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STUDY OF THE BACTERIAL LEAF SPOT OF PEPPER – *XANTHOMONAS VESICATORIA* DOIDGE IN ORGANIC AGRICULTURE

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Key words: *disease attack pepper, bacterial leaf spot of pepper, organic agriculture*

INTRODUCTION

Pepper is an important vegetable in Romania, being grown on the surface of 17.900 thousands ha in 2016 and an annual production of 201.8 thousands t (Romanian Ministry of Agriculture and Rural Development, 2019)). Bacterial leaf spot of pepper - *Xanthomonas vesicatoria* Doidge can cause significant production losses (Marinescu et all., 1986) and can be found in protected areas and open fields in all phases of pepper plants. The host range of bacterial spot includes a wide range of plants belonging to the Solanaceae family: pepper - *Capsicum annuum*, chilli peppers – *C. frutescens*, *C. baccatum, C. anomalum, C. chinensis* and *C. pubescens* tomato - *Solanum lycopersicum*, cherry tomato - *S. lycopersicum* var. *cerasiforme*, currant tomato - *L. pimpinellifolium*, (Baker et al., 2014). Pepper plants can be attacked at all stages of development. On the leaves, the disease has the round necrotic spots up to 1 mm, scattered over the entire surface of the leave, solitary or confluent. In this case they have wider areas of necrosis (3-5 mm). On the underside of the leaf, plants have a punctiform bacterial exudates. In advanced stages of the evolution of the disease produced by *X. vesicatoria* leaf (Kebede et al., 2014), strongly attacked, dry, crushed, detached and falling. Symptoms similar to those on the leaves are also found on the stem, where the attacked tissues suberify over time, forming irregularly shaped verucosities. During the flowering period, when the attack is strong, abortion of flowers can take place. In contrast to the leaf attack, which is quite frequent, it has been found that the fruit attack is sporadic, manifested by necrotic spots, which appear to mimic the "bird's eye" produced by the bacterium *Corybacterium michiganense*, but laboratory tests have shown that the respective stains are produced by *Xanthomonas vesicatoria* (Marinescu and all., 1986). The plant resistance was identified in pepper and tomato genotypes. Pathogenic races were identified based on differential reactions. Thus, four tomato races and 11 pepper races have been observed (Stall et al., 2009). Among the four species, various pepper and tomato races of *X. euvesicatoria*, *X. vesicatoria* and *X. perforans* (tomato only) have been observed. *Xanthomonas gardneri* has also been associated with pepper and tomato bacterial spot from different regions of the world (Horvath et al., 2012). In 2010, an *X. perforans* strain was isolated from a pepper field in Florida, suggesting recent host range expansion. Strains within *X. euvesicatoria, X. vesicatoria and X. gardneri* that are pathogenic only on tomato, only on pepper, and on both tomato and pepper have been identified. Avr genes (avirulence) that restrict the strains to pepper or tomato include avrBs4 (resulting in a hypersensitive response on both tomato and *C. pubescens*) and avrBsT (resulting in a hypersensitive response on pepper) (Ballvora et al., 2001). With both Avr genes being plasmid borne, the loss of a plasmid allows a strain to become pathogenic on that host (Canteros et al., 1991). Apart from specific races, host–pathogen combination is important for pathogen aggressiveness, e.g. *X. euvesicatoria* was found to be more aggressive on pepper than on tomato (Ignjatov et al., 2010). The primary management strategy of bacterial spot begins with use of certified pathogen-free seed and disease-free transplants. The bacteria do not survive well once host material has decayed, so crop rotation is recommended. Once the bacteria are introduced into a field or greenhouse, the disease is very difficult to control. For the control of *X. vesicatoria* pepper plants are sprayed with copper-containing bactericides to maintain a "protective" cover on the foliage and fruit. Biological control options for bacterial spot are limited (Ritchie, 2000). However, a biological control method that uses bacterial viruses (bacteriophages) that specifically kill the bacterial pathogens is now available. Other biological fungicides can be used to limit the lost of crop (Ritchie, 2000).

MATERIAL AND METHODS

Research on the efficacy of biological products and herbal extracts for the control of

Bacterial leaf spot at round pepper, Creola variety was studied at Vegetable Research and Development Station Bacau, in open field conditions (Table 1).

Table 1. Study of the efficacy of some products in the control of Bacterial leaf spot at round pepper

Vari-ant	The product	Active substance	Concen-tration (%)
V1	Condor	*Trichoderma atroviride* and *Glomus* spp	0,25
V2	Funres	Extract from *Mimosa tenuifolia* L. and citrus seeds	0,25
V3	Blocks	Seaweed	0,25
V4	Nettle macera-ate	One kg of fresh plants / 10 l of water macerated in 10 days	0,5
V5	The bordeaux mixture	Copper sulphate neutralized with lime	0,5
V6	Untrated	x	x

The study of the efficacy of products used in organic farming for Bacterial leaf spot at round pepper was performed in the field on natural infections.

The trial was accomplished during end of spring, summer and early autumn period. The maximum day temperature was 18-32°C with peaks up to 40°C. When *X. vesicatoria* attack exceeded the economic threshold, the treatment variants were applied (table 1). Each variant area was 7 m^2.

The effectiveness of treatment variants was determined by observations of the attack on the plant and monitoring the disease attack.

Observations were taken every 10 days throughout May to September. The attack estimation was determined using the following indicators: Frequency of attack (F%), Intensity of attack (I%), Degree of attack (DA%). The effectiveness analysis of variants in control of for Bacterial leaf spot at round pepper was performed according to the Abbott method (Püntener, 1981).

The obtained results will be used in future researches of integrated disease management control in organic agriculture in order to increase the ecological disease control practices in vegetable growing.

RESULTS AND DISCUSSIONS

The degree of attack of *X. vesicatoria* exceeded the economical threshold in 2018 (fig 1). In 2019 the degree attack of Bacterial leaf spot at round pepper did not exceed 1.2%.

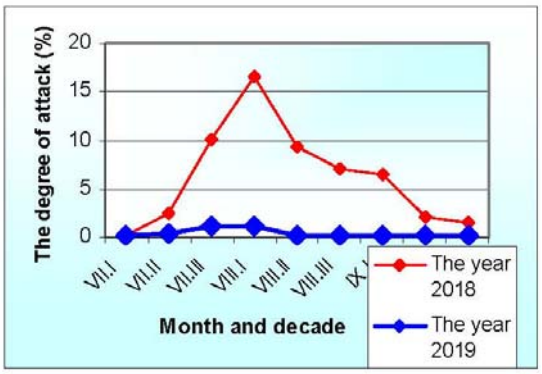

Fig. 1 The degree of attack of Xanthomonas vesicatoria in round pepper

The products tested in the control of Bacterial leaf spot at round pepper showed the following results (table 2).

Table 2. Effectiveness of products tested in control of Bacterial leaf spot at round pepper in 2018

Variant	Degree of attack		Eficien - cy (%)*
	At the leaves	To fruits	
V1 Condor – 0,25%	1.3	0.1	80.0
V2 Funres – 0,25%	1.2	0.1	81.5
V3 Blocks – 0,25%	2.1	0.1	67.7
V4 Nettle maceraate - 0.5%	4.2	0.1	35.4
V5 The bordeaux mixture 0.5%	1.0	0.1	84.6
Untrated	6.5	0.1	x

* 7 days after treatments

The data presented show that the best efficacy in the control of Bacterial leaf spot at round pepper in open field had the variant treated with The bordeaux mixture - 0.5%, the percentage of efficiency at 7 days after infection with Bacterial leaf spot at round pepper sp. being 84%. It was followed at: V2, Funres – 0,25% with 81.5% efficiency, V1 Condor – 0,25%with 80.0 % efficiency, V3 Blocks – 0,25% with 67.7% efficiency and V4 Nettle macerate - 0.5% with 35.4% efficiency.

Percentage of healthy plants (Figure 2) varied depending on the tested variant being 99.0% in V5 treated with The bordeaux mixture 0.5%, 98.8 % in V2 – Funres 0.25%, 98.7% in variant 1 treated with Condor 0.25%, 97.9% in V3 Blocks – 0,25%, and 95.8% in V4 treated with Nettle macerate - 0.5%.

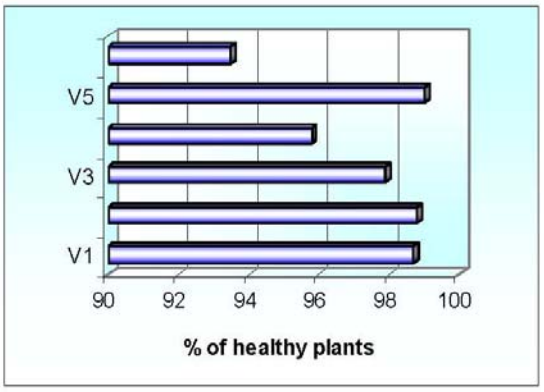

Fig. 2 % of healthy plants in pepper variants

In pepper variants the plants attacked by *X. vesicatoria* during the period of June - the first decade of September resumed their vegetation and fruit set. As a result, GA% decreased progressively.

In 2019 the degree attack of Bacterial leaf spot at round pepper was under economical threshold and there were no significant differences between the variants.

So in the conditions of very low attack of Bacterial leaf spot at round pepper in 2019, the efficiency of all variants was above 97.7% (V1 Condor – 0,25%, 98.9%: V2 Funres – 0,25%, 99.2%: V3 Blocks – 0,25%, 97.7%:V4 Nettle maceraate - 0.5, 98.1%: V5 The bordeaux mixture 0.5%, 99.2%).

CONCLUSIONS

The degree of attack of *X. vesicatoria* in round pepper exceeded the economical threshold in 2018. In 2019 the degree attack of Bacterial leaf spot at round pepper did not exceed 1.2%.

The best efficacy in the control of Bacterial leaf spot at round pepper in the open field had the V5 treated with The bordeaux mixture - 0.5%. The percentage of efficiency at 7 days after infection with Bacterial leaf spot at round pepper sp. being 84%. It was followed at: V2, Funres – 0,25% with 81.5% efficiency, V1 Condor – 0,25% with 80.0 % efficiency, V3 Blocks – 0,25% with 67.7% efficiency and V4 Nettle maceraate - 0.5% with 35.4% efficiency.

Percentage of healthy plants varied depending on the treatment variant being 99.0% in variant 5 treated with The bordeaux mixture 0.5%, 98.8 % in V2 – Funres 0.25%, 98.7% in variant 1 treated with Condor 0.25% , 97.9% in V3 Blocks – 0,25%, and 95.8% in V4 treated with Nettle macerate - 0.5%.

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ABSTRACT

In the researches regarding the efficacy of biological products and herbal extracts for the control of Bacterial leaf spot at round pepper, Creola variety was studied at Vegetable Research and Development Station Bacau, in open field conditions

The degree of attack at *X. vesicatoria* exceeded the economical threshold in 2018. In 2019 the degree attack of Bacterial leaf spot at round pepper did not exceed 1.2%.

The best efficacy in the control of Bacterial leaf spot at round pepper in the open field had the variant treated with V5 - The bordeaux mixture - 0.5%, the percentage of efficiency at 7 days after infection with Bacterial leaf spot at round pepper sp. being 84%. It was followed by: V2, Funres – 0,25% with 81.5% efficiency, V1 Condor – 0,25% with 80.0 % efficiency, V3 Blocks – 0,25% with 67.7% efficiency and V4 Nettle maceraate - 0.5% with 35.4% efficiency.

Percentage of healthy plants varied depending on the treatment variant, the values being 99.0% in variant 5 treated with The bordeaux mixture 0.5%, 98.8 % in V2 – Funres 0.25%, 98.7% in variant 1 treated with Condor 0.25%, 97.9% in V3 Blocks – 0,25%, and 95.8% in V4 treated with Nettle macerate - 0.5%.

In pepper variants the plants attacked by *X. vesicatoria* during the period of June - the first decade of September resumed their vegetation and fruit set. As a result, GA% decreased progressively.

In 2019 the degree attack of Bacterial leaf spot at round pepper was under economical threshold and there were no significant differences between the variants. In the conditions of a very low attack of Bacterial leaf spot at round pepper in 2019, the efficiency of all variants was above 97.7% (V1 Condor – 0,25%, 98.9%: V2 Funres – 0,25%, 99.2%: V3 Blocks – 0,25%, 97.7%:V4 Nettle maceraate - 0.5, 98.1%: V5 The bordeaux mixture 0.5%, 99.2%).

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