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IDENTIFICATION OF MORPHOLOGICAL CHARACTERISTICS OF SORGHUM (*Sorghum bicolor* L.) IN LOWLAND AREAS

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ABSTRACT

This study aimed to identify the morphological characteristics of six sorghum (Sorghum bicolor L.) varieties cultivated in lowland area, specifically in Lubuk Pakan, Punden Rejo Subdistrict, Deli Serdang Regency, North Sumatra. The research was conducted from July to October 2024 using a Non-Factorial Randomized Block Design (RBD) with one treatment factor (variety) and four replications, resulting in 24 experimental plots. Observed morphological parameters included plant height, stem diameter, internode length, leaf length and width, number of leaves, and leaf midrib color. The results of the study showed that Super 2 variety is a variety with maximum plant height, longest internodes, and widest leaves but is at risk of lodging. Soper 9 variety is a sorghum plant variety that shows the best morphology in the lowlands because it has a thick stem, short internodes and a plant height that is not too high so it has the potential to be resistant to lodging. Suri 4 variety has the longest leaves and the largest number of leaves tends to have a greater photosynthetic capacity. All accessions that have been characterized do not have diversity in the color of the midrib of the leaf, namely white.

Keywords: lowland, morphology, sorghum, variety.

INTRODUCTION

Although Indonesia recorded a rice surplus in the first half of 2025, domestic demand was not fully met, making imports still necessary and increasing food vulnerability, particularly when rice prices rise beyond the reach of low-income households. This condition highlights the need for alternative staple foods such as sorghum, which has strong potential as a rice substitute. National sorghum production increased from approximately 7,695 tons in 2019 to around 15,000 tons by mid-2022 due to expanded planting areas (Pujiharti et al., 2022). However, productivity remains relatively low at about 4 tons per hectare, indicating the urgent need for improved cultivation practices and evidence-based development policies (Prasetyo et al., 2024).

Sorghum is recognized for its broad adaptability to both tropical and subtropical regions, enabling it to grow under diverse environmental conditions. Even in less favorable ecological settings, this crop can still produce satisfactory yields. In Indonesia, sorghum can be cultivated from lowland areas up to approximately 800 meters above sea level, with rainfall requirements of 375–425 mm. Optimal growth occurs at temperatures of 23–30°C and relative humidity levels of 20–40% (Siregar, 2021).

Varietal adaptation refers to the ability of a genotype to maintain consistent yield performance across different locations and seasons. It is closely associated with stability, particularly under genotype-by-environment interactions caused by unpredictable environmental factors such as soil type and altitude. This study evaluated several sorghum varieties, namely Numbu, Super 1, Super 2, Soper 7, Soper 9, and Suri 4 (Demelash, 2024).

According to Angkat et al. (2024), morphological characterization is essential because it reflects plant responses to environmental conditions such as temperature and light intensity. These factors influence plant height, leaf size, stem diameter, and other morphological traits. Therefore, identifying sorghum morphological characteristics in lowland areas is an important step in providing baseline information for the development of this crop.

MATERIALS AND METHODS

Place and Time

The research was conducted in Lubuk Pakan, Punden Rejo District, Deli Serdang Regency, North Sumatra, from July to October 2024..

Materials and Tools

The materials used in this study included sorghum seeds of the Numbu, Super 1, Super 2, Soper 7, Soper 9, and Suri 4 varieties, as well as chicken manure and inorganic N, P, and K fertilizers consisting of Urea, TSP, and KCl. The equipment employed comprised hoes, measuring tapes, calipers, watering cans, weighing scales, scissors, machetes, hand weeders, burlap sacks, plastic ropes, a camera, rulers, and writing materials.

Research Method

This study employed a non-factorial Randomized Complete Block Design (RCBD) with one factor, namely sorghum variety, and four replications, resulting in 24 experimental plots. The sorghum varieties consisted of V1: Numbu, V2: Super 1, V3: Super 2, V4: Soper 7, V5: Soper 9, and V6: Suri 4. The observed morphological parameters included plant height, stem diameter, internode length, leaf length and width, number of leaves, and midrib color. The collected data were analyzed using SPSS, followed by Duncan’s Multiple Range Test (DMRT) at the 5% significance level.

Work procedures

Land Preparation

The field was cleared of weeds, plant residues, stones, and other debris. Land preparation was carried out using a hoe to turn and loosen the soil. Experimental plots were then established with a spacing of 100 cm between plots and 100 cm between replications. Each plot was constructed with a height of 20 cm, while drainage channels were made to a depth of 20 cm. Name tags were installed on each experimental plot. The total land area used for the study was 14 m × 9 m, and each plot measured 150 cm × 150 cm.

Growing Media

The growing media consisted of topsoil mixed with chicken manure at a rate of 2.5 kg per plot. Chicken manure was selected due to its relatively high nitrogen (N) content compared to other organic fertilizers. According to Priakamurut Roidah (2013), chicken manure contains approximately 1.7% N, which is about three times higher than sheep manure (0.55%) and five times higher than cattle manure (0.29%).

Planting

Sorghum seeds from six varieties, namely Numbu, Suri 4, Super 1, Super 2, Super 7, and Super 9, were used. Planting was carried out by making holes 3.5 cm deep, with a spacing of 70 × 25 cm.

Thinning and Gap Filling

The plantlet cuttings were carefully planted in sterile cocopeat media. After planting, the pots were covered with transparent plastic to maintain high humidity and prevent excessive evaporation. The adaptation phase lasted for 7 days without treatment, with watering every other day with clean water.

Maintenance

Watering was carried out using a watering can, with an equal amount of water applied to each polybag, in the morning (07:00–09:00 WIB) and afternoon (16:00–18:00 WIB). Irrigation was adjusted according to field weather conditions. When rainfall occurred and the soil remained sufficiently moist, watering was not conducted. Weeding began at one week after planting (WAP). Weeds growing around the plants were removed manually by pulling grasses in the plot area and around the polybags to prevent nutrient competition while simultaneously loosening the soil in the plots.

Fertilization

Chicken manure was applied at a rate of 2.5 g per plot. Basal inorganic fertilizers consisting of N, P, and K sources (Urea, TSP, and KCl) were applied in stages. Urea fertilizer was applied in two split applications: the first at 12 days after planting (DAP) at a rate of 100 kg ha^{-1} or 2.5 g per plot, and the second at 32 DAP at a rate of 150 kg ha^{-1} or 3 g per plot. TSP fertilizer was also applied in two stages, namely at 12 DAP and 32 DAP, with a total rate of 200 kg ha^{-1} or 2.5 g per plot. Meanwhile, KCl fertilizer was applied at 45 DAP at a rate of 90 kg ha^{-1} or 2.5 g per plot..

RESULT AND DISSCUSSION

1. Plant Height (cm)

The results showed that varietal variation in sorghum had no significant effect on plant height at 2 to 5 weeks after planting (WAP) in the highlands, but significantly affected plant height at 6 and 7 WAP. Based on the analysis of variance, the highest mean plant height at 7 WAP was recorded in V3 and V2, reaching 373 cm and 331.75 cm, respectively, while the lowest mean height was observed in V4 at only 222.30 cm. The plant heights obtained in this study were greater than the official varietal descriptions, which was likely influenced by environmental factors, particularly soil fertility. Plants grown on fertile soils tend to reach more optimal heights than those cultivated under less favorable conditions. Similar findings were reported by Hanafiah et al. (2021), who stated that sorghum varieties may exceed their official descriptions when grown under better environmental conditions, while Tsuchihashi et al. (2008) also found seasonal variation in sorghum height, with averages of 306 cm during the rainy season and 198 to 250 cm during the dry season.

Table 1. Mean Plant Height of Sorghum at 2–7 Weeks After Planting (cm)

Treatment	Plant Height (MST)					
	2	3	4	5	6	7
V_1	10.22	22.35	30.74	80.66	117.08b	267.32a
V_2	10.91	22.13	33.98	102.38	151.05a	331.75a
V_3	11.84	22.33	36.94	142.38	153.45a	373.62a
V_4	11.04	19.88	31.96	84.23	108.16b	222.30b
V_5	10.27	20.63	27.80	74.96	101.63b	240.88b
V_6	11.16	19.48	35.65	89.21	121.60b	223.42b

Description: Means followed by different letters indicate significant differences based on Duncan's Multiple Range Test (DMRT) at the 5% significance level.

2. Internode Length (cm)

The analysis of variance on mean data showed that V1, V2, V3, V4, V5, and V6 had a significant effect on the internode length of sorghum plants. The mean internode length of sorghum is presented in Table 2 below.

Table 2. Mean Internode Length of Sorghum Plants (cm)

Treatment	Mean
V_1	15,91b
V_2	24,61a
V_3	26,01a
V_4	19,22b
V_5	15,10b
V_6	15,81b

Description: Means followed by different letters indicate significant differences based on Duncan's Multiple Range Test (DMRT) at the 5% significance level.

The results showed that varietal variation had a significant effect on the internode length of sorghum plants, with the highest mean internode length observed in V3 at 26.01 cm and the lowest in V5 at 15.10 cm. These differences indicate that genetic variation among sorghum varieties directly influences stem growth, particularly internode elongation. In lowland environments, such conditions tend to support the expression of these genetic differences more clearly. According to A'ayuni et al. (2021), variations in internode length are largely determined by the genetic potential of each variety, which affects stem morphology.

3. Stem Diameter (mm)

The analysis of variance on mean data showed that varietal differences had no significant effect on stem diameter at 2 to 5 weeks after planting (WAP), but had a significant effect at 6 and 7 WAP. The mean stem diameter of sorghum plants is presented in Table 3 below.

Table 3. Mean Stem Diameter of Sorghum Plants at 2–7 Weeks After Planting (mm)

Treatment	Stem Diameter (MST)

	2	3	4	5	6	7
V_1	5.36	13.10	22.81	29.46a	27.99	28.19b
V_2	7.12	12.42	20.75	27.69ab	27.2125	27.66bc
V_3	6.70	12.64	21.06	25.27b	26.7625	26.70c
V_4	6.27	12.76	22.00	24.83b	27.2938	27.55bc
V_5	5.09	13.96	20.61	28.83ab	30.8688	31.35a
V_6	6.78	13.26	21.52	27.06ab	27.1125	27.51bc

Description: Means followed by different letters indicate significant differences based on Duncan's Multiple Range Test (DMRT) at the 5% significance level.

Varietal differences in sorghum may not show a significant effect on stem diameter during the early growth phase in lowland areas because environmental factors and early adaptation responses tend to be relatively uniform among varieties. However, at 5 weeks after planting (WAP), these differences began to show significant responses as each variety started to express its genetic potential more clearly. Dewi et al. (2017) reported that early growth of sorghum is generally slow and relatively uniform, but significant differences become more evident during later growth stages, particularly after 60 days after planting, when the plants enter the maximum stem and leaf development phase.

4. Leaf Length (cm)

The analysis of variance on mean data showed that varietal differences had no significant effect on leaf length at 2 to 4 weeks after planting (WAP), but had a significant effect at 5 and 7 WAP. The mean leaf length of sorghum plants is presented in Table 4 below.

Table 4. Mean Leaf Length of Sorghum Plants at 2–7 Weeks After Planting (cm)

Treatment	**Leaf Length (MST)**					
	2	**3**	**4**	**5**	**6**	**7**
V_1	31.64	53.25	68.25	80.75bc	86.94	88.50ab
V_2	35.20	53.13	79.18	88.63a	89.50	89.80a
V_3	32.79	50.89	68.78	78.46c	79.00	79.71c
V_4	34.29	55.18	75.25	79.78bc	84.59	86.19ab
V_5	29.73	48.39	74.00	83.20abc	84.62	84.68b
V_6	28.42	57.01	74.10	86.06ab	87.35	90.13a

Description: Means followed by different letters indicate significant differences based on Duncan's Multiple Range Test (DMRT) at the 5% significance level.

During the early growth stage, sorghum leaf length did not show significant differences because all varieties grew relatively uniformly. By the fifth week after planting, leaf length began to vary as the plants entered the active vegetative phase, during which leaf development progressed more rapidly. This result is consistent with Almodares (2008), who stated that morphological growth responses, including leaf elongation, become more apparent after the initial growth stage. Longer leaves enable plants to capture sunlight more efficiently, thereby enhancing photosynthesis and increasing biomass production. High biomass is important as a forage source because it is associated with abundant and high-quality green fodder, making varieties with longer leaves more suitable for feed purposes (Nugroho et al., 2018).

5. Leaf Width (cm)

The analysis of variance on mean data showed that varietal differences had no significant effect on leaf width at 2, 3, 4, 6, and 7 weeks after planting (WAP), but had a significant effect at 5 WAP. The mean leaf width of sorghum plants is presented in Table 5 below.

Table 5. Mean Leaf Width of Sorghum Plants at 2–7 Weeks After Planting (cm)

Treatment	Leaf Width (MST)					
	2	3	4	5	6	7
V_1	2.68	5.58	8.90	10.48ab	10.49	10.50
V_2	3.10	5.78	8.60	9.85abc	9.95	10,64
V_3	3.03	5.74	9.24	10.60a	10.62	12.06
V_4	3.29	5.38	8.30	9.65c	9.75	10.76
V_5	2.45	5.10	8.32	10.46ab	10.61	10.80
V_6	3.26	5.23	8.31	9.75bc	10.03	10.65

Description: Means followed by different letters indicate significant differences based on Duncan's Multiple Range Test (DMRT) at the 5% significance level.

The highest mean leaf width at 7 weeks after planting (WAP) was observed in variety V3, reaching 12.06 cm, while the lowest was recorded in V1 at 10.50 cm. Wider leaves provide a larger surface area for capturing sunlight, which can enhance photosynthesis and increase biomass production. However, under lowland conditions with moderate humidity, narrower leaves may help regulate leaf surface temperature more efficiently. Somu et al. (2024) suggested that developing varieties with extremely wide leaves may be less advantageous in lowland cropping systems. Therefore, breeding efforts should focus more on stable genetic traits such as plant height and stem diameter, while leaf width may serve as a supporting trait for improving water and light use efficiency.

6. Number of Leaves (leaves)

The analysis of variance on mean data showed that V1, V2, V3, V4, V5, and V6 had no significant effect on the number of leaves of sorghum plants at 2 to 7 weeks after planting (WAP). The mean number of leaves of sorghum plants is presented in Table 6 below.

Table 6. Mean Leaf Width of Sorghum Plants at 2–7 Weeks After Planting (cm)

Treatment	Number of Leaves (MST)					
	2	3	4	5	6	7
V_1	3.50	6.00	7.06	8.75	9.50	10.81
V_2	3.81	5.44	7.38	9.00	9.75	11.31
V_3	3.50	5.13	6.94	7.75	9.50	11.13
V_4	3.81	5.88	7.63	9.50	10.00	11.19
V_5	3.50	5.94	7.44	9.00	9.63	10.75
V_6	3.31	5.69	6.88	8.50	10.25	11.56

Description: Means followed by different letters indicate significant differences based on Duncan's Multiple Range Test (DMRT) at the 5% significance level.

All sorghum varieties showed no significant differences in leaf number from 2 to 7 weeks after planting (WAP), although numerically V6 recorded the highest value at 7 WAP with 11.56 leaves, while the lowest was observed in V5 with 10.75 leaves. This indicates that the sorghum varieties used in this study, when cultivated in lowland conditions, did not produce significantly different leaf numbers among varieties. Pan et al. (2021) reported that the rate of leaf initiation during the early vegetative stage is more strongly influenced by environmental conditions than by genotype. Therefore, leaf number may not serve as a strong indicator of genetic differences under lowland environments.

7. Leaf Midrib Color

Table 7. Leaf Midrib Color of Sorghum Plants

Variety	Description	Photo
V1(Numbu)	White	
V2(Super1)	White	
V3(Super2)	White	
V4(soper 7)	White	

Variety	Description	Photo
V5(Soper 9)	White	
V6(Suri 4)	White	

Observations on the leaf midrib color showed that all accessions had a uniform white coloration. This uniformity indicates that the plants likely lacked genes responsible for pigment formation in that tissue. According to Vermeris (2006), a white leaf midrib reflects the absence of genes regulating pigment synthesis in leaf tissues. The white appearance of the midrib also suggests that this part likely contains no tannins or only very low tannin levels. Sari et al. (2019) explained that plants with high tannin content tend to show a dark coloration on the midrib after reacting with $FeCl_3$, whereas lighter colors indicate lower tannin concentrations. Tannins are known to precipitate proteins because they possess multiple functional groups capable of strongly interacting with protein molecules, forming cross-linked protein–tannin complexes.

CONCLUSIONS AND SUGGESTIONS

Conclusion

Variety Super 2 showed superior vegetative morphological performance, as indicated by the greatest plant height, longest internodes, and widest leaves, suggesting a high potential for greater biomass production. Variety Soper 9 appeared to be the most adaptive variety under lowland conditions, characterized by thick stems, short internodes, and moderate plant height, which may contribute to better lodging resistance and stronger stem structure for optimal growth support. Meanwhile, Variety Suri 4 had the longest leaves and the highest number of leaves, providing greater photosynthetic capacity that could enhance growth efficiency and crop productivity. In addition, all observed accessions showed uniformity in leaf midrib color, which was white, with no variation detected for this trait.

Recommendations

It is recommended to select an appropriate planting time, preferably at the beginning of the dry season, so that the root system develops strongly and plants are less prone to lodging. In addition, stakes should be installed when sorghum plants reach 4 weeks after planting (WAP), especially for plants showing tall stem growth. Fertilizer type and dosage should also be adjusted to the specific nutritional requirements of the crop and the agronomic conditions of the land in order to prevent nutrient imbalance.

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