EFFECT OF BIOCHIKOL 020 PC (CHITOSAN) ON THE PLANT GROWTH, FRUIT YIELD AND HEALTHINESS OF TOMATO PLANT ROOTS AND STEMS

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1. Introduction

Chitosan as the biopreparation can be used for the control or retardation of fungi pathogens on tomato [1 - 4], onion [2, 5], runner bean [6], hobs [7] rose [8] and several ornamental plants [9 - 12]. Borkowski et al. [13] found that spraying the tomato plants with chitosan may to increase the vigour of those plants after some months. This phenomen was probably connected with bigger resistance of tomato roots to fungi pathogens. During the following years the possibility was checked if Biochikol 020 PC (chitosan) is able to control or retard the development of fungi pathogens or of *Orobanche ramosa* L. (only in 2006) on tomato roots or stem.

2. Material and methods

Seeds of old field cultivar "De Barao improved" tolerant to some fungi diseases [Borkowski 14, 15] were sown to multipots (4x4cm) in the warm glasshouse on March 4th 2005 . On April 7th seedlings were transplanted to smoll pots (diameter 7 cm). Tomato plants were planted on May the 6th in 8 liter trays filled with peat substrate which contained following mineral nutrients in $1dm^3$: 370 mg $N\text{-}N0_3$, 113 mg P, 568 mg K, 355mg Mg and 4566 mg Ca.The salinity of the substrate was 4.7g $NaCl/dm^3$ and pH was 6,8. Seven replications were used and in every replication were two plants each placed on trays. Every 5 trays were standing in one long container. After planting, 50% plants (14 pieces) were watered with 200 cm^3 of 2,5% solution of Biochikol 020 PC and three days later the same plants were sprayed with Biochikol 020 PC. The treatment was repeated 4 times in two week intervals. Biochikol 020 PC in concentration 2.5% was used instead of 0.1% chitosan calculated on dry mass. Tomato plants were formed to have 2 shoots and 10 clusters (7+3). During the vegetation season the plants were fertilized with Azofoska fertilizer mixture (N, P, K, Mg, Fe, Cu, Mn, B and Mo) in sum 30 g per pot and with potassium sulphate 10 g per pot. White

fly (*Trialeurodes vaporariorum*) was controled by using yelow tabels and the parasitic insect Encarsia formosa. Breakers and red fruits were harvested every 3 - 7 days from July 21st to October 18th separetely in every replication. During the experiment the observations of plant growth and roots were carried out.

The investigation was repeated in 2006 on a larger scale. Seedlings of cultivar 'De Barao improved' (sowing on March 3th) were planted on April 18th to 12 liter pots filled to 3/4 of its volume with peat substrate. It contained following mineral nutritients per 1 dm^3: 458 mg $N\text{-}N0_3$, 208 mg P, 604 mg K, 450 mg Mg and 4782 mg Ca. The substrate had pH 6.4 and the salinity was 3.9 g NaCl per 1 dm^3. On the top of the substrate in every pot were placed 3 liters of fresh compost, its salinity was only 0.8 g NaCl per 1 dm^3. During the vegetation season the plants were fertilized with Azofoska mixture in sum 50 g per pot and potassium sulphate, in sum 27 g per pot. Tomato plants were formed to have 3 shoots, but one of them grew near the surface of the substrate and formed adventitious roots. The lower shoot was formed only on 2 cluster, but when *Fusarium* or *Phytophthora* infected strongly the tomato plant, frequently only this shoot with adventitious roots remained green and retained full vigour to the end of October. Earlier in the compost used in the investigation the following pathogens were found: *Pyrenochaeta lycopersici, Fusarium oxysporum, Phytophthora nicotianae var. parasitica, Colletotrichum sp.* and *Rhizoctonia solani*. After planting tomato plants into pots and they were divided into 5 parts: One part of them was watered 2 times with 250 ml of Biochikol 020 PC, the second part was sprayed with Biochikol 020 PC and 2 obiects were watered and sprayed with the preparation (Table 2). The watering with Biochikol 020 PC was repeated one time on May 23th. Spraying was repeated 3 times on May 24th, June14th and August 19th. In the object number 5 to every pot (near roots of plant) the seeds of the pathogen Orobanche ramosa L (branched broomrape) were added 8 replications were applied, only in obiect with branched broomrape there were 10 replications. Preparation Betokson was used on flowering clusters to stimulate better fruit set in all investigations. Breakers and red fruits were harvested every 3-7 days from June 7th to November 7th. In the last harvest all fruits were small and green (the glasshouse was unheated). The observations of plant growth and healthiness were carried out during the vegetation season. The healthiness of roots was studied in November and plants were pulled out from pots similarly as in earlier experiments [16]. The root healthiness was evaluated according to 0-5 point scale: 0-healthy roots, they were pulled out with over 2 dm^3 of substrate, 5-plants with roots completly rotten. In this experiment the number 5 was not used, because when old roots were rotten, there appeared the adventitious roots and they were always healthy. All statistical calculations were carried out on 8 replications with Newman-Keuls test at $\alpha = 0.05$.

3. Results and discussion

Plants treated with Biochikol 020 PC in 2005 showed similar growth as the control plants, but they began ripening earlier and gave significantly higher marketable yield (Table 1). Differences in the total yield were not significant because in the yield from the control plants fruits were smaller and diseased. In October the growth of roots over trays in containers was similar in both objects, but it was found in November during extracting roots from peat substrate, that in the control plants the length of roots was 5 - 20 cm, whereas in plants treated with Biochikol 020 PC the roots were 10 - 40 cm long. This sugested that plants treated with

Biochikol 020 PC had healthier roots and the rotting process run across slowly and it may be supposed that Biochikol 020 PC treatment retarded the development of *Pyrenochaeta lycopersici, Fusarium oxysporum* or *Colletotrichum* sp.

Table 1. *Effect of Biochicol 020 PC on the tomato plant growth and fruits yielding in 2005. Average from 7 replications.*

Treatment	Height of plants (cm) July 6th	Yield in grams from one plant					
		Early		Marke-table	Fruits smaller than 36 g	Diseased fruits	Total
		to July 27th	to August 4th	to October 18th			
Control	139 a	182 a	574 a	2368 a	355 a	25 a	3330 a
Biochikol 020 PC	142 a	206 a	649 a	2810 b	315 a	4 a	3768 a

In April 2006 it was found that some plants especialy in two last treatments were a little wilted after watering with Biochikol 020 PC (Table 2). These plants were growing significantly slower than in first three objects. Plants in treatments 4 and 5 were significantly smaller in the period May to July. On September 1st the highest plants were in control and in pots watered with Biochikol 020 PC, but the highest yield was received from plants sprayed only with Biochikol 020 PC (object 3). Probably the highest fruit yield influenced the lower growth of plants in this treatment. Differences in the total yield beetwen all treatments were over 35%, but were not significant, because some plants were early infected with *Fusarium oxysporum* f. sp. *lycopersici* or *Phythophthora nicotiane* var. *parasitica* and there the yield was lower for 1 or 2 kg than from uninfected plants. Plants were infected with *Phythophthora nicotianae* var. *parasitica* only in June and July, because the pathogen did not infected old and lignified plants and was most dangerous when the temperature was over 25 °C [17, 18] and in 2006 in the second part of June and in July were sunny and warm. Infected plants appeared in all treatments except control. The infected plant had at the begining dark green leaves and later rapidly the top of shoot had wilted. Some days later during sunny weather infected plant could be completly dried, but in this investigation this was prevented since the plants were watered with 300 ml of 0.15% Previcur 607 SL and the compost was added 0.5 dm^3. After these treatments plants were wilted during 2 - 3 weeks and produced new advenditious roots and the growth started again, but there the yield was low. On the contrary *Fusarium oxysporum* appeared in the control plants already in May, in other treatments the pathogen appeared later, but in November over 85% of plants in all treatments were more or less infected by the pathogen. There on the stem of infected plants appeared many adventitious roots often 50 cm over the surface of substrate (Figure 1, see page 220). Leaves on the plant infected by *Fusarium oxysporum* became yellow from below to the top and later dried. The process ran across from 3 weeks to 3 months or more, in the autumn in lower temperature (the glasshouse was unheated) the infection stoped [17]. The lower part of the stem of infected plants had dark xylem on the cross-section (Figure 2, see page 220). The pathogen caused also a big problem in the field production in Nederland [19]. Often in November *Fusarium oxysporum* was found in the lover part of stem of plants, which were earlier were infected with *Phytophthora nicotiane* var. *parasitica*. It is interesting that chitosan showed antifungal activity agaist *Pfytophthora infestans* [20] and in our experiments had not antifungal activity against *Phytophthora nicotianae* var. *parasitica*.

Figure 1. *The stem of tomato after yielding with many adventitious roots.*

Figure 2. *The cross-section of the lover part of stem infected with Fusarium oxysporum f. sp. lycopersici*

It was found that only spraying tomato plants with Biochikol 020 PC significantly decreased the infection of *Pyrenohaeta lycopersici* and *Fusarium oxysporum* var *lycopersici* (the pathogen not injured visible roots), because only in third treatment the fruit yield was the highest. The watering with Biochikol 020 PC was not effective (Table 2). In all treatments the healthiness of roots was similar.Althoght in many plants old roots were rotten but they were replaced by new, healthy adventitious roots. In the treatment, where the yield of fruits was the highest, plants had roots no healthier than the control plants. It was found in November that in all treatments roots were infected with following pathogens: *Fusarium oxysporum* f.sp. *lycopersici*, *Pyrenochaeta lycopersici*, some times *Colletotrichum* sp. (Table 3). Earlier treatments with Biochikol 020 PC had any influence on the appearance of *Botrytis cinerea* on tomato stems.

Chitosan effectively retarded Fusarium wild development on carnation [9] and on tomato [21]. In South America chitosan effectively retarded also the development of nemathods on grape plantations [22]. It is suggested that chitosan is able to retard also branched broomrape growth on tomato roots. For that reason in the object number 5 the plants were additional-

Table 2. *Effect of Biochikol 020 PC (chitosan) on the growth and healthiness of tomato cultivated in the infected substrate in 2006; W- watering, S- spraying, * - mean, [1)] 12.5% plants already in May were completly wilted.*

Treatment	Height of plants in cm				Infected plants to the end of July in %		
	May 15 th	June 16th	July 13th	Sept. 1st	*Fusarium oxysporum* f. sp. *lycopersici*	*Phytophthora nicotianae* var. *parasitica*	*Orobanche ramosa*
Control	58.6 a	117 ab	168 a	191 a	25.0[1)]	0	--
Biochikol 020 PC W	56.7 a	12 2 a	167 a	194 a	12.5	37.5	--
Biochikol 020 PC S	57.3 a	117 ab	158 ab	163 b	0	12.5	--
Biochikol 020 PC WS	48.7 b	107 b	146 ab	158 b	12.5	25.0	--
Biochikol 020 PC + Orobanche WS	47.6 b	101 b	139 b	168 b	30.0	20.0	50.0

Table 3. *Effect of Biochicol 020 PC on the fruit yield and healthiness of roots and stems of tomatoes roots cultivated in the infected substrate; W – watering S – spraying * - differences in the yield are not significant [1)] - 10 replications.*

Treatment	Yield from 1 plant kg	Roots healthiness Scale 0 - 5	Per cent of infected plants in the end of November				
			Fusarium oxysporum f. sp. *lycopersici*	*Phytophthora nicotianae* var. *parasitica*	*Orobanche ramosa*	*Botrytis cinerea*	*Pyrenochaeta Lycopersici* and *Colletotrichum* sp.
Control	3.94 a *	1.00	87.5	0		37.5	100
Biochikol 020 PC W	3.80 a	1.75	87.5	37.5	--	25.0	100
Biochikol 020 PC S	4,48 a	1,25	100.0	12.5	--	37.5	100
Biochikol 020 PC WS	3.26 a	1.38	100.0	25.0	--	62.5	100
Biochikol 020 PC + Orobanche WS	3.82 a	1.80	80[1)]	20.0[1)]	70[1)]	40.0[1)]	100

ly accompanied with seeds of pathogen *Orobanche ramosa*. The first shoots of the pathogen appeared on the surface of peat substrate in the glasshouse 73 days after sowing the seeds. In the vegetation season first shoots of *Orobanche ramosa* (branched broomrape) appeared 64 - 65 days after infestation in the field investigations. It sugested that Biochikol 020 PC treatment retarded a little the development of the pathogen. *Orobanche ramosa* is the dangerous parasite of different plants [23]. In genus of *Orobanche* is 170 specieses and beetwen them *Orobanche ramosa* is most dangerous for cultivated plants in warm countries. During last years the parasite appeared also in Poland and it is included in the register of quarantine weeds and plant parasites [24], investigations with them were caried out to control it [25, 26]. In this experiment at the end of June the shoots of *Orobanche ramosa* appeared on 50% pots, where seeds of the pathogen were added, but the development of branched broomrape plants was not great , probably Biochikol 020 PC retarded a little the growth of parasite and significantly lowered its production of seeds in comparision to earlier experiments [25, 26]. In November the per cent of infected plants increased to 70%, but this late infection had no influence on the growth of plants or the fruit yield (Table 3). The experiment will be continued in next year.

4. Conclusions

Spraying with 2.5% Biochikol 020 PC of tomato plants cultivated in the infected substrate increased the fruit yield. The higher fruit yield probably was connected with higher root resistance of followig fungi diseases:*Fusarium oxysporum* f. sp. *lycopersici, Pyrenochaeta lycopersici* and *Colletotrichum* sp. Treatment with Biochikol 020 PC did not increases the resistance of tomato plants to *Phytophthora nicotianae* var. *parasitica*.

5. References

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