1. Introduction

The Chinese cabbage (Brassica rapa L. ssp.pekinensis (Lour.) Hanelt) as the vegetable is cultivated all over the world with increasing popularity. It gives the crop 100 t·ha⁻¹ (sometimes more) for 2 - 3 months cultivation [1, 2]. Rapid growth of this plant makes it very sensitive to tipburn injuries, which are physiological disorders connected with calcium and water deficiency [3 - 7]. Tipburn is the main cause of destroying the whole marketable yield of Chinese cabbage. The disorder concerns also other leaves vegetables [7]. Cultivars of Chinese cabbage differ in susceptibility of tipburn [8, 9]. It seems to be connected with the susceptibility to stress caused by high temperature promoted rapid growth, transpiration and water deficit [7], because cultivars did not differ in calcium concentration in leaves [10]. Chitosan as an elicitor, increased the plant resistance to different diseases [11 - 14]. Experiments were carried out to determine whether chitosan or other preparations can increase the resistance of Chinese cabbage on tipburn similarly as calcium nitrate.

2. Material and methods

Seeds of Chinese cabbage Bilko F₁ cultivar sensitive to tipburn [10] was sown in multipots in the warm glasshouse in April 14th 2004. High temperature was applied to prevent seedlings of Chinese cabbage grown in temperature lower than 18 °C, starting the generative development with lack of heads yield [15, 16]. On May 7th seedlings were transplanted to 5 liter in 11 replications pots filled with peat substrate. It contained in following mineral nutrition: 1 dm³ 622 mg N-N0₃, 142 mg P, 1218 mg K, 698 mg Mg and 6328 mg Ca. The salinity of the substrate was 6,05 g NaCl·dm⁻³ and pH was 6.5.
Sprayings with 2.5% Biochikol 020 PC were carried out 3 times: on May 11th, 19th and on June 9th. The preparation was made by Gumitex Poli-Farm in Łowicz. Biochikol 020 PC in concentration 2.5% was used instead of 0.1% chitosan calculated on dry mass. This preparation was diluted with destilled water to avoid the influence on plants by tap water (pH 7.5). Calcium nitrate fertilizer in concentration 1.5% and 0.02%, foliar fertilizer Tytanit (0.85% of Ti) produced by Intermag Company in Osiek near Olkusz were used 3 times (Table 1). Sprays with Pomonit contained KNAA (potassium salt of naphtalene acetic acid) was done on June 14th. It successful influence in controlling tipburn of internal leaves in lettuce [17]. The observations of tipburn incidences were carried out from half of June and there the scale 0-4 was used:

0 - healthy leaves
0.5 - slight symptoms of tipburn on edgas on the 1-2 leaves
1 - symptoms of tipburn on edgas of some leaves
2 - distinct symptoms of tipburn on numerous leaves
3 - almost all leaves in the head are affected less or more with tipburn, easy rotting.

The picture of the stage of disorder was presented in journal Ochrona Roślin [9].
4 - the plant of Chinese cabbage is as strong affected by tipburn, that the head had not been formed and plant is predominantly rotten. This stage appeared rarely and is presented in Acta Hort. [4].

Chinese cabbage plants in pots grew at strong solar irradiation (southern side of the glasshouse), where the temperature at sunny midday was 5-10 °C higher than on the open area. During the warm days plants were watered 2 or 3 times with tap water. Plant heads were harvested on July 7th.

Similar growing scheme of experiments were carried out in 2005 with the same cv. Bilko F1. On April 4th seeds were sown to multipots (3 x 3 cm). On April 22th seedlings were transplanted to bigger multipots (6 x 6 cm). In 2004 and in 2005 in order to control insects, cabbage fly (Hylemya brassicae), wivil betels (Ceutorrhynhus quadridens and Ceutorrhynhus sp) 0.1% solution of insecticide Grott 20 EC (diasinon) was applied 2 times by watering.

On May 2nd plants of Chinese cabbage were planted to 5 liter pots in 11 replications and grown outdoor under the same conditions as in 2004. The substrate contained following concentration of fertilizers: in 1 dm³ 370 mg N-NO₃, 113 mg P, 570 mg K, 355mg Mg and 4566mg Ca, pH was 6.8 and salinity 4.7g NaCl·dm⁻³. Sprays with 2,5% Biochkol 020 PC were done 5 times: May 6th, 24th, June 8th 20th, and 25th. Other treatments were done in similar shedule as in table 2. One spray with Pomonit contained KNAA (potassium salt of naphthalene acetic acid) and was carried out on June 10th. During plants cultivation ammonium nitrate (8 g per pot) in solution was applied 2 times. Observations of tipburn appearance started on June 10th with harvest time on July 7th.

Each plant head was weighted and then two leaves of each plant were collected for mineral nutrition analisis. The results were evaluated statistically by X² (Chi²) test at
Table 1. Effect of Biochikol 020 PC, Pomonit, calcium nitrogen and Tytanit on the healthiness and yield of Chinese cabbage in 2004.

<table>
<thead>
<tr>
<th>Preparations</th>
<th>Number of treatments</th>
<th>Observations of tipburn incidence in scale 0-4</th>
<th>% rotten plants 2)</th>
<th>Fresh matter of 1 plant, kg</th>
<th>% Ca in dry matter of leaves</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>June 16th</td>
<td>22th</td>
<td>29th</td>
<td>July 6th</td>
</tr>
<tr>
<td>Control</td>
<td>-</td>
<td>0.64</td>
<td>1.09</td>
<td>2.45</td>
<td>3.40</td>
</tr>
<tr>
<td>Biochikol 020 PC 2.5% 1)</td>
<td>3</td>
<td>0.23</td>
<td>0.45</td>
<td>1.73</td>
<td>2.59xx</td>
</tr>
<tr>
<td>Pomonit (25 ppm NAA) 1)</td>
<td>1</td>
<td>0.32</td>
<td>0.55</td>
<td>1.68x</td>
<td>2.41xx</td>
</tr>
<tr>
<td>Ca(NO₃)₂ 1.5% 1)</td>
<td>3</td>
<td>0.0xx</td>
<td>0.36x</td>
<td>1.68x</td>
<td>2.68xx</td>
</tr>
<tr>
<td>Tytanit 0.02% 1)</td>
<td>3</td>
<td>0.23</td>
<td>0.73</td>
<td>1.68x</td>
<td>2.68xx</td>
</tr>
</tbody>
</table>

1) - spraying
2) - It is the first stage of rotting
x, xx Differences significant in comparison to underlined treatment calculated with criterion Chi² at α = 0.05 or 0.01 respectively.

Average fresh matter was calculated with the analysis of variance using Newman Keuls test.

Tipburn scale 0-4: 0 – healthy plant, 0.5 – plant a little injured 4 – cabbage head completely destroyed.
α = 0.05 or 0.01 to tipburn injury scale and Newman - Keuls test at α = 0.05 for fresh matter.

3. Results and discussion

The lowest level of tipburn incidences was found in treatments: Pomonit (NAA), Biochikol 020 PC, calcium nitrate and Tytanit (Table 1). In this treatments the yield was markedly higher than in control, although not all differences were statisticly significant. It was found, that after spraying with calcium nitrate tipburn injures are smaller and the calcium content in leaves increased because calcium make more stiff cells membranes [7, 18, 19].

Biochikol 020 PC also decreased tipburn injures, but in the some time the calcium content was the lowest. It confirms that tipburn injures are dependent not only from calcium content but also on plant resistance on stress (high temperature, wated shortage) as has been shown by Saure [7]. The experiments with tomato in glasshouse showed the influence of chitosan on the enzymes activity in tomato leaves [12]. Similar mechanism may be expected in Chinese cabbage giving the effect on tipburn appearance. Plants treated with Biochikol 020 PC were less affected with bacterial rotting than other. It confirms the data of Mackowiak and Pośpieszny [20].

As was found earlier for lettuce cv. Ilanka and Marcia [17] Pomonit (KNAA) decreased significantly tipburn injuries in Chinese cabbage. However per cent of rotten plants was the highest (Table 1). Pomonit decreased also strongly the level of phenolic compounds in these plants [17]. It is interesting if Biochikol 020 PC or Tytanit had similar effect on phenolic compounds level in Chinese cabbage. High level of these compounds probably are connected with tipburn appearance. Spraying with Tytanit solution decreased the tipburn injures and increased the yield similarly to Pomonit treatment, and also lowered per cent of rotten heads. It is the similar result to earlier described favorable influence of titanium on plant growth and stress resistance [21, 22].

In 2005 experiments the best results in the tipburn control were received in obiects treated with 3 preparations: 1.5% calcium nitrate and 2.5% Biochikol 020 PC, calcium nitrate and Tytanit or with calcium nitrate alone (Table 2). It is interesting that tipburn incidences on plants treated with 3 preparations together: Biochikol 020 PC, calcium nitrate and Tytanit were similar as in control. The mechanism of action of Biochikol and Tytanit are different [12]. For that reason it seems to be rather some kind of antagonistic effect between this preparations than expected additive one. Not significant differences between treatments in the cabbage yield were observed (Table 2). The lowest per cent of rotten plants was in obiects treated with Biochikol 020 PC (similarly as in 2004), calcium nitrate alone, calcium nitrate with Biochikol 020 PC and Tytanit with Biochikol 020 PC. In 2004 Biochikol 020 PC decreased calcium level in Chinese cabbage leaves. It is interesting,that chitosan is able also decrease the calcium level in animal cells [23]. Similarly as in 2004 spraying with calcium nitrate
Table 2. Effect of preparations Biochikol 020 PC and Pomonit and fertilizers calcium nitrate and Tytanit on the healthiness and yield of Chinese cabbage in 2005.

<table>
<thead>
<tr>
<th>Objects</th>
<th>Number of sprays</th>
<th>Observations of tipburn incidences in scale 0 – 4</th>
<th>% rotten plants 1)</th>
<th>Weight of one head and leaves a), kg</th>
<th>% Ca in dry matter of leaves</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>June 21th 27th 4th 7th</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>-</td>
<td>1.32 1.50 1.73 1.91</td>
<td>36</td>
<td>1.19</td>
<td>2.24</td>
</tr>
<tr>
<td>2.5% Biochikol 020 PC</td>
<td>5</td>
<td>1.18 1.36 1.36 1.36 xx</td>
<td>9</td>
<td>1.21</td>
<td>2.40</td>
</tr>
<tr>
<td>1.5% calcium nitrate</td>
<td>4</td>
<td>0.91x 0.95 1.09x 1.14xx</td>
<td>9</td>
<td>1.26</td>
<td>2.75</td>
</tr>
<tr>
<td>0.02% Tytanit</td>
<td>5</td>
<td>1.14 1.27 1.64 1.82</td>
<td>45</td>
<td>1.19</td>
<td>2.38</td>
</tr>
<tr>
<td>2.5% Biochikol and 1.5% calcium nitrate</td>
<td>5+4</td>
<td>0.82x 0.82xx 0.91x 0.91xx</td>
<td>9</td>
<td>1.11</td>
<td>2.78</td>
</tr>
<tr>
<td>1.5% calcium nitrate and 0.02% Tytanit</td>
<td>4+5</td>
<td>0.64xx 0.91xx 1.05x 1.05xx</td>
<td>36</td>
<td>1.32</td>
<td>2.77</td>
</tr>
<tr>
<td>Biochikol, calcium nitrate and Tytanit</td>
<td>5, 4, 5</td>
<td>1.14 1.32 1.64 1.86</td>
<td>45</td>
<td>1.16</td>
<td>2.76</td>
</tr>
<tr>
<td>Pomonit (25 ppm NAA)</td>
<td>1</td>
<td>1.18 1.27 1.41 1.50</td>
<td>54</td>
<td>1.11</td>
<td>2.63</td>
</tr>
<tr>
<td>1.5% calcium nitrate and Pomonit</td>
<td>4+1</td>
<td>0.73xx 0.86xx 1.00x 1.14xx</td>
<td>18</td>
<td>1.24</td>
<td>2.51</td>
</tr>
<tr>
<td>0.02% Tytanit and Biochikol 020 PC</td>
<td>5</td>
<td>1.14 1.14 1.18x 1.23xx</td>
<td>9</td>
<td>1.22</td>
<td>2.33</td>
</tr>
</tbody>
</table>

a) - Differences not significant by use Newman-Keuls test at $\alpha = 0.05$

xx - Differences significant in comparison to underlined treatment calculated with criterion Chi$^2$ at $\alpha = 0.05$ or 0.01 respectively.

Tipburn 0-4 scale: 0 – helthy plant 0.5 – plant slightly injured 4 – cabbage head completely destroyed

1) It is the first stage of rotting.
increased markedly the content of calcium in Chinese cabbage leaves. Biochikol 020 PC did not increased calcium content in leaves, but decreased tipburn symptoms. Spraying with calcium nitrate and Tytanit gave also similar effect.

4. Conclusions

Results of pot investigations carried out in 2004 - 2005 showed that calcium nitrate or Biochikol 020 PC spraying decreased tipburn incidence on Chinese cabbage. The treatments with calcium nitrate and Biochikol 20 PC together gave the best effect, because strong decreased tipburn incidences and decreased per cent of rotten plants. Spraying with calcium nitrate and Tytanit gave better results than calcium nitrate alone or Tytanit alone. The treatment with combination of 3 components (calcium nitrate, Biochikol 020 PC and Tytanit) used together is not usefull because there the effect would be similar as in control.

5. References

Effect of different compounds Biochikol 020 PC, calcium nitrate, tytanit and pomonit ...