Scientific Papers. Series B, Horticulture. Vol. LXVII, No. 1, 2023
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

STUDY REGARDING THE INFLUENCE OF DIFFERENT SOWING DATES ON THE PRODUCTION OF SOME *BRASSICA* SPECIES CULTIVATED IN NUTRIENT FILM TECHNIQUE (NFT)

Sovorn CHAN, Ovidiu Ionuț JERCA, Adnan ARSHAD, Elena Maria DRĂGHICI

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author emails: draghiciem@yahoo.com, chansovorn@gmail.com

Abstract

Brassicaceae or the mustard family is one of the popular crops which is cultivated in both open fields and protected culture. It is being used as an oil, condiment, or leafy vegetable type in many countries around the world, and in Asia, it is commonly used as a vegetable due to its nutritional value and health benefits. Usually, growing this type of crop is unpredicted with growth and yield because environmental factors such as temperature, light, humidity, etc might influence during cultivation. The study aimed to compare the growing condition of some Brassica species cultivated in the NFT system. The investigation took place throughout two growing cycles during distinct cultivating times at greenhouse in USAMV. We found the interaction between the variety and growing period in all observed except leaf width and number of leaves per plant.

Key words: *Brassica, species, growing condition, NFT.*

INTRODUCTION

The *Brassica* genus is in the Brassicaceae family. Usually, it is called Cruciferae or the mustard family. It is practically used everywhere in the world, in the form of fresh vegetables, preserved or canned vegetables, oil products, and condiments. Within the *Brassicaceae* family, there are approximately 3709 species, 338 genera, and 25 tribes (Šamec & Salopek-Sondi, 2019; Al-Shehbaz et al., 2006).

The species in this genus were divided into oily, fodder, spice, and vegetable categories, according to Salehi et al. (2021). The six main species include three diploid species, *Brassica nigra* (L.) K. Koch, *Brassica oleracea* L., and *Brassica rapa* L., and three amphidiploid species, *Brassica carinata* A. Braun, *Brassica juncea* (L.) Czern., and *Brassica napus* L., which are important for the world economy. The Brassica family also has a long story regarding plant evolution which current species are related to the wild parents. Dixon (2017) and Arias et al. (2014) reported that the origin of brassicas was in the Horn of Africa and the Arabian Peninsula dating back around 24 million years ago.

For vegetable crops, many factors influence the growth and yield such as temperature, light intensity, CO2, Related Humidity (RH), pH, EC, and fertilization. For instance, Hayat et al. (2009) conducted a study of *Brassica juncea* L. under heat stress at the seedling stage, The plant exposed to both higher temperatures resulted in negative growth, at 40°C, all the growth parameters were decreased such as root length (53.7%), fresh mass (68.3%), and dry matter (65.8%). Siemonsma (1993) said that day length influences flowering, and the bolting happens during a long day without depending on how low the temperature is. When the light intensity was increased from 100 to 600 $\mu mol^{-2} \cdot s^{-1}$ for 16 hours of photoperiod, Jones-Baumgardt et al. (2019) found that the fresh weight of kale, cabbage, and mustard increased by up to 36 percent, 56 percent, and 82 percent. Furthermore, dry weight rose from 65% to 69%, and 145%. When mustard is grown in an open field with solar light intensity below 67 percent, *Brassica juncea*'s growth and yield are reduced (Alam et al., 2018). Dong et al. (2020) reviewed over 100 articles related to the effect of CO_2 on the yield of vegetables, and they found that yield of vegetables increased by

34% when CO_2 elevated to 827 µmol/mol. Roosta (2011) revealed that a pH higher or lower affects plant growth. For instance, pH 8.0 decreased fresh weight, dry weight, and shoot growth. Reduction in shoot growth means the ability of photosynthesis is low, which abrupted the chlorophyll process. While pH 5.0 was best for fresh weight, dry weight, shoot growth, phytochemical yield, and other minerals such as iron, manganese, and zinc. Lower in pH, a soilborne disease easily outbreaks. For instance, clubroot disease usually occurs when the soil pH is lower than 5.7 for cabbage, and mustard crops, while pH from 5.7-6.2 could reduce the occurrence of the disease drastically (Kioke et al., 2003). Samrakoon et al. (2006) found that EC 1.4 dS/m of Albert's solution had a bigger leaf, higher in fresh weight and dry weight. Based on Lee et al. (2012), the optimum EC for red mustard was 2.0-2.5 mS/cm, within this range, the mustard and pak choi increased the yield and vitamin C content. A similar result was also reported by Ding et al. (2018).

Many research efforts have been focused on, especially in the NFT system with some species such as basil, lettuce over different periods, and obtained the best result (Asmaa et al., 2021; Chan et al., 2022; Govoreanu et al., 2022). The objective of our study was to evaluate the growing condition in two different sowing periods on the production of some Brassica crops in the NFT system.

MATERIALS AND METHODS

The study was carried out in the greenhouse under the natural light condition at the Research Centre for Quality Control of Horticultural Produce, Faculty of Horticulture, UASMV, Bucharest, for two growing cycles. The first growing cycle started from 15 January, 2022 to 10 March, 2022 and second growing cycle started from Oct 24, 2022 to Jan 10, 2023 (Table 1).

Mustard varieties were used in the experiment including two varieties of *Brassica juncea* L., V1 is the local variety, seed multiplication and maintained by Kbal Koh Vegetable Research Station, Cambodia, and V2, is from Green Seeds company navigated on the Cambodia's market. These varieties had green colour and a broad leaf, V3 is the specie of *Brassica rapa* var. *parachinensis* or called choy sum from Nam Viet seeds company, had the long petiole and dark green leaves, V4 is the species of *Brassica oleracea* var. *alboglabra* or called Chinese kale (Kai lan 01), from KsSeed company (Figure 1). All the seeds were sown. In the plastic tray (40 x 60 cm) filled with substrate from peat plantobalt type mixed with perlite in the proportion of 75% and 25%. The seeds were placed in the row covered by vermiculite. Seven days after sowing, the young seedlings were transferred into Jiffy pot (peat pellets) and watering manually with tap water.

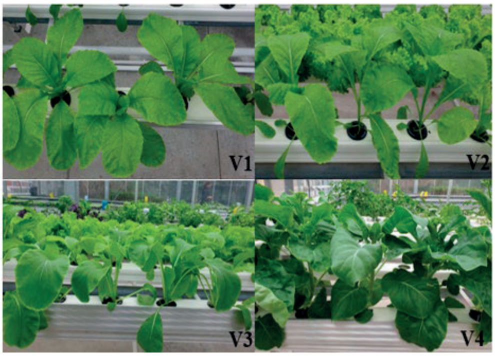

Figure 1. Brassica species grown on Nutrient Film Technique

Table 1. Sowing and harvesting date of the four brassica crops

Variety	Sowing date		Harvesting date	
	Cycle 1	Cycle 2	Cycle 1	Cycle 2
Brassica juncea L. (V1)	15-Jan-22	24-Oct-22	1-Mar-22	19-Dec-22
Brassica juncea L. (V2)	15-Jan-22	24-Oct-22	1-Mar-22	19-Dec-22
Brassica rapa L.(V3)	15-Jan-22	24-Oct-22	1-Mar-22	19-Dec-22
Brassica oleracea L.(V4)	15-Jan-22	24-Oct-22	19-Mar-22	10-Jan-23
Harvesting day (day)			45-63	56-78

All the seedlings were transferred into NFT when it reached 3-4 true leaves about 21 days from the date of sowing. Each variety were place in NFT with 20 plants and five plants of each variety were observed. EC were maintained at 1.2-14 mS/cm during the first week in the NFT while increased to 1.8-2.2 mS/cm until harvest, and pH was 5.8 during the first week in and elevated to 6.2 during the growing cycle. The average CO_2 was 550-600 ppm, the temperature and humidity were monitored in the greenhouse (Figure 2).

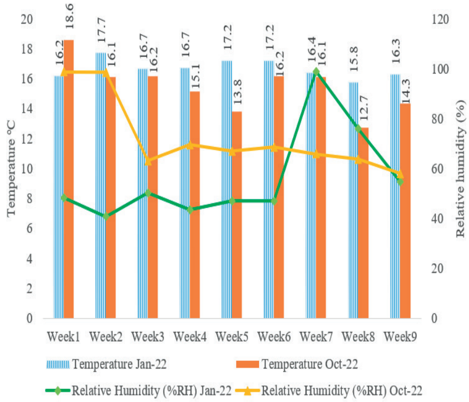

Figure 2. Temperature and relative humidity in the greenhouse in two different growing periods

All the data were recorded at the harvesting stage for five individual plants for each variety including the number of leaves per plant, plant height, leaf width, leaf length, fresh mass using ruler and electronic balance, Brix using reflectometer, Chlorophyll content index using chlorophyll meter CCM-200 plus, OPTI-SCIENCE, nitrate using portable nitrate Greentest ECO, and dry mass using 1 gram of fresh leaves by cutting leaves into fine pieces, dried at constant temperature 105°C for 24 hours. Statistical analysis was used STATISTICA, StatSoft software (version 10) to perform ANOVA analysis at $p \leq 0.05$, 0.01 or 0.001 levels, and Tukey HSD was used to compare the significant difference of each dependent variable at $p \leq 0.05$.

RESULTS AND DISCUSSIONS

The average temperature in the first growing cycle started from 16.2°C in week 1 and increased to 17.7°C in week 2, from week 3 and week 4, the temperature remained stable at 16.7°C (Figure 2). However, at week 5 and week 6, the temperature rose to 17.2°C and started to reduce to 16.4; 15.8 and 16.3°C in week 7, week 8, and week 9. For relative humidity, from week 1 to week 6, it ranged from 43-50%, and started to increase in week 7 (99%), then dropped from 76 to 55% at week 8 and week 9.

In the second growing cycle, at the beginning of week 1, the temperature was 18.6°C which was the highest temperature, and dropped to 16.1 and 16.2 in week 2 and week 3. It continued further drop to 15.1 to 13.8°C in week 4 and week 5, then it was back to 16.2 and 16.1°C in week 6 and week 7 but dropped again in week 8 and week 9 (12.7 and 14.3°C). For the relative humidity in the second growing cycle, at the beginning of the experiment, the relative humidity was high, around 99% in week 1 and week 2, then from week 3 to week 8, it ranged from 63-69% and reduced to 58% in week 9.

For brassica species, no significant interaction was found for the leaf width and the number of leaves as it was affected by variety. Plant height, leaf length, chlorophyll content index, fresh mass, dry matter, brix, and nitrate had strong interaction between variety and growing season, while brix was not affected by growing season but within variety itself (Table 2).

Table 2. Interaction of varieties and growing periods over the main effect of four brassica species

	Variety (V)	Growing period (G)	V x G
Plant height	***	**	***
Number of leaves	**	ns	ns
Leaf width	***	ns	ns
Leaf length	***	***	***
Chlorophyll content index	***	***	***
Fresh mass	***	***	***
Dry matter	***	***	***
Brix	***	ns	***
Nitrate	***	***	***

ns-Not significantly different at $p \geq 0.05$. *, **, ***-Significantly different at $p \leq 0.05$, 0.01, or 0.001, respectively.

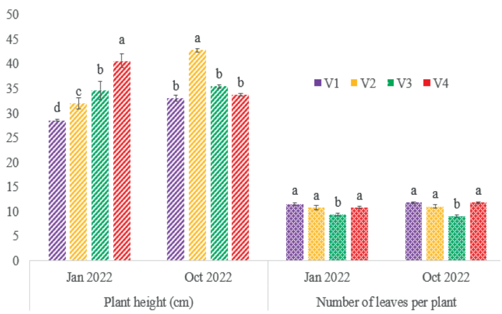

Figure 3. Plant height, number of leaves analysis of four brassica species grown in two different growing cycles in NFT system. Means and standard error followed by the same letters are not significantly different at $p < 0.05$, $n = 5$

Plant height. There was a strong interaction between the growing periods and the variety over plant height at $p \leq 0.001$ (Table 2). The growing periods influence differently over plant height at $p \leq 0.01$. In the first growing period (Jan 2022), V4 had the highest plant height followed by V3, V2, and V1 (40.6 cm; 34.5 cm; 31.9 cm and 28.5 cm). In the second growing period (Oct 2022), V2 had the highest plant height followed by three other varieties (42.74 cm and 33.0 cm to 35.38 cm) (Figure 3). Overall, growing cycle 2 had 2.31 cm higher than growing cycle 1. Almost no correlation found between the plant height and the fresh mass ($R^2 = 0.0044$) (Figure 9. A).

Number of leaves per plant: There was no interaction between growing periods and the variety at p≥0.05 (Table 2). The growing periods had no influence on the number of leaves at p≥0.05. In the first growing cycle, V1 was found higher in the number of leaves (12 leaves), followed by V2, V4, and V3 (11, 11, and 9 leaves) (Figure 3). In the second growing cycle, V1, V2, and V4 had the higher number of leaves (12, 12, and 11 leaves), followed by V3 (9 leaves). There was a slightly low correlation was found between the number of leaves and fresh mass ($R^2 = 0.1032$) (Figure 9. B).

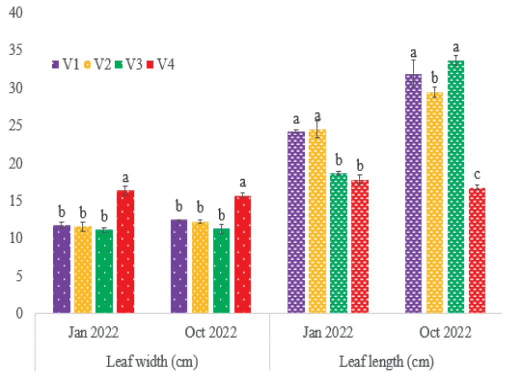

Figure 4. Leaf width, leaf length of four brassica species grown in different two growing cycles in NFT system. Means and standard error followed by the same letters are not significantly different at p < 0.05, n = 5

Leaf width. There was no interaction found between the growing period and the variety over the leaf width at p≥ 0.05 (Table 1). Leaf width was unaffected by the growing period at p≥ 0.05. In the first growing cycle, V4 had a bigger leaf width (16.37 cm) compared to V1, V2, and V3 (11.75 cm; 11.55 cm and 11.11cm), (Figure 4). In the second growing cycle, V4 remained bigger in leaf width followed by V1, V2, and V3 (15.70, 12.44, 12.26, and 11.25 cm). There was a correlation between the leaf width with the fresh mass ($R^2 = 0.5999$) (Figure 10. A).

Leaf length. Interactions between the growing periods and variety over leaf length were found at p≤0.001, and leaf length was influenced by growing periods at p≤0.001. In the first growing cycle, V1 and V2 had similar leaf lengths (24.52 and 24.18 cm) followed by V3 and V4 (18.62 and 17.83 cm) (Figure 4). In the second growing cycle, V3 had a longer leaf length (33.70 cm) than V1, V2, and V4 (31.92; 29.46 and 16.75 cm). In general, Leaf length was affected by the growing cycle 6.67 cm difference between the first and second growing cycles. A negative correlation was presented between the leaf length and the fresh mass ($R^2 = 0.6497$) (Figure 10. B).

Chlorophyll content index (CCI). There was a strong interaction between the growing periods and the variety over the CCI at p≤0.001. A significant difference at p≤0.001 was found within the growing periods as well (Table 1). V4 had a higher CCI in both growing cycles (25.59 and 24.49), followed by V3, V2, and V1 (Figure 5). On average 1.66 CCI was found difference between both growing cycles. There was a strong correlation between the CCI with fresh mass ($R^2 = 0.87$) (Figure 11). CCI differed depending on temperatures, consistent with Sharma et al. (2016). Usually, sowing during January gets warmer temperatures compared to October, and from February temperature gradually increasing as the spring began.

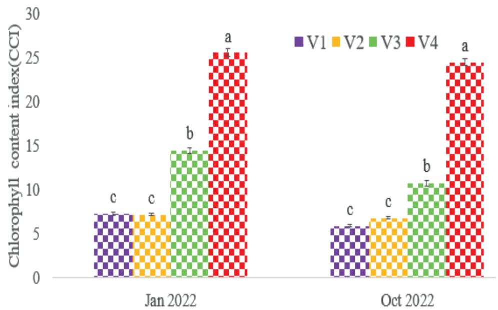

Figure 5. Chlorophyll content index of four brassica species grown in two different growing cycles in NFT system. Means and standard error followed by the same letters are not significantly different at p < 0.05, n = 5

Fresh mass: There was also a strong interaction found between growing periods and variety over fresh mass at p≤0.001, and a significant difference at p≤0.001 was observed for growing periods (Table 1). In the first growing cycle, V4 had more fresh mass (120 g/plant), followed by V3, V1 and V2 (77, 58 and 52.6 g/plant). Moreover, in the second growing cycle, V4 still remained more fresh mass (141 g/plant) compared to V1, V3 and V2 (43.17; 42.73 and 37.68 g/plant). The growing periods affected the fresh mass by 10.67 g on average. This result was consistent with Zhou et al. (2022), the yield varies depending on the temperature and the light regimes.

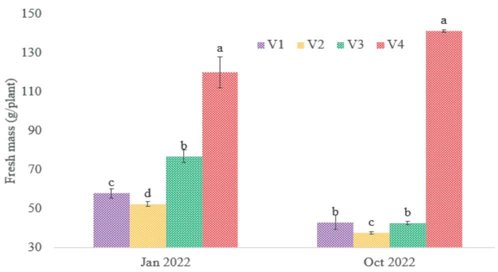

Figure 6. Fresh mass of four brassica species grown in two different growing cycles in NFT system. Means and standard error followed by the same letters are not significantly different at $p < 0.05$, n = 5

Brix. A strong interaction was presented between the growing periods and variety over brix at $p \leq 0.001$. However, within the growing periods, there was not a significantly different at $p \geq 0.05$. In the first growing cycle, V4 had a higher brix content (5.94), followed by V1, V3, and V2 (5.42, 5.02 and 4.86) (Figure 7).

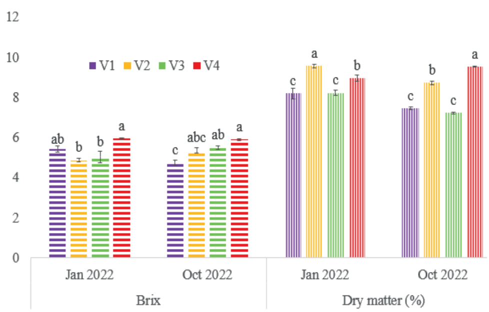

Figure 7. Brix and dry matter of four brassica species grown in two different growing cycles in NFT system. Means and standard error followed by the same letters are not significantly different at $p < 0.05$, n = 3

The brix in V4 remained higher (5.90) in the second growing cycle compared with V3, V2, and V1 (5.48, 5.34 and 4.74).

Dry matter. A strong interaction was observed between the growing periods and variety over the dry matter at $p \leq 0.001$, and a significant difference at $p \leq 0.001$ for growing periods. In the first growing cycle, V2 had the higher percentage of dry matter (9.56%), followed by V4, V3, and V1 (8.94, 8.21 and 8.18%), figure 7. V2 and V4 remained higher in the percentage of dry matter (9.53 and 8.72%) in the second growing cycle, compared with V1 and V2 (7.44 and 7.22%). On average, the difference in the dry matter of both growing cycles was 0.50 %. There was a low correlation between the dry matter associated with fresh mass ($R^2 = 0.2929$) (Figure 12).

Nitrate. There was a strong interaction between the growing periods and variety over the nitrate content in fresh produce at $p \leq 0.001$, and a significant difference was also observed for the growing cycle at $p \leq 0.001$. In the first growing cycle, V4 had the highest nitrate content (1834 mg/kg of fresh produce), followed by V1, V3, and V2 (1539, 1432 and 1299 mg/kg). In the second growing cycle, V1 had the highest nitrate content (1166 mg/kg), followed by V4, V3, and V2 (1121, 1106 and 1032 mg/kg). On average, the difference of nitrate between the two growing cycle was 419 mg/kg (Figure 8).

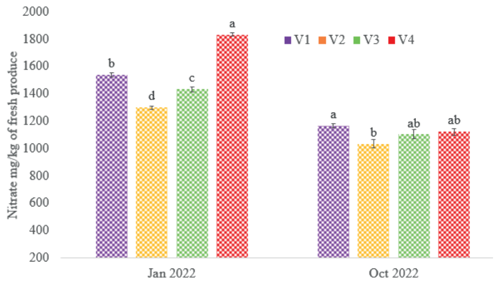

Figure 8: Nitrate of four brassica species grown in two different growing cycles in NFT system. Means and standard error followed by the same letters are not significantly different at $p < 0.05$, n = 5

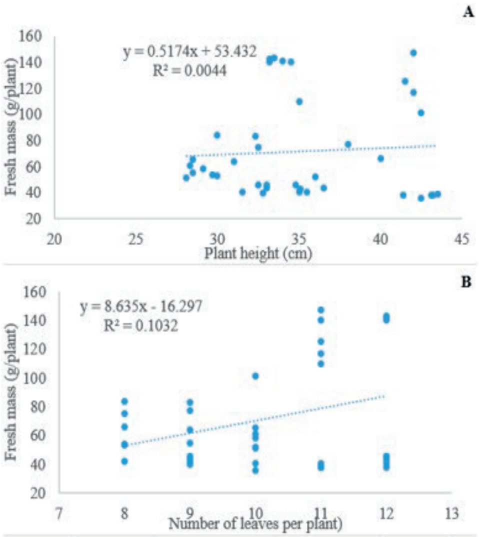

Figure 9. The corelation between plant height with fresh mass (A), and the Number of leaves with fresh mass (B)

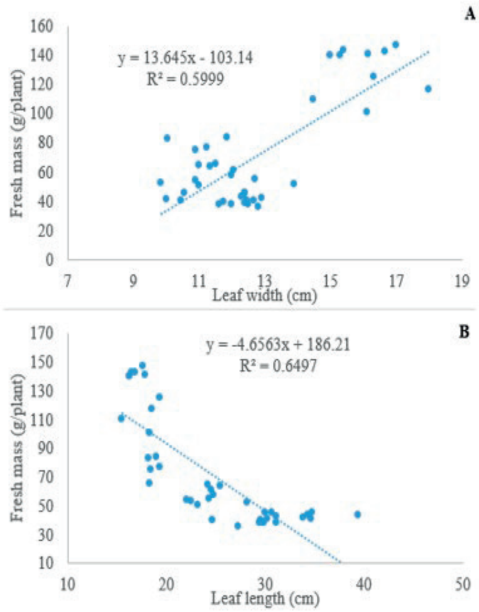

Figure 10. The corelation between Leaf width with fresh mass (A), and the leaf length with fresh mass (B)

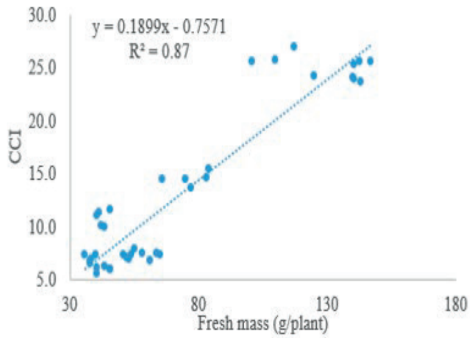

Figure 11. The corelation between CCI with fresh mass

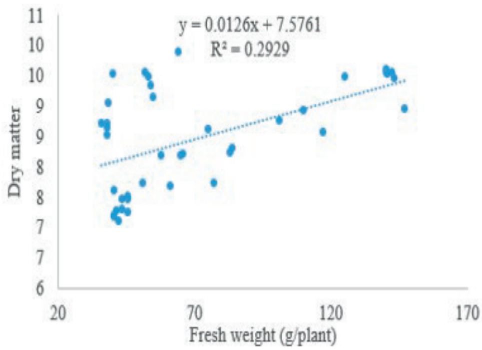

Figure 12. The corelation between dry matter with fresh mass

CONCLUSIONS

Based on the obtained results of our experiments in both growing periods on four brassica species, there was an effect of growing periods with plant height, leaf length, CCI, fresh mass, dry matter, and nitrate.

Overall, in the growing of brassica crops, the growth and yield vary, depending on the characteristic of the species and environmental condition. V4, produced 21.33 g/plant more productivity during Oct 2022 compared with Jan 2022, while the other three cultivars V1, V2, and V3 produced 14.83 to 34.27 g/plant more yield during Jan 2022 than Oct 2022. There were 11-15 days delayed in harvesting when sowed in Oct 2022.

A further observation should be carried out to investigate the specific period of time for the cultivation of the brassica crops, especially during summer and spring.

REFERENCES

Al-Shehbaz, I.A., Beilstein, M.A., Kellogg, E.A. (2006). Systematics and phylogeny of the *Brassicaceae* (*Cruciferae*): an overview. *Plant Syst. Evol*. 259, 89–120.
https://www.researchgate.net/publication/226671012_Systematics_and_phylogeny_of_the_Brassicaceae_Cruciferae_An_overview

Alam, B., Singh, R., Chaturvedi, M., Newaj, R., & Chaturvedi, O. P. (2018). Determination of critical low light limit and adaptive physiological and biochemical traits regulating growth and yield of mustard (*Brassica juncea* Coss.). *Physiology and Molecular Biology of Plants*, 24(5), 985–992. https://doi.org/10.1007/s12298-018-0537-0.

Asmaa A. J., Jerca O.I., Badea M.L. & Drăghici E.M., 2021. Comparative study regarding the behavior of some varieties of basil cultivated in nft system (nutrient film technology), *Current issue - scientific papers. Series b. Horticulture*, vol. Lxvi, no. 1, 2022 http://horticulturejournal.usamv.ro/index.php/scientific-papers/current-issue

Arias, T., Beilstein, M. A., Tang, M., McKain, M. R., & Pires, J. C. (2014). Diversification times among Brassica (Brassicaceae) crops suggest hybrid formation after 20 million years of divergence. *American Journal of Botany*, 101(1), 86–91. https://doi.org/10.3732/ajb.1300312

Chan S., Jerca O.I. & Drăghici E.M. (2022). The effect of fertilization on the growth parameters of seedlings and lettuce plants grown in the nft system (Nutrient Film Technique), *Scientific Papers. Series B, Horticulture*, Vol. LXVI, No. 1, 541-547, http://horticulturejournal.usamv.ro/pdf/2022/issue_1/Art80.pdf

Ding, X., Jiang, Y., Zhao, H., Guo, D., He, L., Liu, F., Zhou, Q., Nandwani, D., Hui, D., & Yu, J. (2018). Electrical conductivity of nutrient solution influenced photosynthesis, quality, and antioxidant enzyme activity of pakchoi (*Brassica campestris* L. ssp. *Chinensis*) in a hydroponic system. *PLOS ONE*, 13(8), e0202090. https://doi.org/10.1371/journal.pone.0202090

Dixon, G.R. (2017). The origins of edible brassicas. *Plantsman*, 16 (3). 180-185. https://centaur.reading.ac.uk/75821/

Dong, J., Gruda, N., Li, X., Tang, Y., Zhang, P., & Duan, Z. (2020). Sustainable vegetable production under changing climate: The impact of elevated CO2 on yield of vegetables and the interactions with environments-A review. *Journal of Cleaner Production*, 253, 119920. https://doi.org/10.1016/j.jclepro.2019.119920

Govoreanu E. A., Ion V. A., Săvulescu E., Badea M. L., Popa V. & Drăghici E. M., 2022, Anatomical and biochemical research on the species *Ocimum Basilicum* L. (*Lamiaceae*) cultivated in the Nutrient Film Technique system, *Scientific Papers. Series B, Horticulture*. Vol. LXVI, No. 1, 460-465, http://horticulturejournal.usamv.ro/pdf/2022/issue_1/vol2022_1.pdf

Hayat, S., Masood, A., Yusuf, M., Fariduddin, Q., & Ahmad, A. (2009). Growth of Indian mustard (Brassica juncea L.) in response to salicylic acid under high-temperature stress. *Brazilian Journal of Plant Physiology*, 21(3), 187–195. https://doi.org/10.1590/S1677-04202009000300003

Jones-Baumgardt, C., Llewellyn, D., Ying, Q., & Zheng, Y. (2019). Intensity of Sole-source Light-emitting Diodes Affects Growth, Yield, and Quality of *Brassicaceae* Microgreens. *HortScience*, 54(7), 1168–1174. https://doi.org/10.21273/HORTSCI13788-18

Kioke, S., K. V. Subbarao, R. M. David, and T. A. Turini. 2003. Vegetable Diseases Caused by Soilborne Pathogens. Publication 8099. Davis: University of California Division of Agriculture and Natural Resources. https://anrcatalog.ucanr.edu/pdf/8099.pdf

Lee, S. G., Choi, C. S., Lee, J. G., Jang, Y. A., Nam, C. W., Yeo, K.-H., Lee, H. J., & Um, Y. C. (2012). Effects of Different EC in Nutrient Solution on Growth and Quality of Red Mustard and Pak-Choi in Plant Factory. *Journal of Bio-Environment Control*, 21(4), 322–326. https://doi.org/10.12791/KSBEC.2012.21.4.322

Roosta, H. R. (2011). Interaction between water alkalinity and nutrient solution pH pn the vegetative growth, chlorophyll fluorescence and leaf magnesium, iron, manganese, and zinc concentrations in lettuce. *Journal of Plant Nutrition*, 34(5), 717–731. https://doi.org/10.1080/01904167.2011.540687

Salehi, B., Quispe, C., Butnariu, M., Sarac, I., Marmouzi, I., Kamle, M., Tripathi, V., Kumar, P., Bouyahya, A., Capanoglu, E., Ceylan, F. D., Singh, L., Bhatt, I. D., Sawicka, B., Krochmal-Marczak, B., Skiba, D., El Jemli, M., El Jemli, Y., Coy-Barrera, E., & Martorell, M. (2021). Phytotherapy and food applications from Brassica genus. *Phytotherapy Research*, 35(7), 3590–3609. https://doi.org/10.1002/ptr.7048

Šamec, D., & Salopek-Sondi, B. (2019). *Cruciferous* (*Brassicaceae*) Vegetables. In Nonvitamin and Nonmineral Nutritional Supplements (pp. 195–202). *Elsevier*. https://doi.org/10.1016/B978-0-12-812491-8.00027-8

Samarakoon, U.C., Weerasinghe, P.A., Weerakkody, W.A.P. (2006). Effect of Electrical Conductivity (EC) of the Nutrient Solution on Nutrient Uptake, Growth and Yield of Leaf lettuce (*Lactuca sativa* L.) in Station Culture. *Tropical Agriculture Research* Vol.18:13-21
https://www.researchgate.net/publication/260364158

Sharma, L., Priya, M., Bindumadhava, H., Nair, R. M., & Nayyar, H. (2016). Influence of high temperature stress on growth, phenology and yield performance of mungbean [Vigna radiata (L.) Wilczek] under managed growth conditions. *Scientia Horticulturae*, *213*, 379–391. https://doi.org/10.1016/j.scienta.2016.10.033

Siemonsma, J.S. (1993) Plant resources of South-East Asia. 8: Vegetables / J. S. Siemonsma... (ed.). Wageningen:Pudoc. https://edepot.wur.nl/326103

Zhou, J., Li, P., & Wang, J. (2022). Effects of Light Intensity and Temperature on the Photosynthesis Characteristics and Yield of Lettuce. *Horticulturae*, *8*(2), 178. https://doi.org/10.3390/horticulturae8020178