problem with rainfalls was that in certain periods prevailed rainy weather, while in others there was a drought, which caused floods. Observed by months the total amount of rainfalls for May was 72.50 mm, June 223.00 mm, July 50.00 mm and August 61.00 mm (table 5). The highest daily rainfalls was recorded on June 22th 2020 with 78 liters/m². In the monitored period were recorded 33 rainy days.

Table 5. – Average monthy temperatures and total amount of rainfalls for period May-August 2020

Month	**Average monthy temperature (°C)**	**Total amount rainfalls (mm)**
May	15.63	72.50
June	19.89	223.00
July	22.43	50.00
August	25.00	61.00

Intensity of diseases and pests was monitored every 7 days with monitoring of plant developmental stages and agroecological conditions.

Chart 1. – Average number of aphids by tomato plant

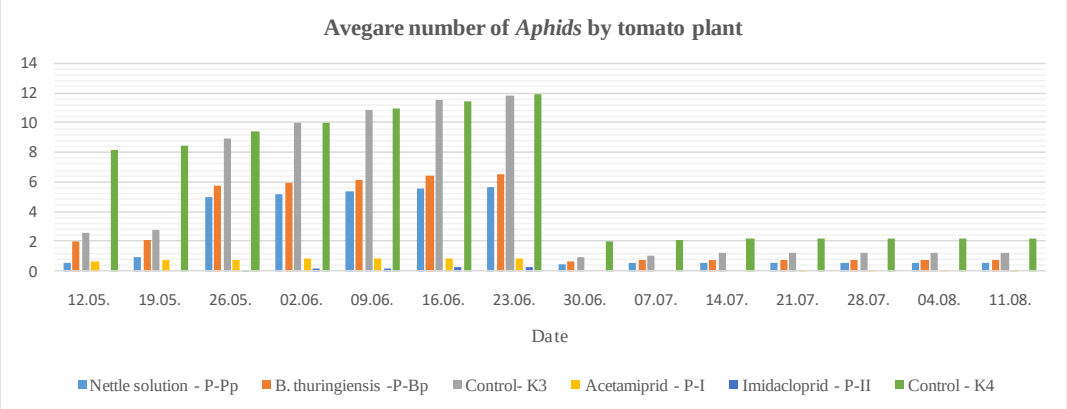
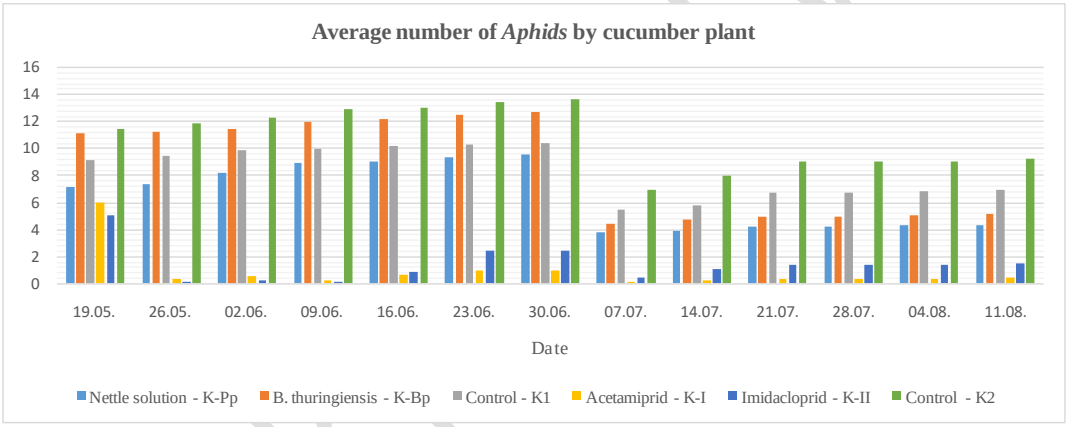
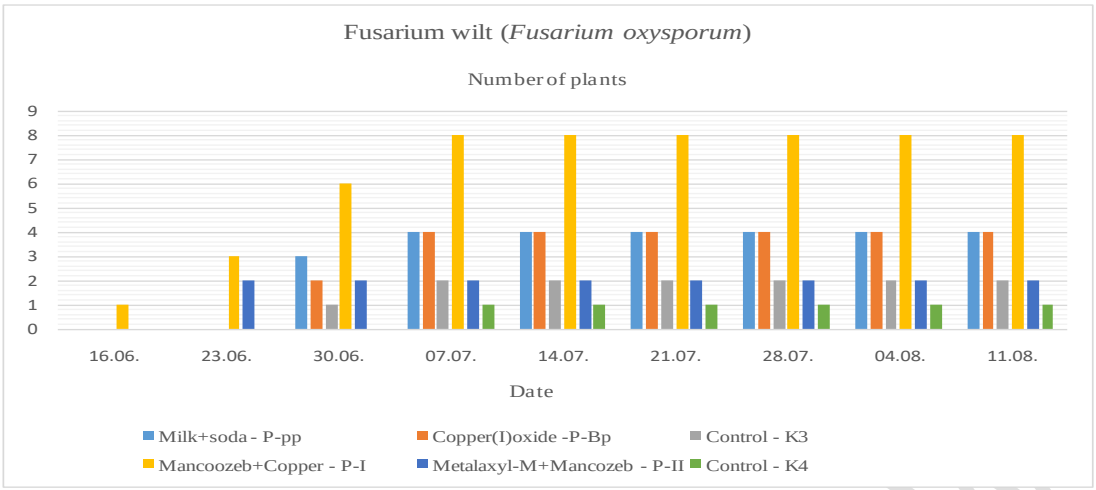


Chart 2. – Average number of aphids by cucumber plant



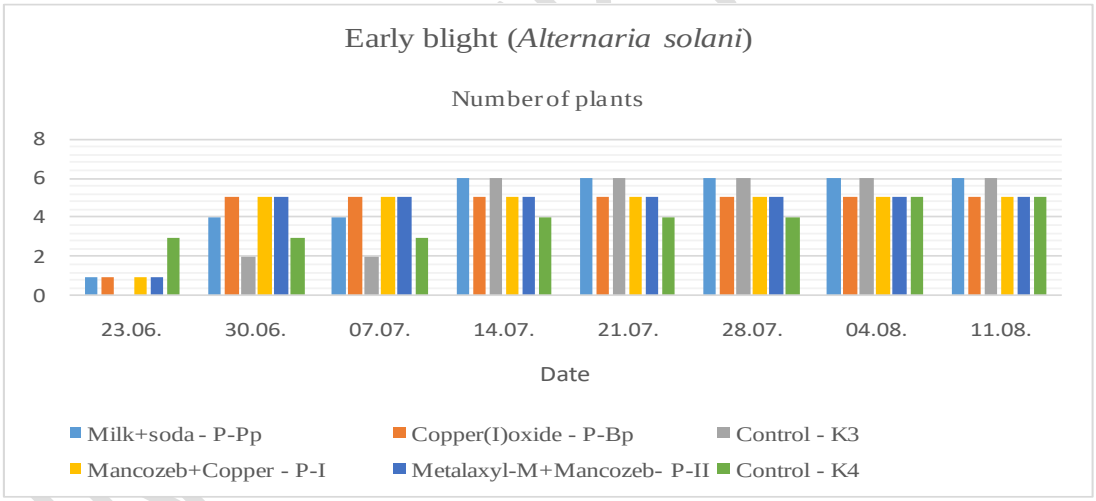
Problem in tests from pests were made aphids, more precisely: green peach aphid (*Myzus persicae*) and black bean aphid (*Aphis fabae*). They showed the highest occurrence in May and June. Generaly, cucumbers had a higher number of aphids compared to tomatoes. Green peach aphids were more prevalent on tomatoes, while black bean aphids were more present on cucumbers. As expected, conventional insekicides had a better effect on aphid control and they reduced their number killing them. Insecticides allowed in organic agriculture didn't have such strong effect on reducing the number of aphids or prolonged activity, but they gave a very statisfying effect in partially stopping spreading of larvaes and eggs on new leaves.

Chart 3. – Number of tomato plants infected with *Fusarium oxyporum*



Fusarium oxysporum is pathogen which causes a disease of wilting which appeared on tomato plants in the second half of June, primarily on test treated with mancozeb + copper, where it caused the most damage. In the period of occurrence and further development *F. oxysporum* the mean daily temperature was 16.8ºC. What is additionally characteristic for this pathogen is that prefer soil with a lack of phosphorus and nitrogen, which was the case with the soils in this research. Since the whole plant was affected and wilted, that plants had to be removed from the experiment to not be a source of infection at other plants.

Chart 4. – Number of tomato plants infected with *Alternaria solani*



Alternaria solani is pathogen which causes disease called „early blight“. First symptoms appeared on the end of June and mean daily temperature for occurrence and furter development of this fungus was 16.9ºC. Symptoms of disease appeared on couple leaves and stem in the form of concentric circles. The highest development of this pathogen was in period from 23th June till 14th July after that it began to stagnate. However, disease wasn't economically significant.

Chart 5. – Number of plants infected with *Phytophthora infestans*

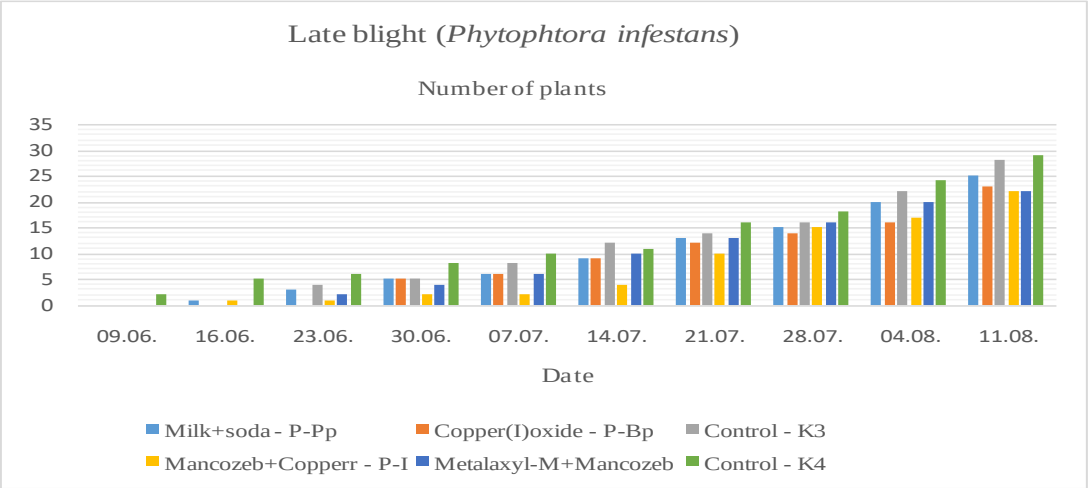
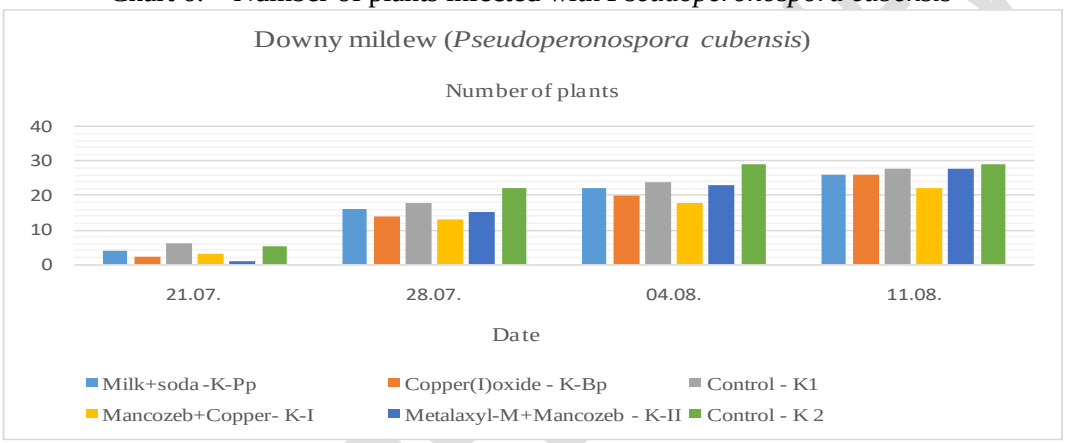


Chart 6. – Number of plants infected with *Pseudoperonospora cubensis*



The first symptoms of cucumber downy mildew were manifested on control tests of conventional protection (K2) at the end of June. After that disease progressed and by the end of August it infected all plants. Symptoms of the disease were manifested only on leaves but as infected leaves dried the assimilation surface descreased and the plant lost vital abilities. Average mean daily temperature for appearance and development of this pathogen was 23ºC. For infection by *Pseudoperonospora cubensis* leaves need to be moistened 90-100% [8]. Since the cucumber harvest began on 24th June adn first symptoms was on 21th July, downy mildew didn't completely affect on yield and harvest of cucumber, as was the case with tomatoes.

Table 6. – Average weight of fruit and total yield of cucumber

Labels	**Average weight of fruit (gr)**	**Yield (gr / plant)**
K-Pp	228.3	3500
K-Bp	232.5	4000
K1	180.9	3300
K-I	152.9	3800
K-II	169.1	5000
K2	150.4	3900

Yield of cucumber was in range 3.30-4.00 kg per plant in organic system of protection and 3.80-5.00 kg per plant in conventional system of protection. Looking at research in organic plant protection the highest yield of cucumber had test treated with commercial biopesticides which amounts 4.00 kg per plant.

Table 7. – Average weight of fruit and total yield of tomato

Labels	Average weight of fruit (gr)	Yield (gr / plant)
P-Pp	116.4	900
P-Bp	181.0	2000
K3	113.7	1400
P-I	100.0	1750
P-II	228.0	3800
K4	127.5	1900

Tomato had very low yield considering that plants diseased because of late blight (*Phytophtora infestans*) very soon after maturity. Yield of tomato in organic system of protection was in range 0.9-2.00 kg per plant and 1.75-3.80 kg per plant for tests in conventional protection system.

4. CONCLUSION

After analysis of all parameters the most important conclusions are:

Nettle leaf solution in concentration 10% applied every 7 days during the vegetation had better effect in reducing of aphids (*Myzus persicae* ; *Aphis fabae*) on tomato and cucumber compared to the use of commercial biopesticide based on *Bacillus thuringiensis*.

Copper (I) oxide in concentration 0.15% applied 2 times during the vegetation showed better protection at cucumber againts *Pseudoperonospora cubensis* compared to the treatment of natural preparations (milk + soda), but not in comparison with conventional fungicides.

Copper (I) oxide in concentration 0.15% applied 4 times during the vegetation showed better protection at tomato againts *Alternaria solani* and *Phytophtora infestans*, compared to the treatment of natural preparations (milk + soda) and protection gave the same results as application of conventional fungicides.

Tests of tomato and cucumber treated with commercial biopesticides accomplished larger yield compared to tests treated with natural preparations.

Summarizing the results of research work treating plants with preparations allowed in organic agriculture gives similar effectiveness in plant protection from economically important diseases and pests as treating plants with conventional pesticides. The difference is thah natural preparations or biopesticides farmers have to apply more ofter in comparison to the conventional pesticides. Also, the yield of both ways of protection was similar. This proves that plant protection in organic agriculture is possible and gives statisfactory yields and indisputable quality with adherence to agricultural techniques, orderly protection and favorable agroecological conditions. However, to reduce the risk of attack by microorganisms or pests recommended is growing in greenhouses.

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