

Effect of Variety on the Early Seedling Growth of Bird's Eye Chili (*Capsicum frutescens* L.)

Fitria Dwi Darmayati¹, Gede Wijana², Ida Ayu Putri Darmawati³

¹Student in Agroecotechnology Master Program, Faculty of Agriculture, Udayana University, Denpasar, Bali, Indonesia

²Lecturer of Agroecotechnology Master Program, Faculty of Agriculture, Udayana University, Denpasar, Bali, Indonesia

³Lecturer of Agroecotechnology Master Program, Faculty of Agriculture, Udayana University, Denpasar, Bali, Indonesia

ABSTRACT: The selection of superior varieties plays an important role in improving the early growth performance of chili seedlings, as varietal genetic differences influence biomass accumulation and seedling development. This study aimed to evaluate the effect of different cayenne pepper (*Capsicum frutescens* L.) varieties on early seedling growth. The experiment was conducted using a Completely Randomized Design (CRD) with a single factor consisting of seven cayenne pepper varieties: Mhanu, Kaliber, Ori 212, Sret, Oertavi, Sigantung, and Sigemoy. Each treatment was analyzed using analysis of variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) at the 5% significance level. The observed variables included normal seedling dry weight and seedling growth rate during the germination phase, number of leaves at 7 and 14 days after sowing (DAS), normal seedling dry weight during the nursery phase, and seedling growth rate during the nursery phase. The results showed that variety had a highly significant effect on normal seedling dry weight during the germination phase, seedling growth rate during the germination phase, number of leaves at 14 DAS, normal seedling dry weight during the nursery phase, and seedling growth rate during the nursery phase, but had no significant effect on the number of leaves at 7 DAS. Sigemoy produced the highest normal seedling dry weight during the germination phase (5.79 mg) and the highest seedling growth rate (0.099 mg KN⁻¹), while Mhanu exhibited the best performance during the nursery phase, with the highest normal seedling dry weight (11.26 mg), seedling growth rate (0.139), and number of leaves at 14 DAS (1.71 leaves). In contrast, Kaliber produced the lowest normal seedling dry weight during the nursery phase (6.92 mg), whereas Sigemoy had the lowest number of leaves at 14 DAS (0.53 leaves). Overall, the results indicate that varietal differences significantly affect the early growth of cayenne pepper seedlings. Mhanu demonstrated superior nursery growth performance, whereas Sigemoy excelled in biomass accumulation during the germination stage. These findings suggest that varietal selection is essential for producing vigorous and high-quality cayenne pepper seedlings.

KEYWORDS: *Capsicum frutescens* L., early seedling growth, variety, normal seedling dry weight, seedling growth rate.

INTRODUCTION

Chili pepper (*Capsicum frutescens* L.) is one of the most important horticultural commodities in Indonesia due to its high economic value and its significant contribution to meeting consumer demand. Increasing demand for chili pepper, driven by population growth and the expansion of the food industry, has made this commodity highly prospective for agricultural development (Budiman et al., 2024). Besides serving as an essential ingredient in Indonesian cuisine, chili pepper represents a major source of income for many farmers; therefore, successful cultivation is crucial for improving farm profitability and supporting the national horticultural sector.

National chili pepper production has fluctuated in recent years. According to Statistics Indonesia (BPS, 2025), the national production of chili pepper reached 1,544,441 tons in 2022, declined to 1,506,762 tons in 2023, and increased again to 1,564,975 tons in 2024. These fluctuations are influenced by several factors, including climatic conditions, pest and disease incidence, cultivation practices, and seed quality. Among these factors, seed quality plays a fundamental role because it determines seedling establishment, plant uniformity, and subsequent crop productivity. Vigorous seedlings with rapid early growth generally exhibit better adaptation to field conditions and higher production potential.

Seed quality is primarily reflected by its physiological performance during germination and early seedling development. Seeds with superior physiological quality produce seedlings that germinate rapidly, establish uniformly, and possess greater

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capacity to withstand environmental stresses during the initial growth stage (Bhosale et al., 2019). Conversely, seeds with poor physiological quality often exhibit delayed germination, weak seedling growth, and reduced field establishment (Bai et al., 2021). Consequently, evaluating early seedling growth is an important approach for assessing seed physiological quality and predicting crop performance.

Genetic differences among chili pepper varieties contribute substantially to variations in seedling vigor and early plant development. Each variety possesses distinct genetic characteristics that influence the mobilization and utilization of seed reserves during germination, resulting in differences in biomass accumulation, growth rate, and seedling establishment. These physiological differences can be evaluated through several parameters, including normal seedling dry weight, seedling growth rate, and leaf development during the early vegetative stage. Such parameters provide valuable information regarding the efficiency of reserve mobilization and the growth potential of different varieties (Cheshmi et al., 2021).

Early seedling growth is considered one of the most reliable indicators of future plant performance. Normal seedling dry weight reflects the efficiency of converting stored food reserves into structural biomass, while seedling growth rate indicates the capacity of seedlings to accumulate biomass during the initial stages of development. Likewise, leaf number observed at 7 and 14 days after sowing represents the progression of vegetative growth and the ability of seedlings to establish photosynthetically active tissues. Seedlings exhibiting superior performance in these parameters are generally expected to adapt more successfully under field conditions and support higher crop productivity (Demir et al., 2020).

Although numerous chili pepper varieties are currently cultivated in Indonesia, comparative information regarding their early seedling growth remains relatively limited. Previous studies have mainly focused on yield performance, agronomic characteristics, or fruit quality, whereas research evaluating varietal differences during the early growth stage has received less attention. This represents an important research gap because information on seedling performance is essential for selecting varieties with superior vigor and better establishment potential.

Therefore, this study was conducted to evaluate the effect of different chili pepper varieties on early seedling growth. The evaluation was based on normal seedling dry weight, seedling growth rate, and leaf number at 7 and 14 days after sowing. The findings of this study are expected to provide scientific information regarding varietal differences in early seedling performance and to support the selection of chili pepper varieties with superior early growth characteristics for improving crop productivity.

RESEARCH METHOD

Research Design

This study employed a Completely Randomized Design (CRD) with a single factor to evaluate the effect of chili pepper varieties on early seedling growth. The treatment factor consisted of seven chili pepper (*Capsicum frutescens* L.) varieties:

- a. Mhanu
- b. Ori 212
- c. Kaliber
- d. Sigantung
- e. O'ertavi
- f. Si Gemoy
- g. Sret

Each treatment was replicated four times, resulting in a total of 28 experimental units for each experimental stage. Each experimental unit consisted of 100 seeds.

The study consisted of two experiments. The first experiment was conducted under laboratory conditions using the Top of Paper (TP) germination method to evaluate seedling growth during germination. The second experiment was conducted under greenhouse conditions using sterilized sand as the growing medium to evaluate seedling growth until 14 days after sowing (DAS).

Research Location and Time

The experiment was conducted from October to December 2025 at the Laboratory and Greenhouse of the Seed Inspection and Certification Center for Food Crops, Horticulture, and Plantation Crops (BPSBTPHBUN), Bali Province, Indonesia.

Tools and Materials

The materials used in this study included seeds of seven chili pepper varieties (Mhanu, Ori 212, Kaliber, Sigantung, O'ertavi, Si Gemoy, and Sret), filter paper, tissue paper, distilled water, sterilized sand, and sample labels.

The equipment used included Petri dishes, germination boxes, an oven, a desiccator, an analytical balance, a ruler, stationery, a digital camera, Microsoft Excel, and IBM SPSS Statistics software.

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Research Implementation

The research was carried out through the following stages:

1. Seed Preparation

Seeds were obtained from physiologically mature chili pepper fruits. The seeds were manually extracted, washed thoroughly, and air-dried until reaching an appropriate moisture content for storage and testing.

2. Germination Test

The germination experiment was conducted using the Top of Paper (TP) method. Seeds were placed on moistened filter paper and tissue paper inside Petri dishes and incubated at $25 \pm 2^\circ\text{C}$. Observations were conducted until 14 days after sowing.

The variables observed during the germination stage were:

- a. Normal seedling dry weight (mg)
- b. Seedling growth rate (mg seedling^{-1})

At the end of the observation period, normal seedlings were dried in an oven at 80°C for 24 hours, cooled in a desiccator, and weighed using an analytical balance.

3. Seedling Growth Test

Seeds were sown approximately 1 cm deep in nursery boxes containing sterilized sand. The growing medium was maintained under adequate moisture conditions through regular watering.

Observations were conducted until 14 days after sowing (DAS).

The variables observed during the seedling stage were:

- a. Number of leaves at 7 DAS
- b. Number of leaves at 14 DAS
- c. Normal seedling dry weight (mg)
- d. Seedling growth rate (mg seedling^{-1})

At the end of the experiment, normal seedlings were dried in an oven at 80°C for 24 hours, cooled in a desiccator, and weighed using an analytical balance.

Observation Variables

The variables observed in this study included:

1. Normal Seedling Dry Weight (mg)

Normal seedling dry weight was determined at 14 days after sowing. Normal seedlings were separated, dried in an oven at 80°C for 24 hours, cooled in a desiccator for approximately 45 minutes, and weighed using an analytical balance. Results were expressed in milligrams (mg) per normal seedling.

The following equation was used:

$$\text{NSDW} = \text{DW} / n$$

where:

NSDW = normal seedling dry weight (mg)

DW = total dry weight of normal seedlings (mg)

n = number of normal seedlings

2. Seedling Growth Rate (mg seedling^{-1})

Seedling growth rate was calculated as the average dry weight of normal seedlings using the following equation:

$$\text{SGR} = \text{DW} / n$$

where:

SGR = seedling growth rate (mg seedling^{-1})

DW = total dry weight of normal seedlings (mg)

n = number of normal seedlings

3. Number of Leaves (leaves)

The number of true leaves was recorded at 7 and 14 days after sowing. Cotyledons were excluded from the observations. Leaf counts were performed visually on each normal seedling, and the average number of leaves was calculated for each treatment.

Data Analysis

The collected data were analyzed using Analysis of Variance (ANOVA) based on a Completely Randomized Design (CRD) to determine the effect of chili pepper varieties on early seedling growth.

Whenever significant differences among treatments were detected at the 5% probability level, mean separation was performed using Duncan's Multiple Range Test (DMRT) at the 5% significance level.

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All statistical analyses were performed using Microsoft Excel and IBM SPSS Statistics. The results were presented in tables and discussed according to the research objectives.

RESULTS

Significance of the Research Results

The results of the analysis of variance (ANOVA) revealed that varietal treatments exerted different effects on the early growth parameters of bird's eye chili (*Capsicum frutescens* L.) seedlings. As presented in Table 1, the varietal effect was highly significant on normal seedling dry weight during the germination stage (G), seedling growth rate during the germination stage (G), number of leaves at 14 days after planting (DAP), normal seedling dry weight during the nursery stage (N), and seedling growth rate during the nursery stage (N). In contrast, the number of leaves at 7 DAP was not significantly affected by varietal differences.

These findings indicate that the genetic characteristics of each variety play an important role in determining the early growth performance of seedlings, particularly with respect to biomass accumulation and seedling growth rate. The differences observed among varieties reflect variations in their ability to utilize seed food reserves to support early seedling development. Meanwhile, the absence of significant differences in leaf number at 7 DAP suggests that all varieties exhibited relatively similar rates of leaf development during the initial stage of vegetative growth. Significant differences became evident at 14 DAP, indicating that the influence of genetic factors on seedling growth became more pronounced as plant development progressed.

Table 1. Significance of the Effect of Variety on the Early Growth of Bird's Eye Chili (*Capsicum frutescens* L.) Seedlings

No	Observed Variable	Variety (V)
1	Normal Seedling Dry Weight (G)	**
2	Seedling Growth Rate (G)	**
3	Number of Leaves at 7 DAP	ns
4	Number of Leaves at 14 DAP	**
5	Normal Seedling Dry Weight (N)	**
6	Seedling Growth Rate (N)	**

Notes:

ns = Not significant ($P \geq 0.05$)

* = Significant ($P \leq 0.05$)

** = Highly significant ($P \leq 0.01$)

V = Variety

Duncan's Multiple Range Test (DMRT) Results for the Early Growth Parameters of Bird's Eye Chili (*Capsicum frutescens* L.) Seedlings

The parameters that exhibited significant or highly significant differences in the analysis of variance were subsequently subjected to Duncan's Multiple Range Test (DMRT) at the 5% significance level to determine differences among varieties for each early seedling growth parameter. The DMRT analysis was performed on normal seedling dry weight during the germination stage (G), seedling growth rate during the germination stage (G), number of leaves at 14 days after planting (DAP), normal seedling dry weight during the nursery stage (N), and seedling growth rate during the nursery stage (N). The results of the multiple comparison test are presented in the following sections to describe the varietal groupings that exhibited significant differences for each observed parameter.

Normal Seedling Dry Weight (mg)

The results for the normal seedling dry weight variable indicated that varietal treatment significantly affected this parameter. Differences in letter groupings based on Duncan's Multiple Range Test (DMRT) at the 5% significance level demonstrated variations in biomass accumulation among the evaluated varieties. The highest normal seedling dry weight was recorded in the **Sigemoy** variety, reaching **5.79 mg**, which was classified in group **c** and differed significantly from all other varieties. This result indicates that the Sigemoy variety possessed the greatest capacity for dry matter accumulation during the germination stage.

The **Sigantung** variety ranked second with a value of **4.72 mg**, belonging to group **b**, and differed significantly from the remaining varieties. Meanwhile, **Oertavi** (3.99 mg), **Sret** (3.83 mg), **Ori 212** (3.82 mg), **Kaliber** (3.74 mg), and **Mhanu** (3.65 mg) were classified in group **a**, indicating no significant differences among these varieties and relatively lower normal seedling dry weights.

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These differences suggest that genetic variation among varieties plays an important role in determining the capacity of seedlings to accumulate biomass during the early stages of growth. A higher normal seedling dry weight does not necessarily correspond to a higher germination rate or seed germination percentage, indicating differences in the physiological characteristics of each variety regarding reserve mobilization during germination. Higher dry weight reflects more efficient tissue formation, whereas lower values may be associated with faster germination accompanied by lower biomass accumulation (Table 2).

Table 2. Effect of Variety on Normal Seedling Dry Weight (NSDW) (DMRT at 5% Significance Level)

Treatment (Variety)	Normal Seedling Dry Weight (NSDW) (mg)
Mhanu	3.65 a
Kaliber	3.74 a
Ori 212	3.82 a
Sret	3.83 a
Oertavi	3.99 a
Sigantung	4.72 b
Sigemoy	5.79 c
DMRT 5%	0.48

Note: Means followed by the same letter are not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level.

Seedling Growth Rate (mg NS⁻¹)

The results for the seedling growth rate (SGR) variable presented in **Table 3** indicated that varietal treatment significantly affected this parameter. This difference was reflected by variations in the letter groupings based on Duncan's Multiple Range Test (DMRT) at the 5% significance level, indicating differences in biomass accumulation capacity among the evaluated varieties.

Table 3. Effect of Variety on Maximum Seedling Growth Rate (SGR) (DMRT at 5% Significance Level)

Treatment (Variety)	Maximum Seedling Growth Rate (SGR) (mg NS ⁻¹)
Mhanu	0.043 a
Kaliber	0.045 a
Ori 212	0.047 a
Sret	0.048 a
Oertavi	0.050 a
Sigantung	0.071 b
Sigemoy	0.099 b
DMRT 5%	0.012

Note: Means followed by the same letter are not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level.

The highest seedling growth rates were recorded in the **Sigemoy** variety (**0.099 mg NS⁻¹**) and the **Sigantung** variety (**0.071 mg NS⁻¹**), both of which belonged to group **b**. These two varieties exhibited significantly greater biomass growth than the other varieties, indicating superior growth efficiency during the early germination stage.

In contrast, **Oertavi** (0.050 mg NS⁻¹), **Sret** (0.048 mg NS⁻¹), **Ori 212** (0.047 mg NS⁻¹), **Kaliber** (0.045 mg NS⁻¹), and **Mhanu** (0.043 mg NS⁻¹) were classified in group **a**, indicating no significant differences among these five varieties and relatively lower seedling growth rates than those in the previous group.

The observed variation in seedling growth rate among varieties demonstrates that genetic factors influence the efficiency of seed reserve utilization during germination. A higher seedling growth rate reflects a more efficient conversion of seed reserves into seedling biomass. However, this parameter is not always directly proportional to germination speed or germination percentage, suggesting differences in the physiological characteristics of the varieties during the early stages of seedling development.

Number of Leaves

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The results for the number of leaves variable presented in **Table 4** showed that varietal treatment had no significant effect on this parameter at **7 days after planting (DAP)**. All varieties recorded a value of **0.00** and were assigned the same letter notation (**a**), indicating that leaf formation had not yet occurred in any of the evaluated varieties during the initial stage of growth. This finding demonstrates the uniformity of early seedling development during the initial growth phase.

Table 4. Effect of Variety on the Number of Leaves at 14 Days After Planting (DMRT at the 5% Significance Level)

Variety	Number of Leaves at 7 DAP	Number of Leaves at 14 DAP
Sigemoy	0.00 a	0.53 a
Sret	0.00 a	1.32 b
Oertavi	0.00 a	1.33 b
Sigantung	0.00 a	1.46 b
Ori 212	0.00 a	1.69 c
Kaliber	0.00 a	1.70 c
Mhanu	0.00 a	1.71 c
DMRT 5%	–	0.23

Note: Means followed by the same letter are not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level.

Observations at **14 DAP** revealed that varietal treatment significantly affected the number of leaves according to the DMRT at the 5% significance level. The highest number of leaves was recorded in the **Mhanu** variety (**1.71 leaves**), followed by **Kaliber** (**1.70 leaves**) and **Ori 212** (**1.69 leaves**), all of which belonged to group **c**. These three varieties were not significantly different from one another but differed significantly from the remaining varieties. An intermediate group consisted of **Sigantung** (**1.46 leaves**), **Oertavi** (**1.33 leaves**), and **Sret** (**1.32 leaves**), which were classified in group **b**.

The lowest number of leaves was observed in the **Sigemoy** variety (**0.53 leaves**), which belonged to group **a** and differed significantly from all other varieties. This result indicates that the Sigemoy variety exhibited slower early vegetative growth than the other tested varieties. The differences in leaf number at 14 DAP suggest that genetic factors strongly influence the rate of early vegetative development. A greater number of leaves reflects superior seedling vigor and a faster growth rate compared with varieties producing fewer leaves (Table 4).

Normal Seedling Dry Weight (mg)

The analysis of the normal seedling dry weight variable indicated that varietal treatment significantly affected this parameter. Differences among varieties were identified through Duncan's Multiple Range Test (DMRT) at the 5% significance level, as reflected by the different letter groupings. These findings demonstrate variations in the capacity of seedlings to accumulate dry biomass, which are influenced by the genetic characteristics of each variety.

The **Mhanu** and **Ori 212** varieties produced the highest normal seedling dry weights, reaching **11.26 mg** and **11.02 mg**, respectively, and were classified in group **c**. These two varieties were not significantly different from one another but differed significantly from the remaining varieties. These results indicate that Mhanu and Ori 212 had the greatest capacity for dry matter accumulation during the seedling stage.

The **Sigemoy**, **Oertavi**, and **Sigantung** varieties produced values of **8.04 mg**, **8.00 mg**, and **7.93 mg**, respectively, and were classified in group **b**. These varieties did not differ significantly from one another but differed significantly from the varieties with the highest dry weights. The **Sret** variety recorded **7.68 mg** and belonged to group **ab**, indicating no significant difference from either group **a** or **b**.

The lowest normal seedling dry weight was observed in the **Kaliber** variety (**6.92 mg**), which belonged to group **a**. This result indicates that Kaliber had the lowest capacity for biomass accumulation and differed significantly from the varieties in groups **b** and **c**.

The variation in normal seedling dry weight among varieties demonstrates that genetic factors play an important role in determining the efficiency of biomass formation and accumulation during early seedling growth. Varieties with higher dry weights exhibit greater efficiency in utilizing stored seed reserves for the formation of new tissues, whereas lower values indicate a relatively limited capacity for biomass accumulation, as presented in **Table 5**.

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Table 5. Effect of Variety on Normal Seedling Dry Weight (DMRT at the 5% Significance Level)

Variety	Normal Seedling Dry Weight (mg)
Kaliber	6.92 a
Sret	7.68 ab
Sigantung	7.93 b
Oertavi	8.00 b
Sigemoy	8.04 b
Ori 212	11.02 c
Mhanu	11.26 c
DMRT 5%	1.08

Note: Means followed by the same letter are not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level.

Seedling Growth Rate

The results for the seedling growth rate variable presented in **Table 6** indicated that varietal treatment significantly affected this parameter. This difference was reflected by variations in the letter groupings based on Duncan's Multiple Range Test (DMRT) at the 5% significance level, indicating differences in seedling growth performance among the evaluated varieties.

The highest seedling growth rate was recorded in the **Mhanu** variety (**0.139**), which belonged to group **d** and differed significantly from all other varieties. This result indicates that Mhanu exhibited the greatest seedling growth efficiency among the tested varieties. The **Ori 212** variety ranked second with a value of **0.123**, belonging to group **c**, and differed significantly from the lower-ranking groups, demonstrating relatively high growth performance despite remaining below that of Mhanu.

The **Sigemoy** variety recorded a value of **0.096** and was classified in group **b**, indicating intermediate-to-high seedling growth performance. Meanwhile, **Oertavi** (**0.087**), **Sret** (**0.088**), and **Sigantung** (**0.089**) belonged to group **ab**, indicating no significant differences among these varieties or between them and Sigemoy, although their numerical values were lower. The lowest seedling growth rate was recorded in the **Kaliber** variety (**0.077**), which belonged to group **a**, indicating the poorest growth performance among all tested varieties.

These differences in seedling growth rate demonstrate that genetic factors play an important role in determining the rate and efficiency of early plant growth. Higher seedling growth rates reflect a greater ability to utilize stored seed reserves for the formation of new tissues during the early stages of development, whereas lower values indicate reduced efficiency in this process and may consequently result in lower seedling vigor.

Table 6. Effect of Variety on Seedling Growth Rate

Variety	Seedling Growth Rate
Kaliber	0.077 a
Oertavi	0.087 ab
Sret	0.088 ab
Sigantung	0.089 ab
Sigemoy	0.096 b
Ori 212	0.123 c
Mhanu	0.139 d
DMRT 5%	0.013

Note: Means followed by the same letter are not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level.

DISCUSSION

This study was designed to evaluate the effect of variety on the early growth of bird's eye chili (*Capsicum frutescens* L.) seedlings based on several physiological parameters, including normal seedling dry weight, seedling growth rate, and leaf number during the early nursery stage. The study focused on determining the ability of each variety to accumulate biomass and support early vegetative seedling growth as indicators of seed physiological quality. The analysis of variance revealed that varietal treatment had a highly significant effect on most of the observed parameters, namely normal seedling dry weight during the germination stage, seedling growth rate during the germination stage, leaf number at 14 days after sowing (DAS), normal seedling

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dry weight during the nursery stage, and seedling growth rate during the nursery stage. In contrast, leaf number at 7 DAS was not significantly affected by varietal differences. These findings indicate that the genetic characteristics of each variety play an essential role in regulating early seedling growth, particularly biomass accumulation and vegetative development following germination. These results are consistent with Reed et al. (2022), who reported that genetic variation among varieties influences metabolic efficiency, early seedling development, and the establishment of uniform seedlings.

For the normal seedling dry weight during the germination stage, the Duncan's Multiple Range Test (DMRT) demonstrated significant differences among varieties. The Sigemoy variety produced the highest normal seedling dry weight (5.79 mg), belonging to group **c**, and differed significantly from all other varieties. Sigantung ranked second with a value of 4.72 mg (group **b**), whereas Oertavi (3.99 mg), Sret (3.83 mg), Ori 212 (3.82 mg), Kaliber (3.74 mg), and Mhanu (3.65 mg) were classified in group **a**, indicating no significant differences among them. These results suggest that each variety possesses a distinct capacity for biomass accumulation during germination.

Normal seedling dry weight represents the amount of dry matter produced during germination through the utilization of seed food reserves. Varieties with higher dry weight demonstrate greater efficiency in converting stored reserves into new tissues. However, higher dry weight is not necessarily accompanied by faster growth because these two parameters are regulated by different physiological mechanisms. Kamanga et al. (2021) reported that efficient mobilization of seed reserves plays a major role in seedling biomass formation, whereas germination speed is primarily determined by early metabolic activities occurring during seed imbibition.

Regarding seedling growth rate during the germination stage, the DMRT results showed that Sigemoy (0.099 mg KN⁻¹) and Sigantung (0.071 mg KN⁻¹) belonged to group **b** and exhibited significantly higher values than the remaining varieties. Meanwhile, Oertavi (0.050 mg KN⁻¹), Sret (0.048 mg KN⁻¹), Ori 212 (0.047 mg KN⁻¹), Kaliber (0.045 mg KN⁻¹), and Mhanu (0.043 mg KN⁻¹) were classified in group **a**. These findings indicate that Sigemoy and Sigantung possess superior efficiency in increasing seedling biomass during the initial stage of growth.

The observed variation reflects differences in the physiological capacity of each variety to utilize seed reserves as an energy source during germination. Varieties with higher seedling growth rates exhibit greater efficiency in converting stored food reserves into seedling biomass, thereby promoting better early growth. Nevertheless, this parameter is not always positively associated with germination speed because certain varieties allocate a larger proportion of energy toward tissue formation rather than accelerating germination. These findings are in agreement with Tonguç et al. (2023), who reported that reserve mobilization efficiency determines seedling biomass accumulation but does not necessarily enhance the rate of germination.

For leaf number, the results showed that no significant differences were observed among varieties at 7 DAS because all treatments produced a value of 0.00 leaves. This finding indicates that all varieties were still undergoing early vegetative organ formation, and leaf development had not yet progressed sufficiently to produce statistically distinguishable differences. Reed et al. (2022) explained that the earliest stage of seedling development is primarily characterized by hypocotyl elongation and root system establishment rather than leaf formation.

Significant differences became apparent at 14 DAS. Mhanu produced the highest leaf number (1.71 leaves), followed by Kaliber (1.70 leaves) and Ori 212 (1.69 leaves), all belonging to group **c** and showing no significant differences among themselves but differing significantly from the remaining varieties. Sigantung (1.46 leaves), Oertavi (1.33 leaves), and Sret (1.32 leaves) were classified in group **b**, whereas Sigemoy produced the lowest value (0.53 leaves) and belonged to group **a**. These findings demonstrate that Mhanu, Kaliber, and Ori 212 possess superior early vegetative growth compared with the other varieties.

Leaf number is an important indicator of successful early vegetative development. A greater number of leaves increases the photosynthetic capacity of seedlings, thereby supporting subsequent plant growth. Habyarimana et al. (2020) stated that early leaf formation is a critical determinant of the plant's ability to produce assimilates required for continued vegetative development. Therefore, Mhanu, Kaliber, and Ori 212 are expected to possess superior early growth potential compared with the other evaluated varieties.

For normal seedling dry weight during the nursery stage, the DMRT results revealed significant differences among varieties. Mhanu (11.26 mg) and Ori 212 (11.02 mg) belonged to group **c** and produced the highest values. Sigemoy (8.04 mg), Oertavi (8.00 mg), and Sigantung (7.93 mg) were classified in group **b**, while Sret (7.68 mg) belonged to group **ab**. The lowest value was recorded for Kaliber (6.92 mg), which belonged to group **a**.

The increased normal seedling dry weight observed during the nursery stage indicates that Mhanu and Ori 212 exhibit greater efficiency in biomass accumulation after entering the seedling growth phase. This pattern differs from that observed during germination, where Sigemoy produced the highest dry weight. Such differences suggest that each variety adopts a distinct physiological strategy for energy allocation throughout plant development. Hoque et al. (2022) reported that biomass accumulation is influenced by photosynthetic efficiency, reserve mobilization, and the genetic characteristics of each variety.

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Regarding seedling growth rate during the nursery stage, Mhanu produced the highest value (0.139), belonging to group **d**, and differed significantly from all other varieties. Ori 212 ranked second with a value of 0.123 (group **c**), whereas Sigemoy recorded a value of 0.096 (group **b**). Oertavi (0.087), Sret (0.088), and Sigantung (0.089) belonged to group **ab**, while Kaliber produced the lowest value (0.077) and was classified in group **a**.

Seedling growth rate reflects the ability of seedlings to utilize both photosynthetic products and stored reserves for the formation of new tissues after germination. The superior performance of Mhanu indicates that this variety possesses greater seedling vigor, enabling sustained growth throughout the nursery stage. This conclusion is further supported by its highest leaf number (1.71 leaves) and normal seedling dry weight (11.26 mg), demonstrating consistently superior early vegetative performance. These findings agree with Wirianto et al. (2024), who reported that seedling vigor is closely associated with metabolic efficiency in supporting biomass accumulation and vegetative growth.

Overall, the integration of all measured parameters demonstrates that each variety possesses distinct physiological characteristics. Sigemoy exhibited superior performance during the germination stage, producing the highest normal seedling dry weight (5.79 mg) and seedling growth rate (0.099 mg KN⁻¹). However, during the nursery stage, Mhanu consistently showed the best performance, recording the highest normal seedling dry weight (11.26 mg), seedling growth rate (0.139), and leaf number (1.71 leaves) at 14 DAS. These findings indicate that superior biomass accumulation during the initial germination stage does not necessarily translate into the best seedling growth performance during subsequent developmental stages. Therefore, the evaluation of seed physiological quality and early seedling growth should incorporate multiple parameters simultaneously to provide a more comprehensive assessment of the growth potential of each variety. This conclusion is consistent with Wang et al. (2023), who emphasized that seed and seedling quality should be evaluated using a multidimensional approach because no single parameter is sufficient to represent all aspects of plant growth.

CONCLUSION

Based on the results and discussion of this study, the following conclusions can be drawn:

1. During the germination stage, the Sigemoy variety exhibited the highest normal seedling dry weight (5.79 mg) and seedling growth rate (0.099 mg NS⁻¹), indicating superior efficiency in biomass accumulation during the early phase of germination. Conversely, the Mhanu, Kaliber, Ori 212, Sret, and Oertavi varieties produced relatively lower values for these parameters.
2. At the nursery stage, the Mhanu variety demonstrated the best overall performance, with the highest normal seedling dry weight (11.26 mg), the highest seedling growth rate (0.139), and the greatest number of leaves (1.71 leaves) at 14 DAP. These findings indicate that Mhanu possesses superior physiological capacity to support early vegetative growth compared with the other tested varieties.
3. The results indicate that high biomass accumulation during the germination stage does not necessarily translate into superior seedling performance during the nursery stage. Each variety exhibited distinct physiological characteristics in terms of reserve mobilization, biomass accumulation, and early vegetative growth.
4. Evaluation of seed physiological quality and early seedling growth should therefore be based on multiple parameters rather than a single indicator, providing a more comprehensive assessment of varietal performance and seedling vigor.

ADVICE

Based on the findings of this study, the Mhanu variety is recommended for seedling production because it demonstrated superior early growth performance during the nursery stage, as indicated by its high normal seedling dry weight, rapid seedling growth rate, and greater number of leaves at 14 days after planting. Since each variety exhibited distinct physiological characteristics during germination and early seedling development, the evaluation of seed quality should not rely on a single parameter. Instead, multiple physiological indicators should be used simultaneously to obtain a more comprehensive assessment of seed vigor and seedling performance.

Future research is recommended to include additional physiological and biochemical parameters, such as germination percentage, vigor index, chlorophyll content, root development, enzyme activity, and photosynthetic efficiency, to provide a more comprehensive evaluation of seed quality and early seedling growth. Furthermore, studies should be conducted under different environmental conditions, including variations in growing media, water availability, nutrient management, and field environments, to evaluate the stability of varietal performance and determine the relationship between early seedling growth and subsequent plant growth, yield, and productivity.

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