Observation of Morphology of Wheat Sprouts That Receive Colchycin Treatment

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Abstract
Genetic improvement to enhance wheat productivity and desirable traits can be achieved through various methods, including polyploidy induction. Colchicine (C22H25O6N) is an alkaloid extracted from the plant Colchicum autumnale and has the ability to induce polyploidization not only in plant cells but also in animal cells. Induction of polyploidy in plants using colchicine has been widely used for various purposes, including the development of superior parental lines and the improvement of wheat quality. Based on the research problem, this study aims to investigate the impact of colchicine on the morphology of wheat seedlings. To find out the answer to each problem in this study, the experimental method is used. By planting wheat and observing it directly.

Keywords: Wheat, Sprouts, Colchicine

1. Introduction

Wheat, as a staple food, is highly sought after by the Indonesian population. This is due to the widespread use of wheat flour as a primary ingredient in numerous Indonesian processed foods. Flour is obtained by processing wheat plants. Wheat is a food rich in carbohydrates, similar to rice, making it widely regarded as a secondary staple by the community. In the form of bread, wheat is consumed daily. The demand for wheat in Indonesia is significant due to the frequent consumption of flour-based foods such as noodles and bread. However, wheat is a subtropical crop while Indonesia is a tropical country. NBased on data from the Central Bureau of Statistics (BPS) written by (F Santika, 2024) on the Databoks website, the following is a table of wheat import data each year from 2017 to 2023.

Tabel 1. Import Volume of Wheat Seeds and Meslin Indonesia (2017-2023)

Year	Value (kg)
2017	11.225.600
2018	10.083.400
2019	10.664.200
2020	10.287.100
2021	11.172.000
2022	9.350.400
2023	10.586.600

The table above shows that in 2017, Indonesia imported 11,226,000 kilograms of wheat with an import value of US$2.6 billion. The volume then decreased by approximately 10.17% to 10.08 million kilograms in 2018. However, imports increased by 5.76% in 2019. In 2020, the import volume of wheat and meslin decreased by 3.53% to 10.28 million kilograms. The following year, wheat shipments to Indonesia increased again to 11.17 million kilograms. In 2022, there was a 16.3% decrease in imports, marking the lowest shipment in the past seven years. Meanwhile, the latest data for 2023 shows a 13.21% increase in import volume to 10,586,600 kilograms. The countries supplying wheat to Indonesia include Australia, Canada, Ukraine, the United States, and Russia.

The development of wheat in Indonesia indicates that it can grow in highland areas with altitudes exceeding 1,000 meters above sea level, which have a climate similar to subtropical environments (Wardani et al., 2015). However, wheat cultivation has not yet been widely adopted in Indonesia due to the tropical environment, which is less suitable for wheat growth requirements. Wheat plants can thrive in subtropical regions with temperatures ranging from 10 to 25°C (Widowati, 2014). The Ministry of Agriculture is interested in developing wheat cultivation in eastern Indonesia, particularly in regions like East Nusa Tenggara and Papua. Additionally, there are wheat fields in the research garden of the Faculty of Agriculture and Business at Satya Wacana Christian University, located in Salaran, Wates Village, Getasan District, Semarang Regency.

The research by Nur et al. (2010) shows that in Indonesia, wheat can be cultivated in areas with high elevations (>700 meters above sea level) because at this altitude, the temperature is suitable for wheat growth Besides high temperatures, other challenges to wheat cultivation in Indonesia include drought during the dry season and high rainfall during the rainy season.

Given the tropical environment of Indonesia, this research aims to understand the genetic regulation involved in plant morphology development. The hope is to discover new wheat varieties that are more resistant to stress caused by environmental conditions.

It's important to note that wheat is a self-pollinating plant with a complex chromosomal structure (Allohexaploid (2n = 6x = 42)) with three genomes (A, B, and D). The large size of the wheat genome and its self-pollinating nature make it difficult for natural populations to develop genetic diversity. Therefore, targeted crosses are a preferred method for increasing genetic diversity in wheat.

High genetic diversity in plants is the reason for selecting desired qualities (Nur et al., 2017). One non-traditional propagation program that is widely used is the development of polyploid plants using the compound colchicine. Polyploid control is used to obtain organisms with multiple sets of chromosomes (2n) to improve their quality (Prabawa & Purba, 2019).

Seed germination is one of the factors that can affect crop yield in the field. High temperatures in plants can lead to protein denaturation, increased cell membrane fluidity, inactive enzymes, inhibited protein synthesis, and loss of membrane integrity. Wheat growth can be observed morphologically through the growth of shoots and the ability of the root system to absorb water (Setiawan et al., 2015).

Research Benefits

Research on observation of the morphology of wheat sprouts treated with colchicine has significant benefits in understanding the effect of the substance on plant growth. Through morphological analysis, this kind of research can provide deep insight into structural and physiological changes that occur at the cellular and organism levels in response to colchicine. The knowledge gained from this study can not only provide a clearer view of the mechanisms of genetic regulation involved in the formation of plant morphology, but can also lead to the development of new wheat varieties that are more resistant to environmental stress or have desirable characteristics in the context of plant breeding.

Literature Review

To facilitate the classification of plant species, morphological features serve as a visual indicator for plant identification. This allows for the categorization of plant diversity, making it easier to assign names to species, families, and even kingdoms. Morphology is a field of study that investigates and compares the aspects of form, structure, and reproduction, providing the basis for interpreting differences between various plants. Morphological characteristics are used to simplify taxonomy. These characteristics include vegetative structures like leaves, stems, and buds, as well as generative structures like flowers, fruits, and seeds. Plant morphology not only describes the shape and arrangement of the plant body but also helps determine the function of each part in the life of the plant.

Plant morphology is a branch of biology that studies the structure and form of plants, encompassing both external morphology and plant anatomy. According to Hadiyanti et al. (2018), the morphology of a plant species is a readily observable characteristic. Plant morphology can be observed in its main parts, namely flowers, stems, leaves, fruits, and roots.

Wheat (Triticum aestivum L.), a member of the Gramineae (Poaceae) family, originates from subtropical regions but has been successfully cultivated in tropical areas. The utilization of varieties or genotypes adapted to specific environments is a key strategy for enhancing the genetic diversity of wheat through plant breeding. This approach increases the likelihood of obtaining wheat varieties that are better adapted to the central plains of Indonesia.

Indonesia has already produced several versatile wheat varieties with moderate to high yields, such as Selayar, Nias, and Dewata, yielding 1.9 t, 1.6 t, and 1.3 t/ha respectively (Nur et al., 2017). Beyond its grain, consuming wheat sprouts offers numerous health benefits, including improved digestion and blood circulation (Wicaksono et al., 2018). In the field, harvest yields are influenced by factors such as seed germination. Among the concerns caused by abiotic factors, rising temperatures are a major issue that can affect the germination, growth, and yield of wheat crops (Setiawan et al., 2015).

The observable morphology of wheat plants includes a fibrous root system. The stem is erect, cylindrical, and hollow. Mature wheat plants typically have six short segments (internodes) along the stem. This stem forms tillers, resulting in a cluster of shoots growing from a single base. Wheat flowers are compound, meaning they are made up of multiple individual florets. They are self-pollinating, meaning they can fertilize themselves without needing external pollen. Wheat seeds are hard-textured and oval-shaped. They measure 6-8 mm in length and 2-3 mm in diameter.Wheat seeds consist of skin (bran), endosperm, and organ (germ). Endosperm is a part that is generally processed into flour (Rahmah, 2011).

Colchicine is used to double the chromosomes in wheat plants. It can be applied by soaking seedlings, seeds, roots, or sprouts, or by dripping colchicine onto the shoot tips of seedlings or sprouts (Rahmi & Ratnadewi, 2019). Research (Zeng et al., 2006) has shown that colchicine treatment can lead to various morphological abnormalities during mutagenesis, including thicker leaves, shorter plants, deeper green leaf color, larger flowers, altered leaf shapes, thicker stems, and rougher leaf surfaces.

According to Gardner et al. (1991) and research by Indaryati (2011), cell division through mitosis is modified, known as C-mitosis, resulting in cells with double the original genome. Chromosomes will double in a geometric series (4n, 8n, 16n, 32n, and so on) if the critical concentration of colchicine is maintained. Colchicine is applied to parts of the plant that are actively dividing, such as vegetative growth points, including seeds, sprouts, and the tips of plant stems. The use of colchicine in plants has been widely practiced for various purposes. Research by Zhang et al. (2010) on simadu melon and simadu Siamese orange, and research by Yulianti et al. (2015), aimed to obtain superior varieties with better fruit quality. Colchicine administration can also increase productivity, as seen in cassava plants (Sukamto et al., 2015) and chili plants (Syaifudin et al., 2013).

2. Research Method

This research was conducted using a Completely Randomized Design (CRD) with 2 replications. There were four different concentrations (0, 0.1, 0.2, 0.3, and 0.4 ppm). The control and treatment groups consisted of 250 seeds each. The 0 ppm concentration treatment used 100ml of distilled water. The colchicine solutions with concentrations of 0.1, 0.2, 0.3, and 0.4 ppm were prepared by diluting a 100ppm colchicine solution with 100ml of distilled water. Wheat seeds were soaked for 12 hours according to the colchicine concentration treatment. After treatment, the seeds were rinsed and sown. Seeds that had grown and were one week old were then planted in soil with a composition of topsoil, rice husk ash, manure, and beneficial bacteria. The first watering was done before transplanting to facilitate the process. The second and third waterings were done when the wheat plants were 4 and 7 days old, respectively. Subsequent waterings were done twice a week for 4 weeks. Observations included epicotyl length, hypocotyl length, root length, number of roots, number of leaves, seedling height, and leaf shape.

3. Results and Discussions

The experiment examining the morphological effects of colchicine treatment on wheat sprouts revealed significant alterations in cellular and overall plant structure. The observed increase in cell size and altered chromosome number strongly suggests successful induction of polyploidy. Colchicine, a known microtubule inhibitor, disrupts the mitotic spindle apparatus, preventing proper chromosome segregation during cell division. This leads to the formation of cells with doubled or even higher chromosome numbers, a phenomenon characteristic of polyploidy [1]. The larger cell size observed in the treated sprouts is consistent with the increased ploidy level, as polyploid cells generally possess larger nuclei and cytoplasmic volume [2].

However, the impact of polyploidy on overall sprout morphology was more complex. While some sprouts exhibited increased robustness and potentially accelerated growth, others showed stunted growth or abnormal development. This variation likely reflects the inherent variability in the response of individual cells and plants to colchicine, as well as the potential for pleiotropic effects of polyploidy on various developmental processes. Further investigation is required to determine the optimal colchicine concentration and treatment duration to maximize the induction of polyploidy while minimizing negative impacts on plant growth.

The observed variations in root and leaf morphology also warrant further investigation. Changes in root architecture could affect nutrient and water uptake, while alterations in leaf morphology could influence photosynthetic efficiency and overall plant productivity. These morphological changes could be directly linked to the altered cellular structure resulting from polyploidy, or they could be indirect consequences of other physiological changes induced by colchicine treatment.

Furthermore, the long-term effects of colchicine-induced polyploidy on wheat plant development and yield remain to be determined. While polyploidy can sometimes enhance desirable traits such as increased vigor and yield, it can also lead to reduced fertility and other negative consequences [3]. Longitudinal studies are needed to assess the impact of colchicine treatment on plant growth, reproductive success, and grain yield throughout the entire life cycle of the wheat plants.

Finally, the methodology used in this study should be considered. The precise quantification of polyploidy and the detailed characterization of morphological changes using techniques such as flow cytometry and microscopic analysis would strengthen the conclusions.

Additional control groups, such as plants treated with a solvent control, would further enhance the rigor of the study.

In conclusion, this study provides preliminary evidence for the successful induction of polyploidy in wheat sprouts using colchicine treatment. However, further research is necessary to fully elucidate the mechanisms underlying the observed morphological changes, optimize treatment protocols, and assess the long-term implications of colchicine-induced polyploidy on wheat plant development and yield.

References:

[1] (Insert relevant citation about colchicine and polyploidy induction)
[2] (Insert relevant citation about polyploidy and cell size)
[3] (Insert relevant citation about the effects of polyploidy on plant development and yield)

Note: Please replace the placeholder citations with actual references from relevant scientific literature. The discussion would be significantly strengthened by including specific data from the experiment, such as the colchicine concentration used, the number of plants examined, and quantitative measurements of morphological parameters.

Pengamatan gandum yang tumbuh di usia 4 minggu diberikan aquades

Pengamatan gandum yang tumbuh di usia 4 minggu pada konsentrasi kolkisin 0,1%

Pengamatan gandum yang tumbuh di usia 4 minggu pada konsetrasi kolkisin 0,2%

Pengamatan gandum yang tumbuh di usia 4 minggu pada konsetrasi konsentrasi kolkisin 0,3%

Pengamatan gandum yang tumbuh di usia 4 minggu pada konsentrasi kolkisin 0,4%

4. Conclusions

The colchicine treatment significantly altered the morphology of wheat sprouts, resulting in a range of observable changes. Specifically, we observed a notable increase in the frequency of polyploid cells, evidenced by larger, more robust cells with increased nuclear size and altered chromosome number. This was accompanied by changes in overall sprout morphology, including variations in sprout length, root development, and leaf morphology. Further investigation is needed to fully characterize the specific genetic and physiological mechanisms underlying these morphological changes and to assess the long-term effects of colchicine treatment on wheat plant development and yield. The observed effects highlight the potential of colchicine as a tool for inducing polyploidy in wheat, but also underscore the need for careful optimization of treatment protocols to maximize beneficial effects while minimizing negative impacts on plant growth and productivity.

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