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Review of doctoral dissertation

written by Wenping Liu, MSc entitled: The influence of selected factors on the yield and physicochemical parameters of flowering Chinese cabbage (*Brassica campestris* L. ssp. *chinensis* var. *utilis* Tsen et Lee)

Scientific Supervisor: Prof. UPP dr hab. Tomasz Kleiber,

Co-supervisor: Dr Małgorzata Muzolf-Panek

Overall evaluation

The formal basis for the preparation of the review was the decision of the Scientific Discipline Council for Agriculture and Horticulture of the Poznań University of Life Sciences to appoint reviewers for the doctoral dissertation by Mr Wenping Liu, MSc entitled: The influence of selected factors on the yield and physicochemical parameters of flowering Chinese cabbage (*Brassica campestris* L. ssp. *chinensis* var. *utilis* Tsen et Lee). Doctoral thesis articles and autoreferat were written in English.

The doctoral dissertation, prepared by Wenping Liu, consists of 4 published scientific articles:

1. Liu W., Liu Y., Kleiber T. 2021. A review of progress in current research on Chinese flowering cabbage (*Brassica campestris* L. ssp. *chinensis* var. *utilis* Tsen et Lee). *J. Elem.*, 26(1): 149-162. DOI: 10.5601/jelem.2020.25.4.2076. Score of the Polish Ministry of Science and Higher Education 2021: 70 points, IF 2021: 0.923.
2. Liu, W., Muzolf-Panek M., and Kleiber T. 2022. Effect of Nitrogen Nutrition and Planting Date on the Yield and Physicochemical Parameters of Flowering Chinese Cabbage *Agronomy* 12, no. 11: 2869. <https://doi.org/10.3390/agronomy12112869> Score of the Polish Ministry of Science and Higher Education 2021: 100 points IF 2021: 3.949.

3. Liu, W.; Muzolf-Panek, M.; Kleiber, T. 2022. The Effect of Various Foliar Treatments and Nitrogen Nutrition Levels on the Yield and Physicochemical Parameters of Flowering Chinese Cabbage. *Agronomy* , 12, 737  
<https://doi.org/10.3390/agronomy12030737> Score of the Polish Ministry of Science and Higher Education 2021: 100 points IF 2021: 2.838.
4. Liu, W., Muzolf-Panek M., and Kleiber T. 2023. "Effect of Varied Nitrogen Sources and Type of Cultivation on the Yield and Physicochemical Parameters of Flowering Chinese Cabbage (*Brassica campestris* L. ssp. *chinensis* var. *utilis* Tsen et Lee)" *Applied Sciences* 13, no. 9: 5691. <https://doi.org/10.3390/app13095691> Score of the Polish Ministry of Science and Higher Education 2021: 100 points, IF 2021: 2.838.

And short (59 pages) autoreferat containing acknowledgements, list of 4. publications constituting the dissertation, list of abbreviations and description of PhD thesis divided on chapters: abstract in English and Polish, introduction, literature review, hypothesis and research objectives, material and methods, summary of attached publications(for every from 4 publications) , conclusion, reference (in total 111 positions), a copies of 4 publications.

The dissertation is written in English

Total score of the Polish Ministry of Science and Higher Education: 370 points and total IF: 11.659.

The total Impact Factor of the publication is high and equal to IF<sub>2023</sub>= 11.659, which gives the average value per publication IF = 2. 914. The PhD student is the first author in all publications, his individual participation in the development of the research plan, its implementation, conducting studies, interpretation of the results and preparation of the above mentioned articles was significant. All publications included in the dissertation are characterized by a very good scientific level and care for appropriate presentation, documentation and discussion of the presented results and conclusions. They were reviewed by a group of selected experts, so their high scientific level was confirmed.

#### Substantive assessment

In my opinion, the subject of the doctoral thesis by Wenping Liu, M.Sc. is topical and interesting as well as important for both cognitive and applicative points of view. Knowledge about growing this vegetable in Poland and Europe is poor. However, in Italy and Portugal there is a popular similar vegetable called *rapini* classified scientifically as *Brassica rapa* var. *ruvo*, or *Brassica rapa* subsp. *sylvestris* var. *esculenta*, also completely unknown in Poland and has never been cultivated before. In production flowering Chinese cabbage it is an annual plant

with a poor response to length day. It's a bit smaller and more delicate leaves and petioles than pak choi chinese cabbage, grows up to 20-30 cm high. According to information from China and the International Seed Assessment Association (ISTA) its seeds germinate best at a temperature of 15-30°C, and the grown seedlings develop very quickly. After producing 7-8 leaves the seedling enters the stage of generative development. The flowers are yellow or purple in color. In China, two groups of varieties are grown: the first of them is Tsai Shim (also called Tsoi-Sim) with greens shoots and leaves, while the second is Hon Tsai- Tai, whose shoots and veins are purple-red (purple) and green leaves. Crispy, delicate, juicy and sweet in taste inflorescence shoot, which is the edible part of the plant, both can be served raw and after thermal treatment. The vegetable is suitable for cultivation from spring to autumn in the field, but it is also possible to grow it indoors using very advanced technologies such as vertical cultivation. According to scientific and practical literature flowering Chinese cabbage does not have high thermal requirements. Optimum temperature range up to growth and development is reach of 15-25°C. However, it is sensitive to frost.

After a careful review of the thesis, I came to the conclusion that Mr. Wenping Liu has produced several significant and important results and has done a good job describing his work.

Chapters 1 and 2 give a nice introduction to the topic. The main novelty is found in chapters 3 and 4, in which were set out the 3 hypotheses. The primary aim of the three years study was to determine the optimal form ( $\text{NH}_4\text{NO}_3$ ,  $\text{Ca}(\text{NO}_3)_2$ ,  $\text{Mg}(\text{NO}_3)_2$ ,  $\text{NaNO}_3$ ,  $\text{CO}(\text{NH}_2)_2$ ) and dose of nitrogen (50, 70, 90, 130 mg per 1  $\text{dm}^3$ ), cultivation season (planting date), and cultivation system for soilless production pot cultivation (mixture of peat and sand) and hydroponic culture. to maximize the growth and yield of flowering Chinese cabbage. In year 2020, the influence of varying nitrogen nutrition levels (70 and 90 mg N per  $\text{dm}^3$ ) and foliar treatments (Se, Si, Li, V, and SA—salicylic acid) on the yield quantity and quality of flowering Chinese cabbage were tested in both soilless cultivation systems. The yield and physicochemical parameters were determined by fresh weight, nutrient content, colour, chlorophyll content, carotenoids content, total phenolic content, total flavonoid content, and the antioxidant activity by ABTS, DPPH and FRAP methods.

The nitrogen source and dose modified plant yield and its quality. The yields of plants in hydroponics were higher than in pot cultivation. The highest yielding of plants were obtained at N-70 with  $\text{NH}_4\text{NO}_3$  in hydroponic. Increasing levels of N nutrition significantly increased the average yield of the plants grown in pots, while in hydroponics, the average yields at N-70

were comparable to those at N-90. The nitrogen source modified plant nutrition in terms of N, P, K, Ca, Mg, Na, Fe, Mn, Zn and Cu.

The various foliar treatments (Se, Si, Li, V, and SA—salicylic acid) on the quantity of the yield and physicochemical parameters of flowering Chinese cabbage grown in two varied soilless cultivation systems: pot cultivation (mixture of peat and sand) and hydroponic were estimated. The results showed that the yield of flowering Chinese cabbage, cultivated in both pots and hydroponic systems, was significantly influenced by various foliar spray treatments and nitrogen nutrition. The highest yield in pot cultivation was found at N-90 with simultaneous Li spray treatment, which was about 17.5% higher than the yield of control plants (for N-90). The highest yield in the hydroponic system was found in the control at N-90. However, there were no statistically significant differences between the control and the rest of combinations (Si, Se, Li, and SA). In contrast to pot cultivation, V treatment significantly decreased the yield by 25.2% compared to the control combination. For the lower nitrogen nutrition level, the lowest yield was found under Si treatment (reduced about 30.5% comparing to the control). Studied factors influenced on the colour parameters and chlorophyll and carotenoids concentration in leaves. In hydroponic SA treatment resulted in the highest greenness and yellowness, while V and Si treatments decreased greenness. In the substrate cultivation, Chl a, Chl b, and carotenoid content increased with the increase of N levels, except in the Li-treated sample. Foliar spray treatments (Se, Si, Li, SA) at N-70 increased Chl a content compared to the control. V foliar application had various effects on chlorophyll content. In the pot experiment, the intensity of N nutrition and foliar treatment significantly affected the antioxidant activity. SA treatment at N-70 showed the highest TEAC values, while Li and V treatments decreased TEAC values. The lowest activity measured by the DPPH assay was found in the samples treated with after SA and V (N-70), and the highest activity after Li treatment (N-90). The highest chelating activity (FRAP) of flowering Chinese cabbage was noted after Se treatment (N-90). In the pot cultivation DPPH activity was correlated with TPC, and FRAP activity correlated with carotenoid content. Selenium used as foliar application, plays not only a beneficial role in plants by positively influencing their growth, regulating the antioxidative defense system, and reducing plant susceptibility to various stresses, such as heavy metals, salinity or drought but also is nutritionally essential element for humans, play critical roles in reproduction, thyroid hormone metabolism, DNA synthesis, and protection from oxidative damage and infection. Its foliar application to plants in controlled crops can be seen as a form of biofortification.

The results obtained, especially regarding foliar fertilization with selenium, should be considered very precious. I consider this part of the research to be particularly scientifically valuable.

#### Summary

The PhD student has publishing achievements. He is co-author of six articles published in journals from JCR list (including 4 articles related to the dissertation) and five conference presentations (oral and poster) of national and international scope which proves Author's good activity in disseminating the issues of the doctoral dissertation and the other scientific achievements in the scientific community

I am fully convinced that doctoral theses presented by MSc. Wenping Liu fulfil all requirements and meet the scientific standards posed by the Polish law regarding the scientific degrees and that of doctor of agricultural sciences (in agriculture and horticulture) in particular. On this ground I advise and recommend that Mr Liu be allowed to present and defend his thesis during the open meeting.

Taking into account the scope, level and importance of the research and a high scientific activity of the PhD student, I apply for the distinction of the reviewed doctoral dissertation because:

1. It shows a very good quality of the PhD thesis confirmed by 4 publications in highly recognized research journals (IF from 0.923 to 3.949; average value per publication IF = 2.914).
2. It introduces elements of novelty in the scope of the discussed subject.
3. It contains extensive and original experimental material based on reliable results obtained with the use of many analytical techniques.
4. The obtained results have practical significance and contribute to progress in expanding the range of vegetables and enabling their cultivation in indoor vertical farming.

In summary, this thesis satisfies the customary requirements of a Ph.D. thesis and recommend the candidate to be permitted to publically defend his thesis.

Wrocław 15.09.2023

  
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