Growth Evaluation of Provit-A1 Maize (*Zea mays* L.) Variety as a Potential Source of Carotenoid Compounds

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ABSTRACT

Maize (*Zea mays* L.) is one of the major food crops cultivated in many countries, including Indonesia. It is grown as an alternative carbohydrate source to rice and is also widely used in the livestock feed industry. As a food crop, maize contains various nutrients, among which carotenoids play an important role as antioxidants for human health. The objective of this research was to identify the growth performance of the Provit-A1 maize variety, which is known for its high carotenoid content.

The research was conducted from July to October 2025 on agricultural land in Jatikuwung Village, Gondangrejo District, Karanganyar Regency, Central Java Province. A descriptive–exploratory method was employed using a single-plant model without any specific treatments. The observed data were grouped based on kernel color using the Royal Horticultural Society (RHS) Colour Chart. The variables observed included number of leaves, stem diameter, ear diameter, and number of rows per ear.

The results showed that the Provit-A1 maize population exhibited wide variability in the morphological traits of stem diameter and ear diameter. In contrast, the number of leaves and the number of rows per ear showed narrow variability based on their phenotypic variability.

1. Introduction

Maize (*Zea mays* L.) is one of the major food crops cultivated in many countries, including Indonesia. Maize is grown as an alternative carbohydrate source to rice and is also widely used in the livestock feed industry. According to [1], maize production in 2022 reached 22.3 million tons. Data from [2], based on an ubinan survey conducted in 2023 involving 33,118 household maize producers, showed that 70.75% of producers cultivated hybrid varieties, with an average national productivity of 51.80 quintals per hectare [3].

Maize in Indonesia has a wide range of varieties, developed by both government institutions and private sectors at local and national scales, such as Lamuru, Provit A1, Provit A2, Pioneer P21, Pertiwi 2, and many others. The development of these varieties is driven by Indonesia's diverse land types, each with its own advantages and limitations. The improvement of various maize varieties aims to obtain plants with high quality and productivity. This process involves varietal testing. Varietal testing is a crucial step to obtain information or data regarding the feasibility of releasing new varieties for commercial cultivation. Such testing is conducted to determine the adaptability of a variety when grown under specific land conditions with distinct characteristics [4]. Referring to data from [5], the largest share of domestic maize utilization is for feed purposes, reaching 9.78 million tons or approximately 72.48% of the total national maize demand in 2021. The second largest maize-using sector is the non-feed and food industry, accounting for 3.66 million tons or about

25.18% of the total national demand in 2021. Maize consumed directly by households in Indonesia amounts to only around 231,231 tons, equivalent to 1.71% of the total maize demand in 2021. In addition to its use for feed, food, and industrial purposes, maize is also used as seed, with an estimated utilization of approximately 84 thousand tons.

Maize is not only a source of macronutrients for food but also a source of micronutrients and bioactive compounds that are beneficial to human health. The chemical compounds present in maize include tocopherols, tocotrienols, and carotenoids. Carotenoids are plant pigments responsible for the yellow orange color of maize kernels and can be classified into two groups, namely carotenes and xanthophylls [6]. The carotenoids contained in maize have considerable potential to be utilized in the production of their derivative compounds, such as β-ionone. Plant breeding research is conducted to obtain productive varieties with high carotenoid content through the selection of varieties with strong potential for elevated carotenoid accumulation.

2. Method

2.1. Time and Location

This research was conducted from November 2025 to February 2026. The planting site was located on agricultural land in Jatikuwung Village, Gondangrejo District, Karanganyar Regency, Central Java Province. Geographically, the site is situated at coordinates 7°30′00.0″ South Latitude and 110°49′40.0″ East Longitude, at an altitude of 168 meters above sea level.

2.2. Materials and Tools

The materials used in this research consisted of soil, manure, and maize (*Zea mays* L.) seeds of the Provit-A1 variety obtained from the Cereal Crop Breeding and Testing Center, Maros, South Sulawesi. The equipment used in this research included agricultural tools such as hoes, watering cans, dibblers, and sickles. Observation equipment comprised an analytical balance, vernier calipers, a measuring tape, stationery, and documentation tools.

2.3. Research Design and data Analysis

This research was conducted using a descriptive–exploratory method. The planting method followed a single-plant design, in which plants were grown under the same environmental conditions without replication. No specific treatments were applied in this research. The plant population was labeled according to rows and numbering, consisting of eight rows designated A, B, C, D, E, F, G, and H, with individual numbers assigned sequentially from one end of each row.

Growth and yield data of the plants were presented in the form of tables and boxplot graphs to identify data distribution and outliers in the variability of Provit-A1 maize under field conditions. In a boxplot, the components represent the distribution of the central 50% of the observed data, the whisker lines indicate data dispersion below or above the central 50% that is still considered normal, while outliers represent extreme values [7].

3. Results and Discussion

3.1. Research Condition

The research site was located in Jatikuwung Village, Gondangrejo District, Karanganyar Regency, Central Java Province. Geographically, the site is situated at coordinates 7°30′00.0″ South Latitude and 110°49′40.0″ East Longitude, at an altitude of 168 m above sea level. Data related to general research conditions, including initial soil analysis and microclimatic conditions, were collected during the research period. According to [8] data from July to October 2025, the average temperature in Jatikuwung was 28°C with an average relative humidity of 74.46%. Rainfall increased from July to October, with an average of 6.37 mm, and the average wind speed reached 2.10 m s^{-1}. The soil type at the research site was Vertisol. Vertisols are characterized by dark gray to black coloration and a clayey texture. They are fertile black soils formed from various parent materials, dominated by smectite clay minerals, and are typically identified by the development of cracks during the dry season [9]. The available phosphorus (P) content was classified as low, while the potassium (K) content was categorized as moderate.

3.2. Variability of Provit-A1 Maize

Growth and yield parameters were observed in a population of 228 plants. The data are presented in Table 1 as follows.

Table 1. Phenotypic variability of Provit-A1 maize

Observation Parameter	Range	Variance	2 x Sd	Criteria
Number of Leaves (leaves)	13-18	0.885	1.882	Narrow
Stem diameter (mm)	12.9-29.6	12.017	6.933	Wide
Ear diameter (mm)	29.3-53.7	15.731	7.933	Wide
Number of rows per ear (rows)	8-18	2.513	3.171	Narrow

Note: Criteria based on Hanifah et al. (2018); variance ≥ 2×SD = wide; variance < 2×SD = narrow.

Plant variability is required in the selection process to identify and choose desirable individual traits. The criteria for assessing variability were calculated using the formula proposed by [10], in which variability is classified as wide when the variance value is greater than or equal to twice the standard deviation, whereas it is classified as narrow when the variance value is less than twice the standard deviation. Based on observations using the Royal Horticultural Society (RHS) Colour Chart, the color codes identified in the harvested maize kernels were 24B (Strong Orange Yellow B), N25A (Strong Orange A), N25B (Strong Orange B), N25C Strong Orange C), and N25D (Strong Orange Yellow D).

3.3. Number of Leaves

The observation results for the number of leaves showed a range from 13 leaves in the shortest plants to 18 leaves in the tallest plants. The measurement data for the number of leaves are presented in the form of a boxplot graph, with grouping as shown in Figure 1.

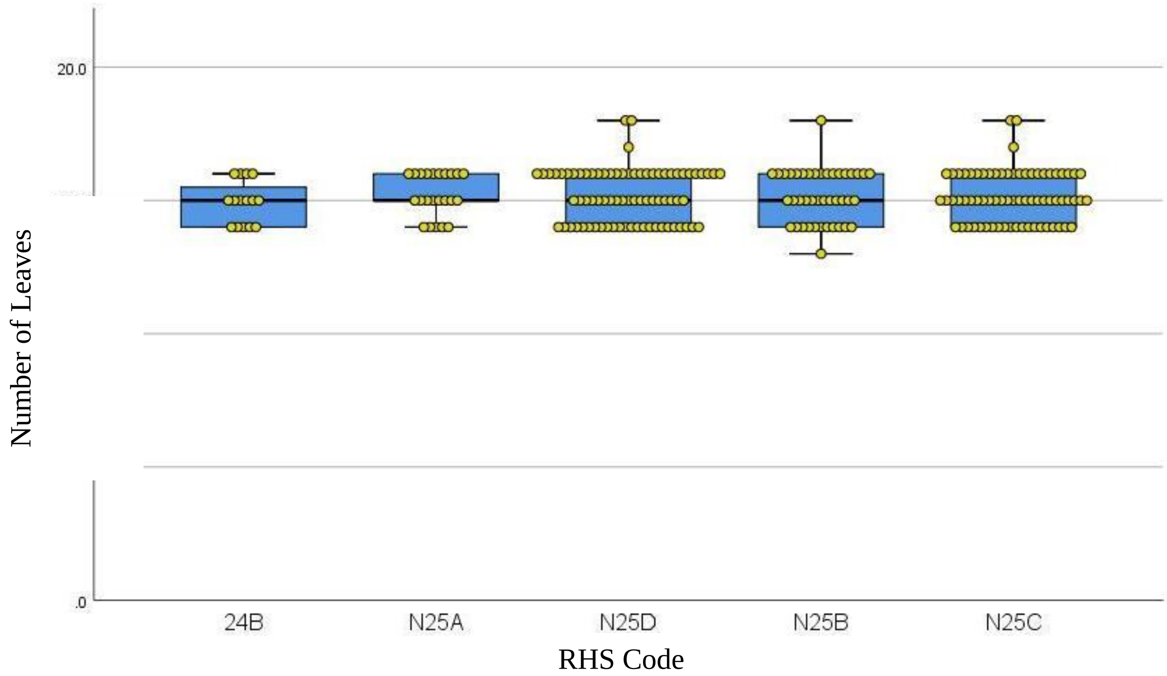

Figure 1. Boxplot Number of Leaves of Provit-A1 Maize Plants

The extent of data dispersion from the boxplot analysis indicates that the number of leaves exhibited narrow variability. This is reflected by the central line representing the median, which was consistent at 15 leaves. The widest data distribution occurred in the N25B color group, as indicated by the presence of individual plants with the lowest number of leaves (13 leaves) and those with the highest number of leaves, reaching up to 18 leaves.

Maize leaves develop at the stem nodes, beginning with the emergence of leaf whorls. According to [11], the number of leaves is one of the variables associated with the rate of photosynthesis, as greater light interception can be utilized for the photosynthetic process. Similar to stem growth, nitrogen availability is a factor influencing leaf development in maize. [12] explained that nitrogen content can increase the photosynthetic rate, which is associated with an increase in leaf number. The increase in leaf number ceases when the plant enters the generative phase.

3.4. Stem Diameter

The observation results for stem diameter showed a range from 12.9 to 29.6 mm, from the smallest to the largest plants. The stem diameter measurement data are presented in the form of a boxplot graph in Figure 2.

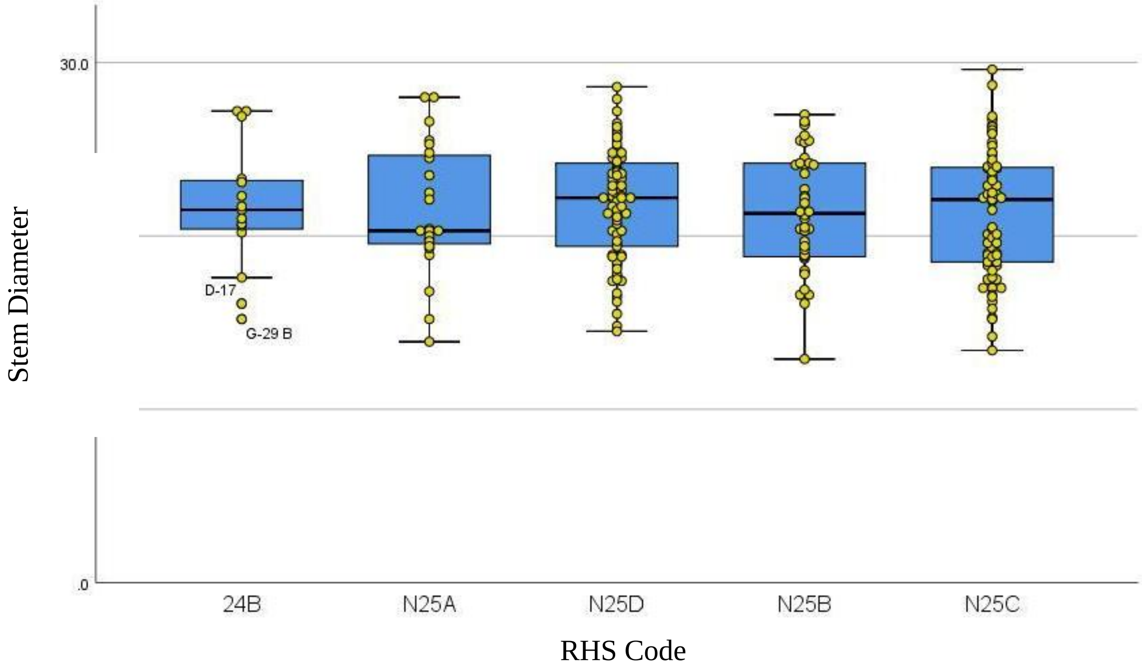

Figure 2. Boxplot Stem Diameter of Provit-A1 Maize Plants

The widest data distribution was observed in individuals belonging to the N25C color group, followed by N25B, N25A, N25D, and 24B. The individual with the smallest stem diameter (12.9 mm) was found in the N25B color group, while the individual with the largest stem diameter (29.6 mm) belonged to the N25C color group. The mean values of each group were close to the population mean, and a similar pattern was observed for the median values.

In general, stem diameter showed an increase because of leaf development, which enhances photosynthesis and leads to greater allocation of photosynthates to the stem. This is consistent with [13], who reported that an increase in photosynthetic activity results in greater photosynthate production, which is subsequently allocated to the stem. According to the varietal description provided in Appendix 1, Provit-A1 maize is classified as a lodging-resistant variety. However, this potential must still be supported by appropriate nutrient management to optimize the genetic potential of the plants. [14] explained that the application of organic materials can provide effects equal to or even better on plant growth and production. A sturdy maize stem plays an important role in supporting overall crop productivity.

3.5. Ear Diameter

The measurement data of maize ear diameter observed in this research are presented in the form of a boxplot graph in Figure 3.

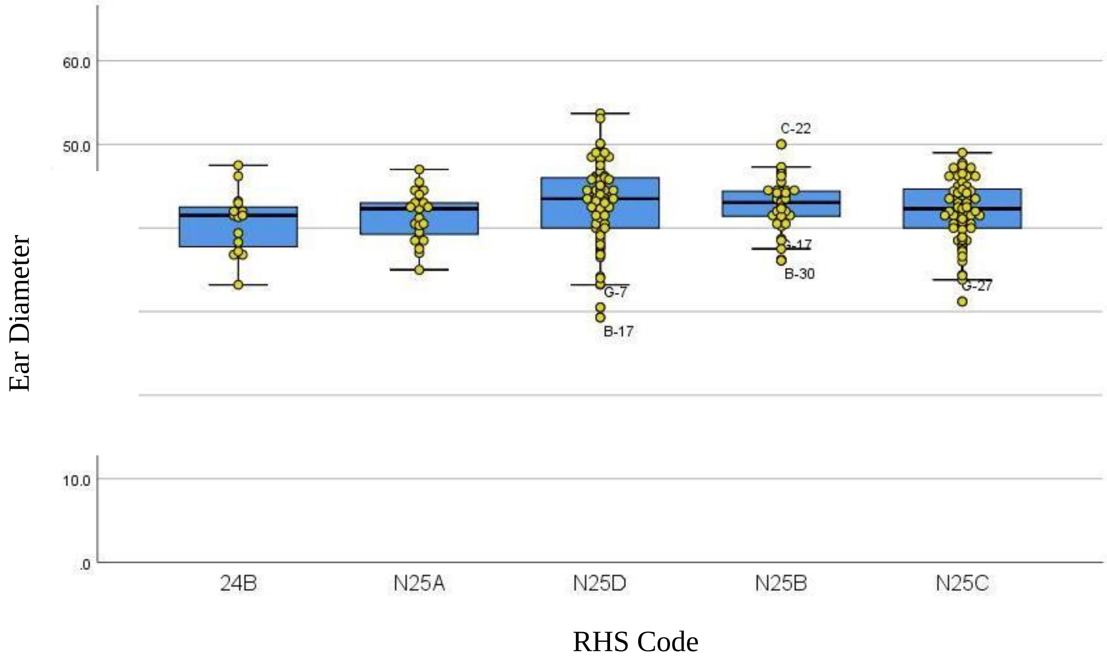

Figure 3. Boxplot Ear Diameter of Provit-A1 Maize Plants

The ear diameter values shown in the boxplot indicate that the widest data distribution occurred in the N25D color group, which was similar to that of the overall population, ranging from 29.3 to 53.7 mm. This was followed by the N25C group with a range of 31.2–49 mm, the 24B group with a range of 33.2–47 mm, the N25B group with a range of 36.1–37 mm, and the N25A group with a range of 35–47 mm. [15] stated that the formation of larger maize ears is influenced by a high availability of photosynthates resulting from photosynthesis. In general, a larger ear diameter tends to increase ear weight per plant.

3.6. Number of Rows Per Ear

The observation results of the number of rows per ear in Provit-A1 maize are presented in the boxplot graph in Figure 4.

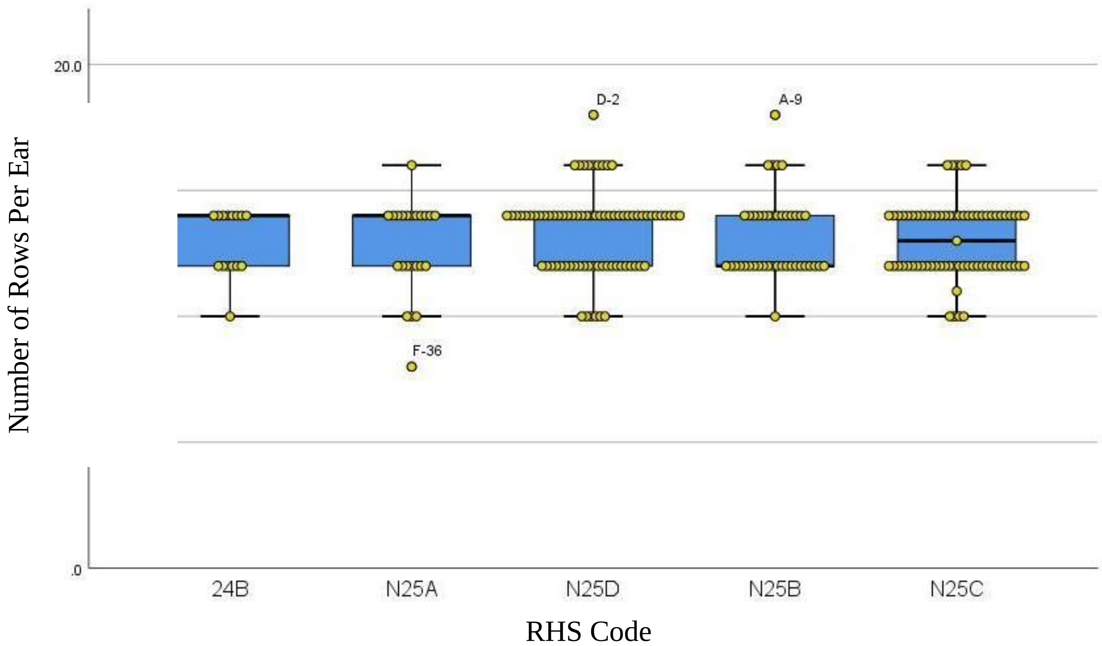

Figure 4. Boxplot Ear Diameter of Provit-A1 Maize Plants

The data distribution of the observed number of rows per ear in the population ranged from a minimum of 8 rows to a maximum of 18 rows. The data ranges for the N25A, N25B, and N25D color groups were similar, followed by the N25C group, while the narrowest range of row numbers was observed in the 24B color group. According to [16], the number of rows per maize ear is influenced by the interaction between the plant's genetic characteristics and environmental suitability. The number of rows per ear is closely related to the yield component of individual plants.

4. Conclusion

The Provit-A1 maize variety exhibits wide variability in growth components, namely stem diameter, as well as in yield components, particularly ear diameter. In contrast, the number of leaves and the number of rows per ear show narrow variability.

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Data and Software Availability Statements

The datasets generated and/or analyzed during the current study are not publicly available but are available from the corresponding author upon reasonable request. All statistical analyses were conducted using IBM SPSS Statistics.

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