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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 is the decision of the 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). The doctoral thesis articles and summary of professional accomplishments were written in English.

The doctoral dissertation, prepared by Wenping Liu, consists of four 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): 149f–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 Lec)" *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 a short (59-pages) summary of professional accomplishments containing acknowledgements, a list of four publications constituting the dissertation, a list of abbreviations and a description of the PhD thesis divided into chapters: an abstract in English and Polish, an introduction, a literature review, a hypothesis and research objectives, material and methods, a summary of attached publications (for each one of four publications), a conclusion, references (a total of 111 items), and copies of four 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 an IF2023 of 11.659, which gives an average value per publication of $IF = 2.914$. The PhD student is the first author in all the publications, and his individual participation in the development of the research plan and its implementation, the conduct of studies, the interpretation of the results, and the preparation of the above-mentioned articles was significant. All publications included in the dissertation are characterised 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; therefore, their high scientific level is confirmed.

In my opinion, the subject of the doctoral thesis by Wenping Liu, M.Sc. is topical, interesting and important from both the cognitive and applicative points of view. Existing knowledge about the growing of 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*. It is also completely unknown in Poland, and has never been cultivated in Poland before. In production, flowering Chinese cabbage is an

annual plant with a poor response to length of day. It has slightly smaller and more-delicate leaves and petioles than the pak choi Chinese cabbage, and 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 grown seedlings develop very quickly. After producing seven to eight leaves, the seedling enters the stage of generative development. The flowers are yellow or purple in colour. In China, two groups of varieties are grown: the first is Tsai Shim (also called Tsoi-Sim) with green shoots and leaves, while the second is Hon Tsai-Tai, whose shoots and veins are purple-red leaves are green. 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 in the field from spring to autumn, but can also be grown indoors using very advanced technologies, such as vertical cultivation. According to scientific and practical literature, flowering Chinese cabbage does not have high thermal requirements. The 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 good introduction to the topic. The main novelty is found in chapters 3 and 4, where three hypotheses are set out. The primary aim of the three-year study was to determine the optimal form (NH_4NO_3 , $\text{Ca}(\text{NO}_3)_2$, $\text{Mg}(\text{NO}_3)_2$, NaNO_3 or $\text{CO}(\text{NH}_2)_2$) and dose (50, 70, 90 or 130 mg per dm^3) of nitrogen, the cultivation season (planting date), and the 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 2020, the influence of varying nitrogen nutrition levels (70 and 90 mg N per 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 of the soilless cultivation systems. The yield and physicochemical parameters were determined by fresh weight, nutrient content, colour, chlorophyll content, carotenoid content, total phenolic content, total flavonoid content, and antioxidant activity by ABTS, DPPH and FRAP methods.

The nitrogen source and dose modified plant yield and quality. The yields of plants grown using hydroponics were higher than of those grown using pot cultivation. The highest-yielding of plants were obtained at N-70 with NH_4NO_3 in hydroponics. 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 with 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 approximately 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 the combinations (Si, Se, Li and SA). In contrast to pot cultivation, V treatment significantly decreased the yield by 25.2% compared with the control combination. For the lower nitrogen nutrition level, the lowest yield was found with Si treatment (decreased approximately 30.5% compared with the control). The factors studied influenced the colour parameters as well as the chlorophyll and carotenoid concentration in the leaves. In hydroponics, 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 and SA) at N-70 increased Chl a content compared with 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 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 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 was correlated with carotenoid content. Selenium used as foliar application not only plays a beneficial role in plants by positively influencing their growth, regulating the antioxidative defence system, and reducing plant susceptibility to various stresses – such as heavy metals, salinity and drought – but is also a nutritionally essential element for humans, and plays 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 those regarding foliar fertilisation with selenium, should be considered very important. 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 the doctoral thesis presented by Wenping Liu, MSc fulfils all requirements and meets the scientific standards posed by Polish law regarding scientific degrees, and that of a doctor of agricultural sciences (in agriculture and horticulture) in particular. Based on this, I advise and recommend that Mr Liu be allowed to present and defend his thesis during an open meeting.

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

1. It demonstrates a very high quality of the PhD thesis confirmed by four publications in highly recognised 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 PhD thesis and I recommend that the candidate be permitted to publicly defend his thesis.



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