E-ISSN-2580-7129
Print- ISSN-1978-6107

TECHNO: JURNAL PENELITIAN
Journal homepage: http://ejournal.unkhair.ac.id/index.php/Techno
Volume 12 Number 02 October 2023 DOI: https://doi.org/10.33387/tjp.v12i2.5807

Study of Nutrient Concentration and Frequency of Drip Irrigation on Mustard Greens (*Brassica rapa* L.) Yields Using a Microcontroller

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Received : 09-02-2023
Accepted : 28-10-2023
Available online : 30-10-2023

ABSTRACT

Plant nutrition and water provision are very important for plant growth and development. Nutrition can be done with AB mix nutrition with a certain concentration while the frequency of water can be controlled with a microcontroller. The purpose of this study was to examine the effect of various concentrations of AB mix nutrients and the frequency of irrigation water using a microcontroller on the yield of mustard greens. This research can be useful as a source of information related to the application of microcontroller sensors in the provision of appropriate AB mix water and nutrition for farmers and practitioners. The research design consisted of two treatments, namely the concentration of AB mix and the frequency of water administration with 3 repetitions. the concentration of AB mix nutrients given consisted of three variations, namely 750 ppm (D1), 1250 ppm (D2), and 1750 ppm (D3) while the frequency variations consisted of variations of 4x water administration (F1), 8x water administration (F2), and 12x water administration (F3). The volume of water has increased by three stages from the beginning of planting to harvest. The results showed that the AB mix concentration treatment showed a significant difference to plant fresh weight but not to other parameters. The frequency of water treatment also showed the same results as the nutrient concentration treatment and there was no interaction between the frequency of water treatment and the AB mix concentration. Furthermore, the best variation is the variation of nutrition 1750 ppm and the frequency of 8x watering.

Keywords: AB mix, Drip Irrigation, Pakcoy, Microcontroller

ABSTRAK

Nutrisi tanaman dan pemberian air sangat penting bagi pertumbuhan dan perkembangan tanaman. Pemberian nutrisi dapat dilakukan dengan nutrisi AB mix dengan konsentrasi tertentu sedangkan pemberian air dapat dikendalikan frekuensinya dengan mikrokontroller. Tujuan penelitian ini untuk mengkaji pengaruh berbagai konsentrasi nutrisi AB mix dan frekuensi pemberian air irigasi menggunakan mikrokontroler terhadap hasil panen sawi pakcoy. Penelitian ini dapat bermanfaat sebagai sumber informasi terkait aplikasi sensor mikrokontroler dalam pemberian air dan nutrisi AB mix yang tepat bagi petani maupun praktisi. Rancangan penelitian terdiri dari dua perlakuan yaitu konsentrasi AB mix dan frekuensi pemberian air dengan ulangan sebanyak 3 kali. konsentrasi nutrisi AB mix yang diberikan terdiri dari tiga variasi yaitu 750 ppm (D1), 1250 ppm (D2), dan 1750 ppm (D3) sedangkan variasi frekuensi terdiri dari variasi 4x pemberian air (F1), 8x pemberian air (F2), dan 12x pemberian air (F3). Volume air mengalami peningkatan sebanyak tiga tahap mulai dari awal tanam sampai panen. Hasil penelitian menunjukkan Perlakuan konsentrasi AB mix menunjukkan perbedaan yang signifikan terhadap bobot segar tanaman tetapi tidak berbeda terhadap parameter lainnya. Pada perlakuan frekuensi pemberian air juga menunjukkan hasil yang sama dengan perlakuan konsentrasi nutrisi dan tidak

ada interaksi antara perlakuan frekuensi pemberian air dan konsentrasi AB mix. Selanjutnya, variasi terbaik adalah variasi nutrisi 1750 ppm dan frekuensi 8x penyiraman.

Kata kunci: AB mix, Irigasi tetes, Pakcoy, Mikrokontroler

INTRODUCTION

Bok choy is a vegetable that has a very good content for health (Haryanto & Rahayu, 2007) and is a one-time crop at the age of 25-30 days after seedling (Cahyono, 2003). The production level of bok choy is 1.5 million tons or about 6.59 tons/hectare (BPS, 2019). Although not included in the classification of exported annual crops, mustard have higher production growth than spinach and kale (BPS, 2019).

Genetic and environmental factors highly influence the growth, development and production of a plant (Brukhin & Morozova, 2011) and one of them is the availability of nutrients. The provision of basic fertilizers in cultivation aims to provide and suffice the nutrients needed by plants (Jayanti & Novianti, 2020). In general, bok choy plants require basic fertilizers during media preparation, namely Urea (300kg/ha), SP36 (200kg/ha), and KCl (100 kg/ha) (Sunarjono, 2013). In the process of cultivating horticultural crops, one of the commonly used inorganic fertilizers is AB mix. AB mix is a fertilizer concoction of chemicals and then applied in liquid form to the planting media (Arifin, 2020). The function of AB mix itself is to supply plant nutrients so that plants grow well and optimally because AB mix nutrition itself contains macro and micro elements needed by plants. In addition, the AB mix nutrient formula is specifically tailored to the needs and types of plants cultivated such as fruit plants or leaf plants (Umarie *et al.*, 2019).

Ecological fertilization, such as applying the right amount, time and type using information technology-based technology is expected to solve the problems caused by current fertilization in modern intensive farming systems. Fertilization combined with drip irrigation is one way of ecological fertilization. Ecological benefits, especially in aspects related to plant growth and yield responses have actually been researched since the 1990s (Ray *et al.*, 2009), but the use of information technology-based sensors only developed in the 2010s (Kaunang *et al.*, 2021).

Water is very important for plants and its provision must be in accordance with what is needed by plants by paying attention to the right amount, time and location of planting. Planting land that experiences a lack or excess of water will result in decreased productivity and even death in plants. Agricultural irrigation is very important in crop production around the world. Irrigation is the analysis and design of systems that optimally supply the right amount of water to the soil at the right time to meet the needs of the plant system (Panda, 2022).

In drip irrigation systems, inorganic fertilizers are still used in the process of crop cultivation. However, through the application of drip irrigation along with fertilization, it is sought to reduce the waste of water and fertilizer (Ray *et al.*, 2009). For example, a nutrient that must be properly dosed is nitrogen because it is one of the essential nutrients (Leghari *et al.*, 2016) but excess nitrogen can cause water pollution or water eutrophication (Pahalvi *et al.*, 2021).

In order to maximize the performance of drip irrigation and also the addition of nutrients, a microcontroller-based control system is used. Microcontroller is a device that functions as an electronic circuit controller consisting of CPU (Central Processing Unit), memory, I/O (input/output), which is intended for an automatic system control (Telaumbanua, 2021). The

use of a microcontroller can also help measure data more easily and in real time (Saydi *et al.*, 2021).

The combination of drip irrigation methods and the use of control systems is one aspect of modern farming that is beneficial for academics, practitioners, and farmers (Ortega-Reig *et al.*, 2017; Jovanovic *et al.*, 2020). This combination has been studied in lettuce cultivation (Novalia *et al.*, 2020), chilies (Fakhrah *et al.*, 2022), and palm oil nurseries (Kurniawan *et al.*, 2020). The application of drip irrigation to pakcoy mustard greens (*Brassica rapa* L.) has the potential to be researched because this plant has high nutritional contents (Alfian & Muhardi, 2022), consumed by the public widely (Widi, 2022), and easy to cultivate (Efendi & Murdono, 2021).

Based on the background and formulation of the problem, the purpose of the research conducted is to examine variations in the frequency of irrigation water delivery and the concentration of AB mix nutrients using microcontrollers on pakcoy mustard plants (*Brassica rapa* L.). This research can be useful as a source of information related to the application of microcontroller sensors and as a guide for plant cultivation in providing the right AB mix water and nutrients for farmers and practitioners.

METHODOLOGY

Experimental Design

This research was conducted in the Greenhouse of the Faculty of Agriculture, University of Jember in July-August 2022. The tools used included microcontroller and its installation devices, TDS meter, EC meter, pH meter, digital scales, moisture meter, chlorophyll meter SPAD-502, stationery, ruler, and other supporting tools. The materials used were bok choy seeds (*Brassica rapa* L.), compost, NPK, polybags, AB mix solution, and other supporting materials.

The research used a completely randomized design (CRD) method with two treatment factors, each of which had three variations with three replications so there are 27 experimental units. The first factor is the frequency of water application which is active at 07.00 until 17.00 with a variation of 4x water application (F1), 8x water application (F2), and 12x water application (F3). The volume of water increased in three stages from the beginning of planting to harvesting by 500ml/plant/day on days 1 to 14 HST, 2000ml/plant/day on days 15 to 21 HST, and 1000ml/plant/day on days 22 to 28 HST. The second factor is the concentration of AB mix nutrients at 750 ppm (D1), 1250 ppm (D2), and 1750 ppm (D3).

Research Procedure

The research is conducted in accordance with the experimental design which will be carried out on several aspects as follows:

1. Planting media preparation begins with preparing soil weighing 5 kg/polybag.
2. Preparation of AB mix nutrient solution starting with the preparation of stock solution and then re-diluted with water to the desired concentration.
3. Seed preparation in the form of Nauli F1 variety seeds. Seeds with good physical and physiological conditions are seeded for 14-20 HSS until they are ready to be planted. Seeds that will be planted have the characteristics of four leaves with a height of about 5-10 cm.
4. Installation of the microcontroller is carried out after the planting media is completed and placed in the greenhouse. Before being used for watering, it is necessary to measure the volume of water coming out of the drip irrigation output.
5. Planting the seeds in the planting media about 2-5 cm depth and covering them with soil.

6. Plant maintenance by periodic observation, especially on the plants condition. If there is an unfavorable plant condition, actions such as replanting, pest control, and greenhouse cleaning are taken to avoid etiolation.
7. Maintenance of the microcontroller installation is also carried out by periodic observation every day to ensure the device is working properly. If there is an error such as water not flowing, hose position is not right, or the device does not turn on according to the settings, repairs are immediately made.
8. Harvesting pakchoy at the age of 28 HST with plant height indicators ranging from 25-28 cm.
9. Measurement of research parameters so that they can be analyzed according to research needs.
10. Data analysis using Analysis of Variance (ANOVA) at the 95% significance level and Duncan Multiple range Test (DMRT) further test at the 95% significance level.

Research Parameters

Measurement of research parameters was carried out to see the effect of the treatments that given. The research parameters consisted of plant height (cm) and number of leaves (strands) which were measured periodically every week, meanwhile plant fresh weight (grams), plant root length (cm), and leaf chlorophyll content (µmol/m2) will be measured at harvest.

RESULTS AND DISCUSSION

Microcontroller Usage

The application of microcontrollers in this research proves that it can improve the accuracy of watering and distribution of nutrients according to the given level. Automatic irrigation control systems using sensors and microcontrollers can make it easier for farmers to water and monitor the entry of water into the soil (Samsugi *et al.*, 2020). However, the use of microcontrollers has several obstacles such as the disruption of the tool's work against high room temperature in the greenhouse so that the command reading process experiences errors. Other obstacles involving the use of microcontrollers include considerable investment costs, knowledge about technology that is not understood by everyone, and constraints in the field that affect microcontroller performance (Ardiansah *et al.*, 2020).

(a)

(b)

(c) (d)

Figure 1. Microcontroller application to plant

Analytical Results

The growth of pakchoy plants was measured according to the observation variables and tested statistically to see the effect of the variations used. Table 1 shows the results of Analysis of variance at 95% significance level.

Table 1. Analysis of variance result of bok choy growth yields

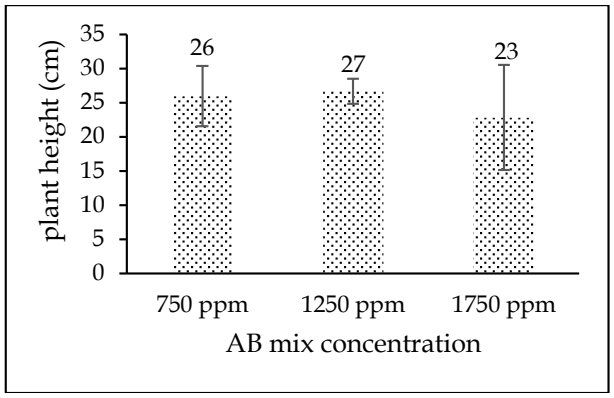
No.	Research Parameter	F value		
		Frequency (F)	AB mix Concentration (D)	Interaction (FxD)
1.	Number of leafs (strands)	1,19 ns	0,17 ns	0,67 ns
2.	Plant height (cm)	0,85 ns	1,88 ns	0,18 ns
3.	Fresh weight (g)	3,64 *	3,44 *	0,19 ns
4.	Root length (cm)	3,16 ns	0,02 ns	0,73 ns
5.	Leaf chlorophyll content (µmol/$m^{2)}$	1,26 ns	0,35 ns	1,10 ns

Note = * mean significantly different and **ns** means not significantly different

Table 1 shows that the frequency of water application gave a significantly different effect on the fresh weight of bok choy plant, but did not give a difference to the number of leaves, plant height, root length, and chlorophyll content. Furthermore, the concentration of AB mix gives a significantly different effect on the fresh weight of pakcoy mustard plants and does not affect other variables. The results of the analysis also showed that the frequency of water application and AB mix concentration did not show any interaction in each research parameter.

Plant Height

The frequency of water and the concentration of AB mix nutrients given did not have a significant effect on the height of bok choy plants. Some measurement indicators that can be done to observe the treatment given that plant height is one of them (Hakim *et al.*, 2006). Plant height measurement is one of the growth indicators to determine the effect of a treatment (Rajametov *et al.*, 2021).



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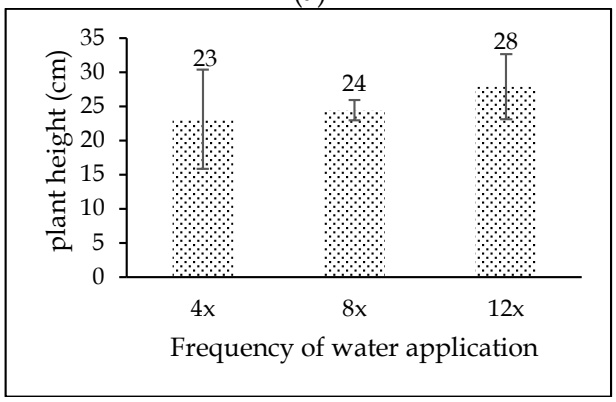
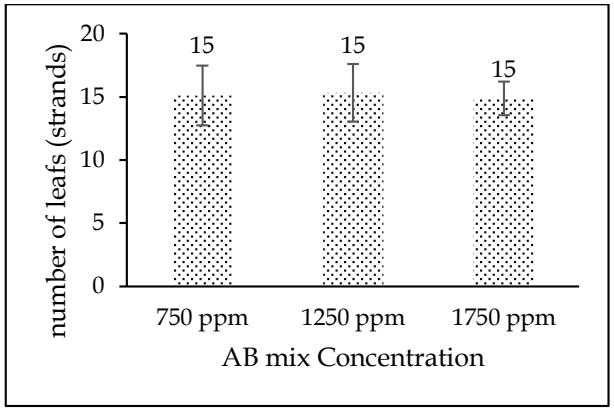


(b)

Figure 2. Graphic of plant height parameter based on: (a) variation of AB mix concentration and (b) variation of water application frequency

Number of Leaves

The results of the analysis on the number of leaf parameters were not significantly different due to variations in AB mix concentrations and this is in line with research on flower cabbage (Maitimu & Suryanto, 2018). Referring to the research that has been done, the response of plants in receiving the treatment applied will be the same and does not affect the number of plant leaves between variations. Leaf growth itself is influenced by the availability of N and P elements during the vegetative period in that phase so most of the carbohydrates received by plants are also used for the growth of leaves, stems, and roots (Rizal, 2017).



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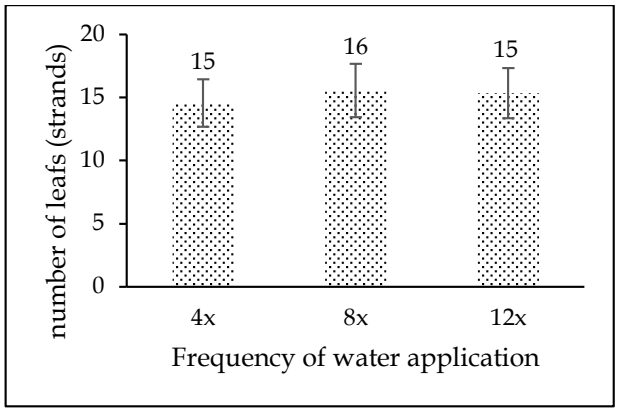
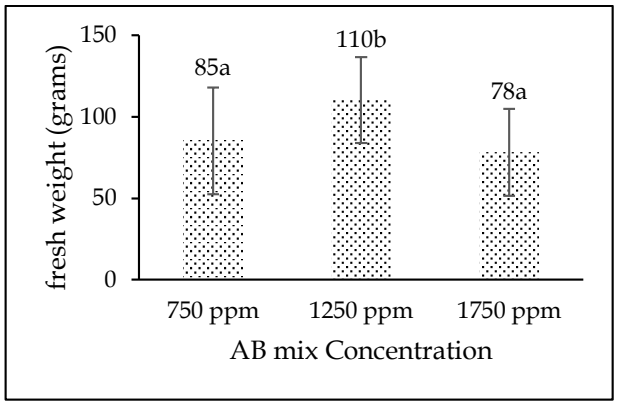


(b)

Figure 3. Graphic of number of leaves parameter based on:
(a) variation of AB mix concentration and (b) variation of water application frequency

Plant Fresh Weight

Plant fresh weight can be used as an indicator of metabolic activity in the plant body that can be observed after harvest in fresh plant conditions. Fresh weight is influenced by several factors including water content in the soil, nutrients availability, and plant metabolic products. The results of fresh weight in the study showed that the frequency of water application and the concentration of AB mix nutrients had a significant effect on plant fresh weight.



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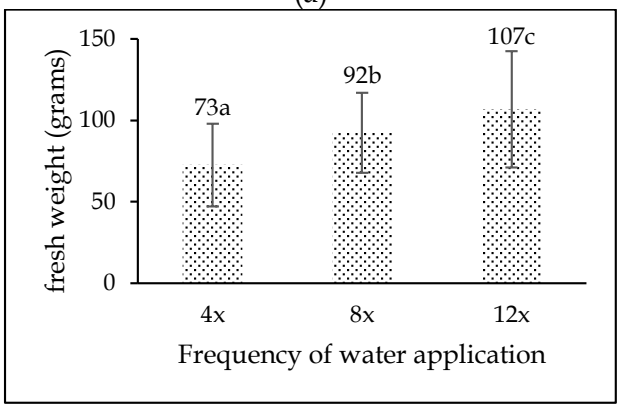


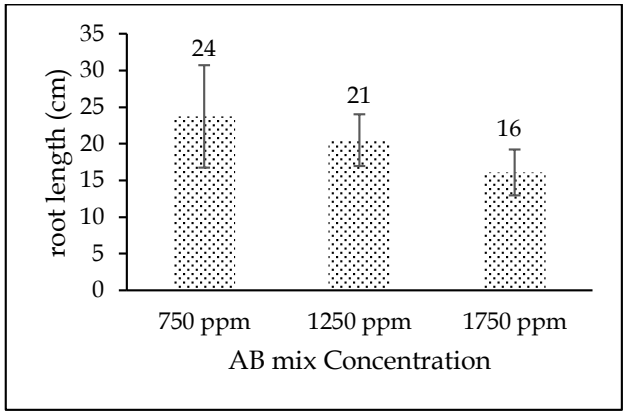
(b)

Figure 4. Graphic of plant fresh weight parameter based on: (a) variation of AB mix concentration and (b) variation of water application frequency

The best variation based on the results of the DMRT test is involved in the letter notation given in Figure 4. in each research factor is 8x frequency per day and AB mix concentration of 1750 ppm. The significantly different effect on each variable in the study can be caused by the water and nutrients given in each of the best variations can fulfill the needs of plants. The provision of higher AB mix nutrients can provide better results (Sundari, 2016) and the availability of nutrients and water that are in accordance with the needs causes plants to absorb nutrients optimally (Ifanto *et al.*, 2019).

Plant Root Length

Plant growth is supported by good root conditions caused by the absorption of nutrients by the roots (Hidayah *et al.*, 2020). The response shown by the roots to the availability of nutrients that can be reached is by root elongation. The less nutrients that can be reached, the roots will grow short and not elongate (Fau, 2020). The availability of water has an impact on good root development and growth, which in turn also has an impact on the distribution of nutrient uptake in the soil to other plant parts to ensure maximum growth and productivity (Bruun *et al.*, 2014).



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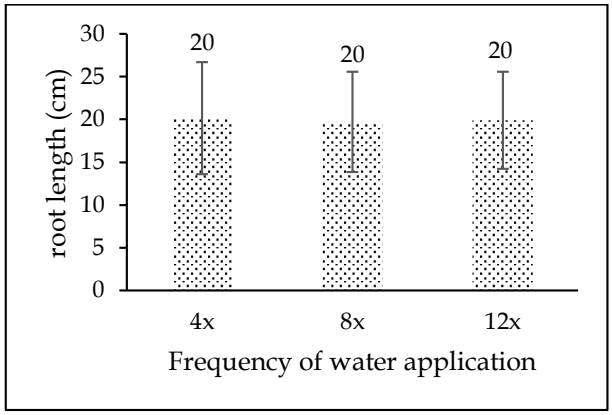


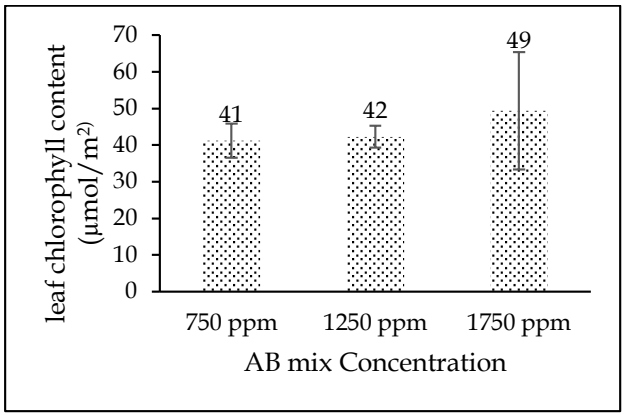
(b)

Figure 5. Graphic of plant root length parameter based on:
(a) variation of AB mix concentration and (b) variation of water application frequency

Chlorophyll Content

A good metabolic process is key in plant growth to achieve optimal productivity levels. The metabolic process in plants is carried out by photosynthesis so that the chlorophyll content of plants has an important role. The availability of chlorophyll to maximize the photosynthesis process in plants depends on the number of leaves that grow on the plant (Gustiar *et al.*, 2022).

Plants that grow optimally show that photosynthesis runs well, which is closely related to the chlorophyll content contained in plant leaves (Junia, 2017).



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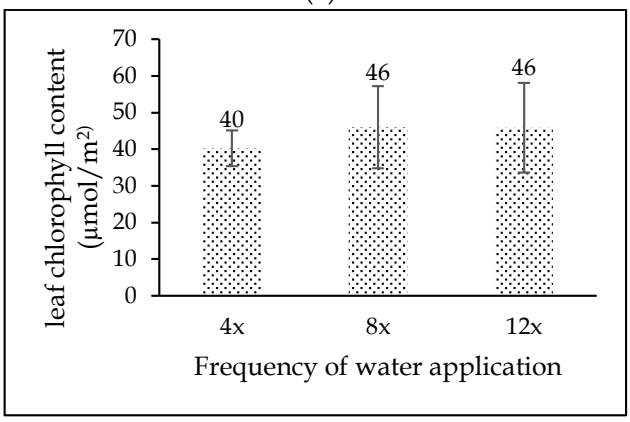

(b)

Figure 6. Graphic of leaf chlorophyll parameter based on: (a) variation of AB mix concentration and (b) variation of water application frequency

CONCLUSION

The treatment of AB mix concentration and frequency of water application affected the fresh weight of bok choy plants significantly but not on other observation variables such as the number of leaves, plant height, and leaf chlorophyll content. The results showed that the best treatment that can be applied is the AB mix concentration of 1750 ppm and the frequency of water application of 8x per day because it gives the highest plant weight results and is significantly different from other variations.

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