EFFECT OF CALCIUM NITRATE, BIOCHIKOL 020 PC AND TYTANIT ON THE HEALTHINESS OF CHINESE CABBAGE, THE YIELD, THE CONTENT OF FENOLIC COMPOUNDS AND CALCIUM

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1. Introduction

The Chinese cabbage (Brassica rapa L. var. pekinensis (Lour.) Olsson) is the vegetable popular in Poland and other countries. It is very sensitive to tipburn injuries, which are physiological disorders connected with calcium and water deficiency [1 - 8]. The last investigations found that Biochikol 020 PC (the marketable preparation of chitosan) also decreased tipburn injures, but this incident was not connected with the increase of calcium content in leaves of Chinese cabbage [6]. It was very interesting and for this reason these investigations were repeated.

2. Material and methods

Seeds of Chinese cabbages Bilko F_1 sensitive of tipburn [9] were sown in multipots (2 × 2 cm) in the warm glasshouse [10] in April 7th 2006. On April 22th seedlings were transplanted to bigger multipots (6 x 6 cm) and on May 8th seedlings were transplanted to 5 liter pots in 11 replications. Pots were filled with peat substrate and it contained following mineral nutritions in 1 dm^3: 500 mg $N\text{-}NO_3$, 259 mg P, 871 mg K, 450 mg Mg, 4291 mg Ca. The salinity of the substrate was 5.4 g NaCl/dm^3 and pH was 6.5. On May 11th Chinese cabbage was watered with 0.1% of insecticide Nomolt to control cabbage fly (*Hylemya brassicae*) wivil betels (*Ceutorrhynhus quadridens* and *Ceutorrhynhus* sp.). Sprayings with Biochikol 020 PC were carried out 5 times: on May 25th, June 7th and 14th, June 20th and 27th. Biochikol 020 PC in concentration 2.5% was used instead of 0.1% chitosan calculated on dry mass.This preparation was diluted with tap water (pH 7.5) with addition acetic acid. Calcium nitrate fertilizer in concentration 1.5% and 0.02% foliar fertilizer Tytanit (0.85%Ti) were used also 5 times (Table 1). The observations of tipburn incidence were carried out from the half of June and the scale 0 - 4 was used, similarly as in earlier experiments [6]. Every plant on June 16th received the top fertilization: 5 g amonium nitrate.

Chinese cabbage plants in pots grew at strong solar irridiation (southern side of the glasshouse), where the temperature at sunny midday was 5-10 °C higher than in open area. Chinese cabbage heads with wrapper leaves were harvested on July 5th. After harvest 3 leaves from every plant were taken for analysis of calcium and soluble fenols content [11, 12] .

3. Results and discussion

In summer 2006 the weather was not normal. At the beginning of June the weather was cloudy and foggy, the temperature at midday was about 20 °C and the humidity of area was about 100%. At the end on June and in July the temperature in the place of experiment was every day over 30 °C and sometimes was about 40 °C and the area humidity fell down to 40%. It was the warmest June in the last 100 years. In these weather conditions 5 sprayings with calcium nitrate, Biochikol 020 PC or Tytanit used in different treatments were not effective and there tipburn appearance was similarly strong as in control plants (Table 1). Only plants sprayed with 1.5% calcium nitrate and 2,5% Biochikol 020 PC or plants sprayed with mixture calcium nitrate and Biochikol 020 PC had significantly lower level of tipburn symptoms and in these treatments the calcium content in leaves was the highest (2.54% and 3.04%). The lowest content of calcium was i the control and in Biochikol 020 PC treatment, similarly as in earlier experiments [6]. These results are very important, because in the warm summer in whole our country also sprayings with calcium nitrate of red peper fruits or also tomato fruits were not effective in the control of blossom-end rot- the physiological disorder connected with calcium and water deficiency in fruits [13 - 16]. During drought and hot weather the physiological disorder increased and the leaf fertilization with calcium nitrate is not effective. This situation was in 2006 and then only addition of Biochikol 020 PC to calcium nitrate solution will give good results, because chitosan contained in Biochikol 020 PC chelated with calcium similarly as with other metals [17 - 19]. Probably during high temperature the complex chitosan and calcium penetrated leaves or fruits better than alone calcium nitrate. Also Biochikol 020 PC used as gel delayed drying up of leaf surface and this made easier the penetration of calcium in to leaf tissue. Biochikol 020 PC influenced also peroxidase activity [20] and it is conected with tipburn appearance. Results of tipburn control by use mixed calcium nitrate solution with Biochikol 020 PC are very important for horticultural practice.

It is interesting that spraying of Chinese cabbage with 3 compounds together (calcium nitrate, Biochikol 020 PC and Tytanit) were not effective: the tipburn injures were similar as in control plants, but rotting of cabbage heads was over 2 time more. The influence of Biochikol 020 PC on plants is different than influence of Tytanit, but both preparations retarded powdery mildew incidences [21]. In our experiment there was the antagonism between these 2 preparations, when they were used together. The differences in the yield between different treatments were to 15% (the control and Tytanit) but were not significant. It was found big differences in the content of soluble phenols in fresh matter of leaves. The highest content of soluble phenols was in control plants (1020 mg) and this date was significantly higher than in other treatments (Table 1). In the leaves of cabbage sprayed with Biochikol 020 PC and calcium nitrate the content of soluble phenols was almost 2 times lower than in the control. Also other authors [22, 23] found higher content of phenolic compounds in lettuce leaves with tipburn.

Table 1. *Effect of Biochikol 020 PC, calcium nitrate, Tytanit and Pomonit on the healthiness and yield of Chinese cabbage and the content of soluble phenols in 2006; *, ** Differences significant in comparison to control calculated with criterion χ^2 at $\alpha = 0.05$ or 0.01 respectively.*

Treament	Observations of tipburn incidences in scale 0 - 4					rotting plants, %	Fresh matter of 1 plant, kg	Soluble phenols mg/kg fresh. matter	% Ca in dry matter
	June 12th	June 19th	June 26th	July 3th	July 5th				
Control	0.23	1.73	1.95	1.77	1.91	18	1.18a	1020 a	1.76
Biochikol 020 PC 2.5 %	0*	1.50	1.64	1.73	1.82	9	1.25a	742 b	1.72
Calcium nitrate 1.5%	0.18	1.64	1.73	1.55	1.59	18	1.27a	614 c	2.17
Tytanit 0.02%	0.05	1.14*	1.55	1.64	1.68	0	1.36a	598 c	2.12
Biochikol 020 PC+calcium nitrate	0*	0.68**	1.32**	1.27*	1.32*	18	1.27a	575 c	2.54
Calcium nitrate +Tytanit	0.41	1.86	1.86	1.64	1.64	0	1.33a	720 b	1.97
Tytanit+Biochikol 020 PC + calcium nitrate	0.09	1.18	1.68	1.73	1.86	45	1.32a	598 c	2.00
Pomonit (25ppm NAA)	0.23	1.68	1.95	1.82	1.91	18	1.29a	-	1.90
Pomonit+Biochikol 020 PC	0.32	1.77	2.14	1.91	1.91	9	1.24a	-	1.65
Tytanit+Biochikol 020 PC	0.09	1.64	1.64	1.41	1.68	18	1.30a	-	2.19
Biochikol 020 PC+ calcium nitrate mixed	0.27	1.23	1.32*	1.14*	1.18*	27	1.20a		3.03

4. Conclusions

When the temperature during whole days was over 28 °C only spraying with 1.5% calcium nitrate mixed with Biochikol 020 PC (concentration 2.5%) gave good effect in the control of tipburn injuries on Chinese cabbage. In this treatment the calcium content in leaves was the highest (about 3.0% Ca in dry matter).

5. References

1. **Berkel van E.:** *Preventing tipburn Chinese cabbage by high relative humitity during the night. Netherlands J. Agri. Sci 36, 1988, 301-308.*
2. **Borkowski J.,Szwonek E.:** *The effect of temperature on Chinese cabbage tipburn and its control by calcium nitrate or citric acid. Acta Hort. 371, 1993, 363-369.*
3. **Imai H.:** *Alleviation of occurence of tipburn and internal rot in tropical Chinese cabbage. Trop. Res. Series 23.1990, 202-217.*
4. *Kobryń J.: Effect of sowing date, cultivars and spacing on the yield and quality of Chinese cabbage in autumn-winter greenhouse production (English sum.). Zesz. Nauk. Akad. Rol. w Krakowie. Ogrodnictwo 211. (16), 1987, 87-107.*
5. **Saure M. C.:** *Causes of tipburn in leaves vegetables. Sci. Hort. 76 .1998,131-147.*
6. **Borkowski J., Felczyńska A., Stępowski J., Niekraszewicz A.:** *Effect of different compounds Biochikol 020 PC, Tytanit and Pomonit on the healthiness and the yield of Chinense cabbage. Progress on Chemistry and Application of Chitin and Its Derivatives. Ed. by M. Jaworska. Monograph XI. 2006, 201-207. Łódź.*
7. **Barta D. J., Tibbitt T. W.:** *Calcium localisation in lettuce leaves with and without tipburn. Comparison of controlled environment and field grown plants. J. Amer. Soc. Hort. Sci. 116, 1991, 870-875.*
8. **Barta D. J., Tibbitts T. W.:** *Calcium localization and tipburn development in lettuce leaves during early enlargement. J. Amer. Soc. Hort. Sci. 125, 2000, 294-298.*
9. **Borkowski J., Kowalczyk W.:** *Relation between tipburn appearance of Chinese cabbage and calcium content and location (English sum.). Acta Agrobot. 56 (1-2), 2003, 53-60.*
10. **Felczyński K.:** *Technologia uprawy kapusty pekińskiej. Instytut Warzywnictwa. Skierniewice, 1997.*
11. **Czapski J., Szwejda J.:** *Antioxidant responses in fermented cabbage and juice during storage. Vegetable Crops Research Bul. 64, 2006, 39-50.*
12. **Ragazzi E., Veronese G.:** *Quantitative analysis of phenolic compounds after thin-layer chromatographic separation. J. Chromatogr. 77 1973, 369-375.*
13. **Bangerth F.:** *Calcium - elated physiological disorders of plants. Ann.Rev. Phytopathol. 7, 1979, 97-112.*
14. **Borkowski J.:** *Przyczyny występowania suchej zgnilizny pomidorów i sposoby jej zapobiegania (are English sum.). Rozprawa hab. 1983. Instytut Warzywnictwa, Skierniewice.*
15. **Karni L., Aloni B., Bar-Tal A., Moreshet S., Keinan M., Yao C.:** *The effect of root restriction n the incidence of blossom-end rot in bell peper (Capsicum annuum L.). J. Hort. Sci. Biotech. 75 (3) 2000, 364-369.*
16. **Marcels L. F. M., Ho L. C.:** *Bossom-end rot in relation to growth rate in calcium content in fruits of sweet peper (Capsicum annuum L). J. Exper. Botany 50 (332) 1999, 357 -363.*
17. **Bodek K. H.:** *Interaction of microcrystalline chitosan with Ni (II) and Mn (II) in aqueous solution. Journal of Applied Polymer Science 98, 2005, 2572-2577.*
18. **Bodek K. H.:** *Wpływ temperatury i postaci chitozanu na proces sorbcji jonów metali. XII Seminarium Robocze "Nowe aspekty w chemii i zastosowaniu chityny i jej pochodnych". 2006, P9. Streszczenia, Polskie Towarzystwo Chitynowe. Łódź.*
19. **Kula K., Jaworska M. M., Guibal E.:** *Chitosan -a sorbent for noble metals. Progress on Chemistry and Application of Chitin and Its Derivatives. Ed. by Struszczyk H., Monograph IX , 2003, 155-160. Łódź.*

20. ***Maćkowiak A., Pośpieszny H.:****Theeffect of chitosan on peroxidase activity in various plant species. Progress on Chemistry and Application of Chitin and Its Derivatives. Ed. by H. Struszczyk, Monograph VI, 2000,145-150, Łódź.*
21. ***Borkowski J., Dyki B., Niekraszewicz A., Struszczyk H.:*** *Effect of the preparations Biochikol 20 PC, Tytanit, Biosept 33 SL and others on the healthiness of tomato plants and their fruiting in glasshouse. Progress on Chemistry and Application of Chitin and Its Derivatives. Ed. by H. Struszczyk. Monograph X, 2004, 167-173.*
22. ***Ostrzycka J., Borkowski J., Jankiewicz L.S.:*** *The influence of naphthalene acetic acid (NAA) on tipburn of internal leaves of lettuce (Lactuca sativa L.). Acta Agrobotanica 42 (1/2), 1989, 55-62.*
23. ***Chi Y. J., Tomas-Barberain F. A., Saltveit M. E.:*** *Wound- induced phenolic accumulation and browning in lettuce (Lactuca sativa L.) leaf tissue is reduced by exposure to n-alcohols. Post-harvest Biology and Technology 37 (1), 2005, 47-55.*